Sleep Breath
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ORIGINAL ARTICLE

Diagnosis and treatment of snoring in adults–S2k Guideline of the German Society of Otorhinolaryngology, Head and Neck Surgery

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Abstract
Objectives This guideline aims to promote high-quality care by medical specialists for subjects who snore and is designed for everyone involved in the diagnosis and treatment of snoring in an in- or outpatient setting.
Discussion To date, a satisfactory definition of snoring is lacking. Snoring is caused by a vibration of soft tissue in the upper airway induced by respiration during sleep. It is triggered by relaxation of the upper airway dilator muscles that occurs during sleep. Multiple risk factors for snoring have been described and snoring is of multifactorial origin. The true incidence of snoring is not clear to date, as the incidence differs throughout literature. Snoring is more likely to appear in middle age, predominantly in males. Diagnostic measures should include a sleep medical history, preferably involving an interview with the bed partner, and may be completed with questionnaires. Clinical examination should include examination of the nose to evaluate the relevant structures for nasal breathing and may be completed with nasal endoscopy. Evaluation of the oropharynx, larynx, and hypopharynx should also be performed. Clinical assessment of the oral cavity should include the size of the tongue, the mucosa of the oral cavity, and the dental status. Furthermore, facial skeletal morphology should be evaluated. In select cases, technical diagnostic measures may be added. Further objective measures should be performed if the medical history and/or clinical

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examination suggest sleep-disordered breathing, if relevant comorbidities are present, and if the subject requests treatment for snoring. According to current knowledge, snoring is not associated with medical hazard, and generally, there is no medical indication for treatment. Weight reduction should be achieved in every overweight subject who snores. In snorers who snore only in the supine position, positional treatment can be considered. In suitable cases, snoring can be treated successfully with intraoral devices. Minimally invasive surgery of the soft palate can be considered as long as the individual anatomy appears suitable. Treatment selection should be based on individual anatomic findings. After a therapeutic intervention, follow-up visits should take place after an appropriate time frame to assess treatment success and to potentially indicate further intervention.

Keywords Snoring · Guideline · Adults · Oropharynx · Airway

Introduction

Snoring has received increasing attention in recent years. Given its high prevalence and its impact on quality of life, diagnosis and treatment of snoring is of major importance. A high number of snorers seek medical help and intervention for snoring, which could also be a symptom of obstructive sleep apnea (OSA). Guidelines for diagnosis and treatment of snoring as an isolated symptom are hard to find in the international literature. This may be explained by the difficulties in defining snoring, in objectively assessing snoring and treatment outcome, and in the lack of well-controlled clinical trials concerning the treatment of this phenomenon. In 2010, the German Society of Otorhinolaryngology, Head and Neck Surgery published the S1 guideline: Diagnosis and Treatment of Snoring in Adults [1]. This guideline has been revised and updated in the present S2k guideline.

Aims of the guideline

The present guideline aims to promote high-quality medical care for adults who snore. Reasonable diagnosis and treatment should be based on the latest research in terms of evidence-based medicine. This guideline is designed for all medical specialists involved in the diagnosis and treatment of adult snorers in an in- or outpatient setting. The guideline was established on behalf of the German Society of Otorhinolaryngology, Head and Neck Surgery.

Methods

The present guideline was designed according to the specifications of the Association of the Scientific Medical Societies in Germany (AWMF) and represents an S2k guideline according to the three-level concept of the AWMF.

> For the international readers the meaning of the expression "S2k" guideline will be explained in the following, deviant from the original German version: S2k stands for a consensus based guideline. This guideline is developed against the background of the current literature as described below. However, the underlying literature review does not fulfil the formal requirements for an evidence based guideline (e.g. S2e or S3). Therefore, formalised grades of evidence or strengths of recommendations can not be provided in such a guideline. A consensus based guideline was selected with regard to the substantial lack of evidence in the field of snoring.

The previous S1 guideline was the basis for this revised guideline. Additionally, a systematic review of the literature was performed to include the latest research. The review of the literature was performed in June 2012 using MedLine (National Library of Medicine) with the following search criteria: {"snoring" NOT "apnea" NOT "apnoea"}, limited to the terms "English," "German," "adults," and "humans." Based on the guideline authors' expertise, appropriate articles were selected and considered in the revision.

Subsequently, the guideline was presented to representatives of the involved societies in a nominal group process and then revised. Final consensus was achieved by the authors with the help of a nonanonymized Delphi method (see guideline report at the end of this guideline). Consensus needs to be achieved when the available evidence is limited in order to promote acceptance and implementation of a guideline. Based on the literature research and the discussion during the nominal group process, the recommendations were verbalized. The strength of the recommendations is reflected in the words used (must, should, may); those recommendations are based on the opinions of the participants in the nominal group process.

Nosology/definition

Historically, multiple terms have been used to refer to snoring: primary snoring, habitual snoring, simple snoring, benign snoring, nonapnoic snoring, continuous snoring, rhythmic snoring, nondangerous snoring, and so on. Snoring can be a singular and independent phenomenon, but it can also be a symptom of a sleep disorder, such as OSA, the latter not being content of the present guideline. To date, there is no clear word that differentiates snoring as a symptom of OSA from snoring as

the phenomenon described in this guideline. According to the authors of the guideline, such a differentiation would be helpful.

A satisfactory definition of snoring is not available to date. According to the International Classification of Sleep Disorders (ICSD-2), snoring is classified under the chapter "Isolated Symptoms, Apparently Normal Variants and Unresolved Issues" [2]. In accordance with the ICSD-2, snoring can be diagnosed under the following circumstances:

- The subject or the bed partner complains about respiration-dependent acoustic phenomena, usually related to inspiration. Objective parameters defining these sounds as "snoring" are lacking.
- The subject does not complain about insomnia or hypersomnia that can be attributed to the snoring.
- Sleep testing shows no signs of sleep-disordered breathing.

Etiology and pathophysiology

Snoring is caused by narrowing of the upper airway during sleep and vibration of the soft tissues as respiration occurs. The narrowing is triggered by relaxation of the upper airway dilator muscles. As a result, the tendency of the soft tissue to vibrate increases and the diameter of the upper airway is reduced, increasing air flow. If the air flow exceeds a certain velocity, turbulences arise and lead to rapidly changing local pressure levels in the pharynx, which cause the soft tissue to vibrate.

Frequently, typical anatomic findings are present, such as excessive soft tissue at the soft palate or the pharynx. The source of the snoring sound is usually located at the soft palate; however, the entire pharynx can be the source of snoring, rarely also the larynx. The frequency of snoring differs depending on its source: Velar snoring usually presents with low frequencies (100–300 Hz), whereas retrolingual snoring presents with high frequencies (>1,000 Hz) and epiglottic snoring with middle frequencies (~500 Hz) [3]. However, there is no method to acoustically differentiate the type of snoring addressed in this guideline from the snoring associated with OSA.

Even though the source of snoring is not located in the nose, snoring is more common in subjects with nasal obstruction [4]. Male gender, increased body weight, parapharyngeal muscle thickness, and adenotonsillar hyperplasia are also associated with a higher prevalence of snoring [5–7]. A potential genetic component also has been described in recent literature [8]. The prevalence of snoring increases with age (up to 65 years) as well as in people who drink alcohol and smoke. Snoring without OSA is associated with decreased pharyngeal sensitivity to cold, vibration, and two-point discrimination. This sensitivity seems to decrease further in patients with OSA depending on its severity [9, 10]. In patients with OSA, neurodegenerative and myopathic changes of the pharyngeal muscles [9] and the extracellular pharyngeal matrix [11] are described. Those changes, however, could not be detected in snorers. Yet, snoring can be interpreted as a chronic pharyngeal trauma, which may contribute to pharyngeal neuropathy that consequently increases the risk of developing OSA. A limited number of longitudinal studies contribute to this hypothesis [12]. To summarize, snoring is of multifactorial origin.

Change of body position, alcohol consumption, or a change from nasal to oral breathing can influence the sound, duration, and intensity of snoring due to a change in the resonance space and changes within the structures involved in snoring. This is the reason why snoring may present differently on different nights and why there is such a high night-to-night variability of snoring [13].

Epidemiology and health effects

The prevalence of snoring in adults ranges from 2 to 86 % depending on the data collected (e.g., polysomnography (PSG), questionnaires for subjects or bed partners) and the snoring definition (kind and frequency) [14]. In a telephone survey performed in Great Britain, 26 % of men and 20 % of women under the age of 24 reported regular snoring. The prevalence was highest in the age group between 45 and 54 years with 62 % of men and 45 % of women snoring. The prevalence declined in the age group >65 years in which 47 % of men and 31 % of women reported snoring [15].

According to multiple Asian, North American, and European longitudinal and cross-sectional studies with up to 72,000 subjects, the risk of developing hypertension, diabetes, hypercholesterinemia, or suffering from a heart attack or stroke was significantly higher in participants who snore [16–18]. In addition, snoring has been associated with hoarseness, headaches, exam failures, fearful dreams, and poor quality of sleep [19–22]. Since all of those studies were based on subjective information provided by the snoring subjects, it has to be taken into account that patients suffering from OSA may have contributed to those results as well. Single polysomnographic or polygraphic controlled studies described a higher risk of hypertension and a higher mortality rate in subjects who snore and have an apnea–hypopnea index (AHI) below 5/h, whereas a longitudinal study over 17 years with 380 subjects could not confirm a higher risk of stroke or myocardial infarction [23–26]. Consequently, the role of snoring as a risk factor for these diseases cannot be assessed reliably to date. Despite this, snoring is still a cardinal symptom of OSA, and the risk for OSA increases fivefold in the presence of snoring [27].

The impact of snoring on the bed partner is not well studied, and OSA usually is not assessed or excluded in these trials. Women whose partners snore regularly

complain more often about sleep disorders, morning headaches, and daytime sleepiness [28]. According to Virkkula et al., 55 % of the bed partners of patients with sleep-related breathing disorders are disturbed by snoring every night, 40 % sleep in a separate room at least once a week, 36 % use earplugs or sleeping pills, and 35 % describe problems in their relationship as a consequence of snoring [29].

Clinical presentation

The snorers (or the bed partners) complain about socially disruptive snoring. The degree of annoyance is essential in the evaluation of snoring and is highly dependent on the bed partner. Furthermore, those affected by snoring often complain about a sore throat and nocturnal awakenings due to his or her own snoring (see section "Epidemiology and health effects"). Due to the high prevalence of snoring, it often occurs simultaneously but independent of a sleep disorder (e.g., snoring and insomnia).

Diagnostic measures

In order to diagnose snoring, it is important to distinguish the snoring addressed by this guideline from snoring related to a partial or complete obstruction in the upper airway. Therefore, the aim of all diagnostic measures should not only be to diagnose snoring, but more importantly, to rule out an obstructive sleep-related breathing disorder. Snoring in the sense of this guideline should therefore be interpreted as a diagnosis of exclusion. From a diagnostic point of view, snoring is often accompanied by obstructions of the upper airway, and therefore, a strict differentiation between snoring and snoring as a symptom of OSA is not easy to make. Often pathological structures along the upper airway may be the reason for snoring with or without obstructions of the upper airway.

Standardized diagnostic measures are listed below. Additional measures may be performed individually, for example, prior to a certain treatment. All diagnostic measures are comprised in an algorithm, which can be found in Fig. 1.

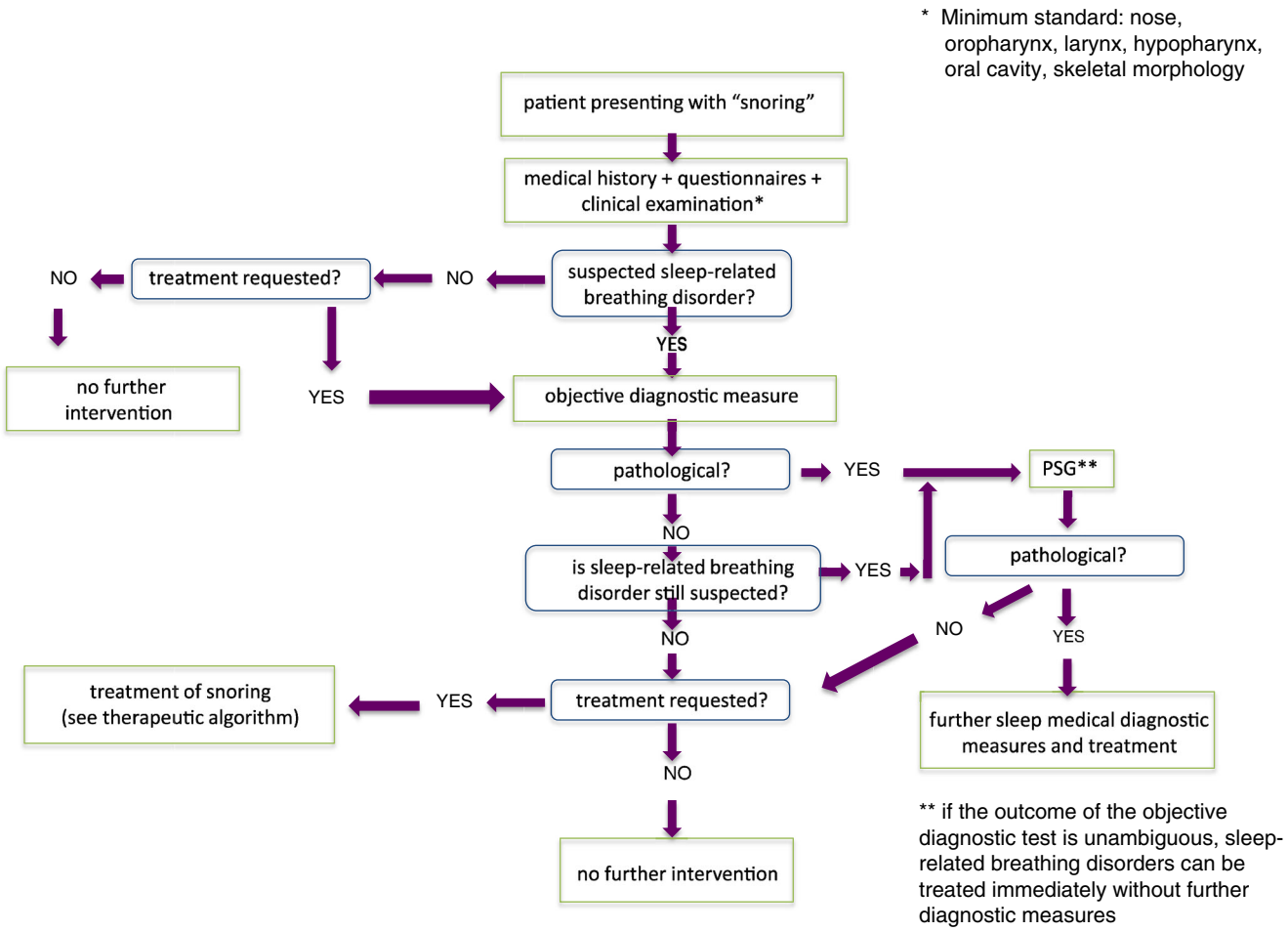

Fig. 1 Algorithm of diagnostic measures

Medical history

Taking a detailed medical history from the snorer, and if possible, from the bed partner, provides the opportunity to acquire essential information about snoring. Medical history can be divided into the following topics.

I. Specific evaluation of snoring (selection):

- Timeline of complaints (e.g., every night, intermittently)
- Occurrence during night (permanently/intermittently, related to body position)
- Causative situations or risk factors (e.g., alcohol or nicotine consumption, presence of allergic or nonallergic rhinitis, nasal obstruction)
- Manner of snoring (e.g., regular or irregular frequency, loudness, character of sound)

II. Sleep medical history (selection):

- Insomnia
- Nocturnal awakenings (e.g., associated with shortness of breath)
- Lack of concentration during the daytime
- Daytime sleepiness
- Reduction in overall performance
- Complaints of dry mouth or headaches in the morning

III. Relevant comorbidities (selection)

- Cardiac and vascular diseases (e.g., hypertension, arrhythmia, myocardial infarction, stroke)
- Overweight or obesity
- Diabetes

Standardized questionnaires are available from different scientific societies to facilitate a medical history. In commonly used questionnaires, snoring may not be mentioned specifically. However, there are questionnaires that ask for snoring as a symptom associated with OSA. To date, there is no validated questionnaire that aims to differentiate the snoring addressed by this guideline from snoring associated with OSA.

Questionnaires usually assess the loudness of snoring; however, this information does not allow differentiation between the snoring addressed by this guideline from snoring related to OSA. Some questionnaires explicitly ask for witnessed apneas. With this information, a rough differentiation from OSA with a complete collapse of the upper airway is possible. Finally, with a medical history alone, it is not possible to differentiate the snoring addressed by this guideline from snoring related to OSA.

A visual analogue scale for snoring may be used to quantify loudness and frequency of occurrence. Visual analogue scales do not provide a differential diagnosis of snoring, but they can be used to assess the timeline of snoring and treatment effects.

Recommendation A detailed medical history involving the bed partner, if possible, should be taken for every subject who snores. Questionnaires can be used additionally.

Clinical examination

The aim of clinical examination is to identify changes in the upper airway that may cause snoring or obstructions of the upper airway. As with a medical history, the results of the clinical examination may be very similar in snorers and those with obstructions of the upper airway. Anatomical findings of the upper airway may cause snoring with or without obstruction of the upper airway.

Nose/nasopharynx

The shape of the outer nose determines the inner anatomy in many cases and may influence nasal airflow. The bony and cartilaginous nasal skeleton prevents collapse of endonasal structures. However, nasal obstruction can cause a labored respiratory sound that normally can be distinguished from snoring. In order to evaluate all nasal structures that may influence nasal airflow, a clinical examination of the nose should be performed, which may also include nasal endoscopy. In the presence of nasal complaints or pathologic findings, an endoscopic examination of the nose should be performed.

The following structures should be examined:

- Bony and cartilaginous nasal skeleton
- Nostrils
- Nasal septum
- Nasal turbinates
- Meatus of the nose
- Nasopharynx

Recommendation In order to evaluate all nasal structures that may influence nasal airflow, a clinical examination should be performed, which may include nasal endoscopy.

Oropharynx

Due to its structural composition, the oropharynx is likely to be the origin of upper airway collapse. A narrowing of the oropharynx can influence airflow and, consequently, cause snoring [30–32]. A direct inspection or endoscopy (flexible transnasal, rigid transoral) allows evaluation of the

oropharynx. Clinical examination of the oropharynx should include the following:

- Size and position of the base of the tongue
- Size of the tonsils
- Size and position of the soft palate
- Size and position of the uvula

The clinical and endoscopic evaluation of these structures mainly provides information about those anatomical structures at rest. Further tests exist that try to evaluate dynamic changes within the collapsing structures. One of these tests is the Müller maneuver, in which the patient creates negative pressure in the upper airway so that the collapse of the pharynx can be induced. In contrast to previous studies, recent work has found the value of the maneuver to be less important. An association between the tendency of the pharynx to collapse and the type of snoring addressed by this guideline has not been described.

Recommendation The clinical examination of the oropharynx is paramount and should be performed.

Larynx/hypopharynx/neck

Laryngeal snoring has been described in clinical experience. Supraglottic snoring comprises vibrations or obstructions caused by supraglottic structures (supraglottic folds, arythenoid cartilage, epiglottis). To verify laryngeal snoring, drug-induced sleep endoscopy is needed. To estimate whether the supraglottis has a tendency to vibrate or obstruct, simulated snoring while awake may be helpful. Sufficient scientific analysis of supraglottic snoring has not been conducted yet. The relevance of laryngeal snoring cannot be assessed, as there is no data available to date.

There seems to be an association between neck circumference and nocturnal apnea, although the influence of neck circumference on snoring in the context of this guideline has not been described.

Recommendation The larynx and hypopharynx should be examined in snorers.

Oral cavity/dentition

During clinical examination of the oral cavity, the size of the tongue, mucosal status, and dentition should be explored. If an intraoral device is considered as a therapeutic measure, the ability of the mandible to protrude should be assessed, and a detailed dentals status should be obtained (see section "Intraoral devices").

Recommendation During clinical examination of the oral cavity, the size of the tongue, mucosal status, and dentition should be assessed.

Facial skeleton

During clinical examination, an orienting evaluation of the facial skeleton should take place in order to find skeletal features that may be of etiological or therapeutic importance. In particular, retrognathia or a narrow maxilla should be considered. If there are any abnormal findings or if treatment with an intraoral device is considered, a dentist or an orthodontist should be consulted.

Recommendation During clinical examination of a snorer, an orienting evaluation of the facial skeleton should be performed.

Technical diagnostic measures

Rhinomanometry, rhinoresistometry, or acoustic rhinometry may be used to objectify nasal airflow. These diagnostic measures may be helpful in select cases.

Computed tomography, magnetic resonance imaging, cone beam computed tomography, lateral X-ray cephalometry, or dental panoramic radiograph may be used as imaging techniques. Although associations between imaging results and OSA have been described, there are no data available for the snoring addressed by this guideline. Those imaging techniques are not routinely required but may be indicated and helpful in select cases. If medical history indicates allergic rhinitis, allergy tests may be indicated.

Acoustic analysis

Snoring can be interpreted as an acoustic phenomenon that can be described by physical means. An acoustic analysis may provide useful information about the underlying pathology (the snoring addressed by this guideline vs. OSA). The snoring addressed in this guideline usually consists of low frequencies (<500 Hz), whereas obstructive events associated with OSA usually comprise frequencies above 500 Hz. Current knowledge finds that lower frequencies originate from vibrations of the soft palate and the uvula. Higher frequencies occur if there is partial or complete airway collapse. Highly collapsible oropharyngeal structures (e.g., tonsils, base of the tongue, lateral pharyngeal walls) are considered to be the origin of snoring sounds [3, 33–38]. If an acoustic analysis of snoring sounds is considered, it should be performed via air conduction to record frequencies over 1,000 Hz correctly [39].

Microphones with body contact or snoring analysis with the help of pressure transducers lead to a reduction of intensities above 1,000 Hz. To date, acoustic analysis of snoring is not a standardized diagnostic measure. Due to improved

polygraphic or polysomnographic recording and analysis, acoustic analysis may provide valuable information in the future to differentiate snoring. The commonly used snoring indices as assessed with outpatient recordings or PSG currently are not validated or comparable, so they cannot be used for qualitative or quantitative snoring assessment.

Recommendation Acoustic analysis of snoring currently is not a routine test for the type of snoring addressed by this guideline, but it may be indicated in select cases.

Drug-induced sleep endoscopy

Drug-induced sleep endoscopy (DISE) has become part of topodiagnostic measures in OSA over the last decade [40–48]. The site of airway obstruction may be localized correctly with the help of DISE, and the test results may have an impact on treatment selection in OSA. In contrast, there are no data available that describe the benefit of DISE in the snoring addressed by this guideline.

Recommendation DISE is not recommended as a routine test for the type of snoring addressed by this guideline, but it may be helpful for treatment selection.

Pressure sensors

Pressure sensors are helpful to assess pharyngeal/esophageal pressure during sleep and may provide useful information about the site of airway obstruction in patients with OSA. There are two-point and multilevel pressure sensors available [49]. To date, snoring without obstruction cannot be localized by pressure sensors.

Recommendation Pressure sensors cannot be recommended as a routine test in snorers.

Sleep testing

PSG is the gold standard to diagnose sleep-related breathing disorders. An objective sleep test (usually an outpatient recording) should be performed if a sleep-related breathing disorder is suspected, if there are relevant comorbidities, or if the subject is seeking therapeutic interventions for snoring. The various systems for outpatient recordings differ in their informative value and need to be evaluated individually. If clinical examination and medical history do not suggest a sleep-related breathing disorder and if the objective sleep test is normal, further sleep testing is not required. In all other cases, further sleep testing, such as PSG, is mandatory.

Recommendation An objective sleep test (usually an outpatient recording) should be performed if a sleep-related breathing disorder is suspected, if there are relevant comorbidities, or if the subject is seeking therapeutic interventions for snoring.

Therapeutic principles

The snoring addressed in this guideline is not a disease associated with medical hazard, and generally, there is no medical indication for treatment. However, given the recent data that shows snoring as a potential risk factor for developing OSA, cardiovascular diseases, and increased mortality, this estimation may change in the future. Currently, there is no evidence that early treatment for snoring in adults can prevent progression to OSA or lower cardiovascular risk. Consequently, snoring is not treated unless the snorer requests treatment.

Against this background, invasive treatment needs to be indicated with care. For surgical treatment, the least invasive procedure for the individual anatomy should be selected with regard to morbidity and complication rate. Even the potential long-term risks of conservative approaches should be considered.

Numerous highly questionable treatments are offered for snoring. The following sections provide an overview of the most important conservative and surgical approaches for snoring. Therapeutic principles are summarized in an algorithm that is presented in Fig. 2. All of the different therapeutic approaches can be used separately or in combination.

Since snoring is not considered to be a disease with medical hazard and since there is generally no medical indication for treatment, the following recommendations are relatively "weak" ("may"). The weakness of these recommendations is related to the lack of a strong medical indication for treatment and does not reflect the efficacy of the therapeutic interventions listed.

Conservative approaches

As increased body weight is associated with snoring, weight reduction is often accompanied with snoring reduction in the experience of the authors. Therefore, weight reduction can be recommended for every overweight subject who snores, although there are no studies available regarding the specific effect of weight reduction on snoring.

Various lifestyle modifications are frequently recommended to subjects who snore. This usually includes avoiding sleeping pills or alcohol intake in the evenings, abstaining from nicotine, and maintaining a regular sleep–wake cycle. Although there is not enough evidence on the efficacy of these recommendations for snoring, they appear appropriate from a sleep medical perspective.

Improvement of snoring using muscle stimulation or other approaches to strengthen the muscles of the floor of mouth (e.g., playing a didgeridoo, singing, etc.) has been discussed [50, 51].

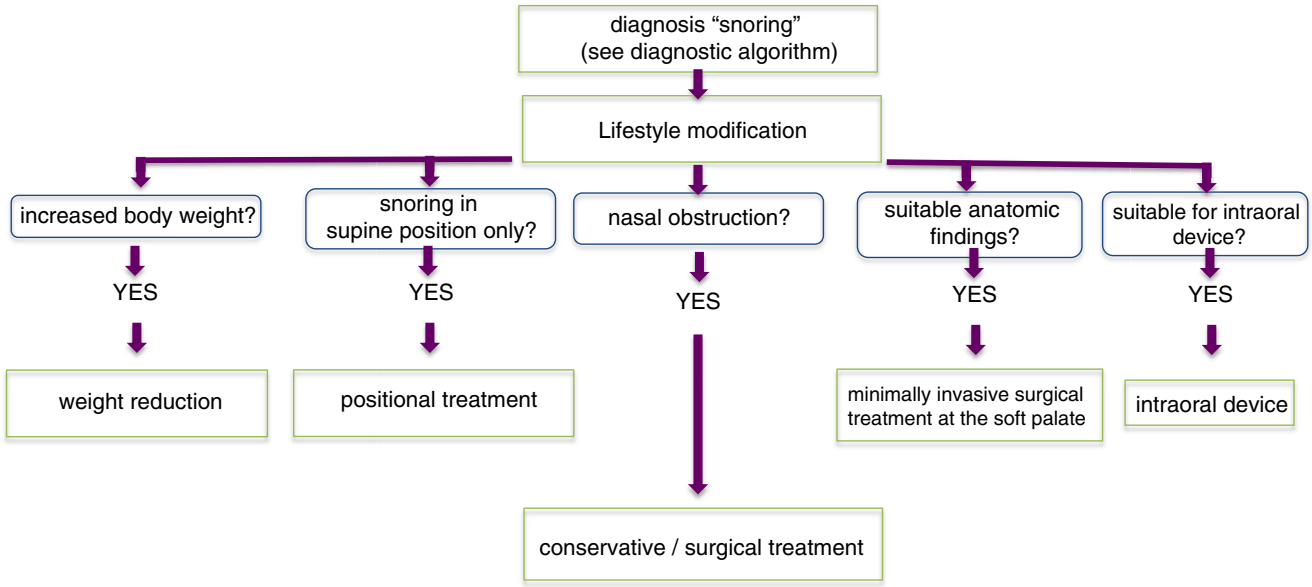

Fig. 2 Algorithm of therapeutic principles

Although one controlled study described an improvement of snoring in patients with OSA using electric stimulation of the muscles of the floor of mouth [52], there are no data available for those who snore without airway obstruction. There are not enough data available to recommend one of those approaches in the treatment of the snoring addressed by this guideline.

An association between singing and snoring also has been described. One study comparing people who regularly sing in a chorus with those who do not regularly sing found lower snoring scores in the group of singers [53]. However, such a difference could not be confirmed in people playing in an orchestra. There was no difference in the presence of snoring in musicians playing a wind instrument compared to other musicians [54]. A noncontrolled study showed a positive effect of regular singing exercise on snoring [55]. Although positive effects of specific oropharyngeal exercises and playing a didgeridoo were demonstrated in controlled trials with OSA patients [50, 51], a positive effect in snorers has not been demonstrated. There is not enough evidence to recommend such exercises in the treatment of the snoring addressed by this guideline.

It has been described that sleep-related breathing disorders and snoring worsen in the supine position. Positional treatment has shown positive effects, especially in patients with OSA, though it has to be taken into account that the effectiveness differs among the various interventions for positional treatment. The data, however, are limited and less homogenous [56]. Furthermore, snoring that is strictly related to supine position is unusual, and compliance with positional treatment is often limited. Elevation of the upper part of the body has been described to reduce snoring in select cases. If snoring only occurs in supine position, positional treatment may be considered.

Dilatators of the nasal valve may be helpful when nasal airflow is obstructed by the nasal valve and may also improve snoring. Several clinical studies have analyzed the efficiency of such nasal dilatators in subjects who snore. Whereas clinical case series seemed to demonstrate efficiency [57–60], PSG-controlled studies showed contradictory results [61–63], although it should be noted that there are problems in objectively describing snoring in PSG (as described in the sections on diagnostic measures). Consequently, internal and external nasal dilatators may be useful in snorers with nasal airflow obstruction caused by the nasal valve.

Long-term use of decongestive nasal spray may damage the nasal mucosa; thus, permanent use is not recommended. Nasal dilators and decongestive nasal spray may be used in combination to mimic the anticipated effect of nasal surgery on snoring. If snoring is caused by chronic nasal obstruction (e.g., allergic rhinitis), nasal corticosteroids have been recommended and evaluated in clinical studies. However, a recent placebo-controlled study could not demonstrate an improvement in snoring [64].

The effect of pseudoephedrine, prokinetic medication (e.g., domperidone), and protryptiline [65, 66] as systemic medical treatment has been examined in clinical studies [65, 66]. Although positive effects have been reported, the potential side effects of this medication should be considered, especially given the lack of a medical indication for treatment. Additionally, those substances usually are not approved for the treatment of snoring. Consequently, a systemic medicamentous treatment of snoring is not recommended.

Topical medications are offered for the soft palate, including oils, sprays, and moistening solutions. A comparison of all available products cannot be made due to the large number of products, ingredients, and dosage forms. Two recent placebo-

controlled studies could not demonstrate a superiority of oil-based sprays compared to a placebo spray [67, 68]. Convincing studies demonstrating a potential benefit of this kind of treatment do not exist to date; therefore, their use cannot be recommended in the treatment of snoring.

Continuous positive airway pressure (CPAP) regularly improves or eliminates snoring in OSA patients. However, due to its limited acceptance, compliance, and high cost, it is not used routinely in the treatment of snoring but may be considered in select cases.

Intraoral devices

Snoring can be treated successfully with intraoral devices. Mainly, mandibular advancement devices are used [69] to enlarge the pharynx in the anterior–posterior dimension by protruding the mandible. These intraoral devices are identical to those used in patients with OSA; thus, the majority of studies evaluating these devices are performed in sleep apnea patients. Clinical trials for the use of intraoral devices in the treatment of snoring are significantly less frequent.

Appropriate selection of snoring subjects for this kind of treatment should be emphasized; however, evidence-based data or recommendations for appropriate selection are mostly lacking. Nevertheless, the most important selection factors in OSA patients, such as dental status, mandibular protrusion mobility, and body weight, are also likely to be appropriate selection factors in snoring. No validated statement concerning side effects and compliance in the treatment of snoring with intraoral devices can be made, as only a limited number of studies are available, and those studies produced inconsistent results [70, 71]. The lack of a standardized classification of side effects and the huge differences between the different intraoral devices may be the reason for this (e.g., the varying construction, size, etc. may cause different side effects). The side effects documented in OSA, such as hypersalivation and discomfort or pain in the masticatory muscles or the temporo-mandibular joint, are also potential side effects in the treatment of snoring. These effects are mainly transient, however [71]. Nevertheless, changes in tooth position have been described in snorers who are treated with a mandibular advancement device [72]. Regular follow-up by a dentist is necessary for early detection of potential dental side effects [73].

Success rates for treatment with intraoral devices are based on subjective snoring assessment, and the data are less solid compared to the success rates of intraoral devices in OSA. In the evaluation of treatment efficiency of a specific intraoral device, stability, friction, and compliance need to be taken into account.

According to the literature, an improvement in snoring can be expected in appropriately selected snoring subjects [71]. A placebo-controlled clinical trial demonstrated a superiority over placebo (nonadvancing intraoral device) with regard to the incidence and loudness of snoring [74, 75]. According to the authors, a significant improvement of snoring can be achieved in about two thirds of an appropriately selected group of snorers [74, 76]. Evaluations of thermoplastic (boil-and-bite) devices have been controversial, especially regarding efficiency and stability. However, a randomized controlled study demonstrated the efficiency of a thermoplastic intraoral device [74].

Adjusting an intraoral device requires specific dental knowledge (number and stability of teeth, paradontal status, dental root canal fillings, implants, dentures, etc.) and should include evaluation of occlusion, end-to-end bite, and functional aspects. Therefore, adjustment of an intraoral device by the user is not recommended.

Recommendation In appropriate cases, treatment of snoring with an intraoral device can be considered.

Deviating from this point of view, the German Society of Dental Sleep Medicine (DGZS) argues that "according to studies regarding long-term treatment, only individually adjusted custom-made devices should be used [77–80], and they should be adjusted by licensed dentists [73, 80]. The DGSZ justifies this recommendation with the fact that for scientific reasons, only individually adjusted custom-made devices are used to treat the stomatognathic system (e.g., for temporomandibular joint disorders, malformations) and that this adjustment is exclusively done by a dentist following clinical examination."

Surgical treatment

The data on success rates of surgical interventions are often limited to short-term follow-up studies, and not all interventions have been sufficiently evaluated. These limitations need to be discussed critically.

In many publications, success rates of certain surgical interventions are described by percentage rates. These percentage rates are based on subjective snoring assessment by the bed partners. Unfortunately, the definition of therapeutic success differs broadly between these studies, making scientific meta-analysis impossible. Thus, this guideline disclaims the usage of percentage rates to describe the success of a surgical intervention.

In the authors' opinion, only minimally invasive surgical procedures should be selected to treat snoring. These procedures are associated with low peri- and postoperative morbidity and complication rates. The surgical intervention should be selected with regard to individual anatomy. An increased body mass index lowers the success rates of surgical interventions; thus, surgical treatment for obese snorers should be indicated with care.

Recommendation For the surgical treatment of snoring, minimally invasive procedures should be favored.

The techniques used to treat nasal obstruction in snoring subjects are identical to those generally used to treat nasal obstruction. There are no surgical interventions for the nose to specifically treat snoring or sleep-related breathing disorders. In the case of nasal obstruction, nasal surgery can improve snoring, although the individual effects and the durability of the results cannot be predicted. Nasal surgery needs to be based on rhinological findings and is only indicated for subjects complaining of nasal obstruction. There is usually no indication for nasal surgery based on clinical findings or functional diagnostic measures (e.g., rhinomanometry) alone. The positive effects on snoring of surgery of the paranasal sinuses in chronic rhinosinusitis with polyposis are related to the improvements in nasal airflow [81].

Recommendation If snoring is accompanied by nasal obstruction, nasal surgery can be considered.

Soft palate surgery for snoring has changed substantially since the early 1990s when it consisted of radical tissue resection. Today, ablative surgery has been replaced by less invasive, functional, and tissue-sparing techniques. Radical resections at the soft palate that are often associated with significant loss of function are no longer indicated. Given that there is no real medical indication for the treatment of snoring and the often limited efficacy of surgery for snoring, preserving the function of the soft palate is of the utmost importance.

The following techniques aim to stiffen the soft palate and/or to resect excessive soft tissue, thereby reducing palatal fluttering and snoring. Apart from various modifications, uvulopalatoplasty (UPP) for resection of excessive soft tissue, interstitial treatment for stiffening of the tissue due to scarring (radiofrequency surgery), and soft palate implants are the most widespread. The use of scleroting agents [82] is discouraged by the authors of this guideline, given that the substances used usually are not approved for this indication.

Extensive data are available for resection of excessive mucosa with cold instruments (UPP) or with the help of a laser [83, 84]. In principle, UPP can be performed with various tools. These procedures are usually performed under local anesthesia on an outpatient basis. Postoperative pain is often significant and requires analgesic medication for 1–2 weeks. Therefore, the authors argue that this procedure cannot be classified as minimally invasive. The muscles of the soft palate need to be conserved as much as possible by the intervention. There is enough evidence, including controlled trials, that UPP reduces snoring; however, long-term follow-up data demonstrate a relapse of snoring in a subgroup of subjects, potentially requiring additional intervention [85]. To a comparable extent, this also is true for other surgical interventions at the soft palate. Further investigation is needed to determine which subjects will benefit long term and which will not.

The classic soft palate surgery, the uvulopalatopharyngoplasty (UPPP), always includes tonsillectomy if the tonsils are still present. Therefore, indication for UPPP with tonsillectomy should be very strict. Less invasive alternative procedures are often available. Nevertheless, UPPP is an effective procedure to reduce snoring that has been well studied. Long-term results up to 10 years post-intervention exist [86]. A reduction in the treatment effect during the first year should be expected in a subgroup of subjects [87].

The efficacy of stiffening of the soft palate using interstitial tissue coagulation (radiofrequency surgery) has been demonstrated in placebo-controlled trials [88]. Although snoring typically cannot be eliminated completely, the procedure is safe and effective to treat snoring [89]. Efficacy increases if the treatment is combined with limited resection of excessive soft tissue (UPP) (e.g., radiofrequency-assisted uvulopalatoplasty (RF-UPP)). This combined approach, however, is associated with higher postoperative morbidity [90].

Soft palate implants can reduce snoring in the majority of subjects and are associated with minimal postoperative morbidity [91]. Anatomical requirements include adequate thickness of the velum so that the implants can be placed securely in the musculature. Extrusion rates of 5 % have been described for the polyester-made implants. A relapse in snoring can be expected in a subgroup of subjects after initial success [92]. Excessive soft tissue cannot be reduced or resected with this technique. Adding conservative soft tissue resection can be considered in those cases.

Recommendation If the velum is presumed to be the origin of snoring, surgical interventions such as UPP, radiofrequency surgery, or soft palate implants may be considered as single procedures or in combination based on individual anatomy. Also, UPPP can be considered, although it leads to higher postoperative morbidity and complication rates.

There is no indication for invasive surgical approaches at the tongue (midline glossectomy or related approaches) or interventions to enlarge the retrolingual airway space (hyoid suspension, genioglossus advancement, tongue suspension). Less invasive surgery at the tongue base (e.g., reduction of the lingual tonsil, radiofrequency surgery) can be considered in select cases.

Interstitial radiofrequency surgery for stiffening of the tongue base or a reduction of the lingual tonsil can be

regarded as minimally invasive surgery at the tongue base. Initial data confirm a limited reduction in snoring for isolated radiofrequency surgery [93]. Comparable data for the reduction of the lingual tonsil are not available to date.

Recommendation If the tongue base is presumed to be the origin of snoring, radiofrequency surgery of the tongue base or reduction of the lingual tonsil may be performed with regard to individual anatomy.

Summarizing recommendation Select minimally invasive surgical interventions at the soft palate can be recommended for the treatment of snoring as long as the individual anatomy is suitable. Treatment selection is highly dependent on the individual anatomy.

Aftercare

After an adequate period of time following therapeutic intervention, the therapeutic outcome should be assessed for quality control or, if necessary, for the planning of additional therapeutic steps. Additional follow-up would be desirable. Postoperative follow-up after 2–3 months and at 1 year is recommended. This is also useful as part of quality management. If symptoms return after time, the sleep medical history, clinical examination and, if necessary, sleep testing should be repeated to detect a potential progression toward sleep-disordered breathing.

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Reference

1. Stuck BA, Abrams J, de la Chaux R, Dreher A, Heiser C, Hohenhorst W, Kühnel T, Maurer JT, Pirsig W, Steffen A, Verse T (2010) Diagnosis and treatment of snoring in adults—S1 Guideline of the German Society of Otorhinolaryngology, Head and Neck Surgery. Sleep Breathing 14:317–321
2. American Academy of Sleep Medicine (2005) International classification of sleep disorders, 2nd edn, diagnostic and coding manual. American Academy of Sleep Medicine, Westchester
3. Agrawal S, Stone P, McGuinness K, Morris J, Camilleri AE (2002) Sound frequency analysis and the site of snoring in natural and induced sleep. Clin Otolaryngol Allied Sci 27:162–166
4. Hiraki N, Suzuki H, Udaka T, Shiomori T (2008) Snoring, daytime sleepiness, and nasal obstruction with or without allergic rhinitis. Arch Otolaryngol Head Neck Surg 134:1254–1257
5. Kara CO, Tümkaya F, Ardic N, Topuz B (2008) Does tonsillectomy reduce the risk of being a habitual or severe snorer? Eur Arch Otorhinolaryngol 265:1263–1268
6. Knuiman M, James A, Divitini M, Bartholomew H (2006) Longitudinal study of risk factors for habitual snoring in a general adult population: the Busselton Health Study. Chest 130:1779–1783
7. Ozturk E, Dalayman D, Sonmez G, Mutlu H, Sildiroglu HO, Basekim CC, Kizilkaya E (2007) The effect of pharyngeal soft tissue components on snoring. Clin Imaging 31:259–263
8. Carmelli D, Bliwise DL, Swan GE, Reed T (2001) Genetic factors in self-reported snoring and excessive daytime sleepiness: a twin study. Am J Respir Crit Care Med 164:949–952
9. Friberg D (1999) Heavy snorer's disease: a progressive local neuropathy. Acta Otolaryngol 119:925–933
10. Sunnergren O, Broström A, Svanborg E (2011) Soft palate sensory neuropathy in the pathogenesis of obstructive sleep apnea. Laryngoscope 121:451–456
11. Dantas DA, Mauad T, Silva LF, Lorenzi-Filho G, Formigoni GG, Cahali MB (2012) The extracellular matrix of the lateral pharyngeal wall in obstructive sleep apnea. Sleep 35:483–490
12. Lindberg E, Elmasry A, Gislason T, Janson C, Bengtsson H, Hetta J, Nettelbladt M, Boman G (1999) Evolution of sleep apnea syndrome in sleepy snorers: a population-based prospective study. Am J Respir Crit Care Med 159:2024–2027
13. Cathcart RA, Hamilton DW, Drinnan MJ, Gibson GJ, Wilson JA (2010) Night-to-night variation in snoring sound severity: one night studies are not reliable. Clin Otolaryngol 35:198–203
14. Hoffstein V (2005) Snoring and upper airway resistance. In: Kryger MH, Roth T, Dement WC (eds) Principles and practice of sleep medicine. Philadelphia Elsevier Saunders, Philadelphia, pp 1001–1012
15. Ohayon MM, Guilleminault C, Priest RG, Caulet M (1997) Snoring and breathing pauses during sleep: telephone interview survey of a United Kingdom population sample. BMJ 314:860–863
16. Hu FB, Willett WC, Manson JE, Colditz GA, Rimm EB, Speizer FE, Hennekens CH, Stampfer MJ (2000) Snoring and risk of cardiovascular disease in women. J Am Coll Cardiol 35:308–313

17. Roopa M, Deepa M, Indulekha K, Mohan V (2010) Prevalence of sleep abnormalities and their association with metabolic syndrome among Asian Indians: Chennai Urban Rural Epidemiology Study (CURES-67). J Diabetes Sci Technol 4:1524–1531
18. Zamarrón C, Gude F, Otero Otero Y, Rodríguez-Suárez JR (1999) Snoring and myocardial infarction: a 4-year follow-up study. Respir Med 93:108–112
19. de Groen JH, Op den Velde W, Hovens JE, Falger PR, Schouten EG, van Duijn H (1993) Snoring and anxiety dreams. Sleep 16:35–36
20. Ficker JH, Wiest GH, Lehnert G, Meyer M, Hahn EG (1999) Are snoring medical students at risk of failing their exams? Sleep 22:205–209
21. Hamdan AL, Al-Barazi R, Kanaan A, Al-Tamimi W, Sinno S, Husari A (2012) The effect of snoring on voice: a controlled study of 30 subjects. Ear Nose Throat J 91:28–33
22. Scher AI, Lipton RB, Stewart WF (2003) Habitual snoring as a risk factor for chronic daily headache. Neurology 60:1366–1368
23. Bixler EO, Vgontzas AN, Lin HM, Ten Have T, Leiby BE, Vela-Bueno A, Kales A (2000) Association of hypertension and sleep-disordered breathing. Arch Intern Med 160:2289–2295
24. Marshall NS, Wong KK, Cullen SR, Knuiman MW, Grunstein RR (2012) Snoring is not associated with all-cause mortality, incident cardiovascular disease, or stroke in the Busselton Health Study. Sleep 35:1235–1240
25. Peppard PE, Young T, Palta M, Skatrud J (2000) Prospective study of the association between sleep-disordered breathing and hypertension. N Engl J Med 342:1378–1384
26. Rich J, Raviv A, Raviv N, Brietzke SE (2011) An epidemiologic study of snoring and all-cause mortality. Otolaryngol Head Neck Surg 145:341–346
27. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S (1993) The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med 328:1230–1235
28. Ulfberg J, Carter N, Talbäck M, Edling C (2000) Adverse health effects among women living with heavy snorers. Health Care Women Int 21:81–90
29. Virkkula P, Bachour A, Hytönen M, Malmberg H, Salmi T, Maasilta P (2005) Patient- and bedpartner-reported symptoms, smoking and nasal resistance in sleep disordered breathing. Chest 128:2176–2182
30. Alcoceba E, Gonzalez M, Gaig P, Figuerola E, Auguet T, Olona M (2010) Edema of the uvula: etiology, risk factors, diagnosis, and treatment. J Investig Allergol Clin Immunol 20:80–83
31. Pasman JW, Joosten EM, Wouters HJ (1998) Increased daytime sleepiness and snoring—obstructive sleep apnea syndrome caused by webbing of the soft palate. Clin Neurol Neurosurg 90:75–78
32. Scherler MR (2000) Chirurgische Behandlungsmöglichkeiten des Schnarchens und der Schlafapnoe. Ther Umsch 57:454–457
33. Brietzke SE, Mair EA (2006) Acoustical analysis of snoring: can the probability of success be predicted? Otolaryngol Head Neck Surg 135:417–420
34. Herzog M, Schmidt A, Bremert T, Herzog B, Hosemann W, Kaftan H (2008) Analysed snoring sounds correlate to obstructive sleep disordered breathing. Eur Arch Otorhinolaryngol 265:105–113
35. Herzog M, Kuhnel T, Bremert T, Herzog B, Hosemann W, Kaftan H (2009) The upper airway in sleep-disordered breathing: a clinical prediction model. Laryngoscope 119:765–773
36. Jones TM, Swift AC, Calverley PM, Ho MS, Earis JE (2005) Acoustic analysis of snoring before and after palatal surgery. Eur Respir J 25:1044–1049
37. Osborne JE, Osman EZ, Hill PD, Lee BV, Sparkes C (1999) A new acoustic method of differentiating palatal from non-palatal snoring. Clin Otolaryngol Allied Sci 24:130–133
38. Saunders NC, Tassone P, Wood G, Norris A, Harries M, Kotecha B (2004) Is acoustic analysis of snoring an alternative to sleep nasendoscopy? Clin Otolaryngol Allied Sci 29:242–246
39. Herzog M, Kuhnel T, Bremert T, Herzog B, Hosemann W, Kaftan H (2009) The impact of the microphone position on the frequency analysis of snoring sounds. Eur Arch Otorhinolaryngol 266:1315–1322
40. Babar-Craig H, Rajani NK, Bailey P, Kotecha BT (2012) Validation of sleep nasendoscopy for assessment of snoring with bispectral index monitoring. Eur Arch Otorhinolaryngol 269:1277–1279
41. Croft CB, Pringle M (1991) Sleep nasendoscopy: a technique of assessment in snoring and obstructive sleep apnoea. Clin Otolaryngol allied Sci 16:504–509
42. den Herder C, van Tinteren H, de Vries N (2005) Sleep endoscopy versus modified Mallampati score in sleep apnea and snoring. Laryngoscope 115:735–739
43. El Badawey MR, McKee G, Heggie N, Marshall H, Wilson JA (2003) Predictive value of sleep nasendoscopy in the management of habitual snorers. Ann Otol Rhinol Laryngol 112:40–44
44. Iwanaga K, Hasegawa K, Shibata N, Kawakatsu K, Akita Y, Suzuki K, Yagisawa M, Nishimura T (2003) Endoscopic examination of obstructive sleep apnea syndrome patients during drug-induced sleep. Acta Otolaryngol Suppl 550:36–40
45. Johal A, Battagel JM, Kotecha BT (2005) Sleep nasendoscopy: a diagnostic tool for predicting treatment success with mandibular advancement splints in obstructive sleep apnoea. Eur J Orthod 27: 607–614
46. Kezirian EJ, Hohenhorst W, de Vries N (2011) Drug-induced sleep endoscopy: the VOTE classification. Eur Arch Otorhinolaryngol 268:1233–1236
47. Pringle MB, Croft CB (1993) A grading system for patients with obstructive sleep apnoea—based on sleep nasendoscopy. Clin Otolaryngol Allied Sci 18:480–484
48. Steinhart H, Kuhn-Lohmann J, Gewalt K, Constantinidis J, Mertzlufft F, Iro H (2000) Upper airway collapsibility in habitual snorers and sleep apneics: evaluation with drug-induced sleep endoscopy. Acta Otolaryngol 120:990–994
49. Dreher A, Klemens C, Patscheider M, Kramer M, Feucht N, Schultheiss C, Baker F, de la Chaux R (2007) Use of pharyngeal pressure measurement to localize the source of snoring. Laryngo-Rhino-Otologie 86:789–793
50. Guimarães KC, Drager LF, Genta PR, Marcondes BF, Lorenzi-Filho G (2009) Effects of oropharyngeal exercises on patients with moderate obstructive sleep apnea syndrome. Am J Respir Crit Care Med 179:962–966
51. Puhan MA, Suarez A, Lo Cascio C, Zahn A, Heitz M, Braendli O (2006) Didgeridoo playing as alternative treatment for obstructive sleep apnoea syndrome: randomised controlled trial. BMJ 332:266–270
52. Randerath WJ, Galetke W, Domanski U, Weitkunat R, Ruhle KH (2004) Tongue-muscle training by intraoral electrical neurostimulation in patients with obstructive sleep apnea. Sleep 27: 254–259
53. Pai I, Lo S, Wolf D, Kajieker A (2008) The effect of singing on snoring and daytime somnolence. Sleep Breath 12:265–268
54. Wardrop PJ, Ravichandran S, Hair M, Robertson SM, Sword D (2011) Do wind and brass players snore less? A cross-sectional study of snoring and daytime fatigue in professional orchestral musicians. Clin Otolaryngol 36:134–138
55. Ojay A, Ernst E (2000) Can singing exercises reduce snoring? A pilot study. Complement Ther Med 8:151–156
56. Ravesloot MJ, van Maanen JP, Dun L, de Vries N (2013) The undervalued potential of positional therapy in position-dependent snoring and obstructive sleep apnea-a review of the literature. Sleep Breath 17:39–49
57. Loth S, Petruson B (1996) Improved nasal breathing reduces snoring and morning tiredness. A 6-month follow-up study. Arch Otolaryngol Head Neck Surg 122:1337–1340
58. Loth S, Petruson B, Wirén L, Wilhelmsen L (1999) Better quality of life when nasal breathing of snoring men is improved at night. Arch Otolaryngol Head Neck Surg 125:64–67

59. Petruson B, Theman K (1992) Clinical evaluation of the nasal dilator Nozovent. The effect on snoring and dryness of the mouth. Rhinology 30:283–287
60. Petruson B (1990) Snoring can be reduced when the nasal airflow is increased by the nasal dilator Nozovent. Arch Otolaryngol Head Neck Surg 116:462–464
61. Liistro G, Rombaux P, Dury M, Pieters T, Aubert G, Rodenstein DO (1998) Effects of Breathe Right on snoring: a polysomnographic study. Respir Med 92:1076–1078
62. Pevernagie D, Hamans E, Van Cauwenberge P, Pauwels R (2000) External nasal dilation reduces snoring in chronic rhinitis patients: a randomized controlled trial. Eur Respir J 15:996–1000
63. Todorova A, Schellenberg R, Hofmann HC, Dimpfel W (1998) Effect of the external nasal dilator Breathe Right on snoring. Eur J Med Res 3:367–379
64. Hultcrantz E, Harder L, Harder H, Zetterlund EL, Roberg K (2010) To treat snoring with nasal steroids—effects on more than one level? Acta Otolaryngol 130:124–131
65. Larrain A, Hudson M, Dominitz JA, Pope CE 2nd (2006) Treatment of severe snoring with a combination of pseudoephedrine sulfate and domperidone. J Clin Sleep Med 2:21–25
66. Sériès F, Marc I (1993) Effects of protriptyline on snoring characteristics. Chest 104:14–18
67. Ulfberg J, Nyström B (2001) Treatment of snorers with a volatile oil: a randomized, double-blind placebo-controlled trial. ORL J Otorhinolaryngol Relat Spec 63:298–301
68. Wijewickrama RC, Blalock D, Mims JW (2004) Study of lubricant-induced changes in chronic snorers (SLICCS). Otolaryngol Head Neck Surg 131:606–609
69. Stradling JR, Negus TW, Smith D, Langford B (1998) Mandibular advancement devices for the control of snoring. Eur Respir J 11:447–450
70. Neill A, Whyman R, Bannan S, Jeffrey O, Campbell A (2002) Mandibular advancement splint improves indices of obstructive sleep apnoea and snoring but side effects are common. N Z Med J 115: 289–292
71. Smith AM, Battagel JM (2004) Non-apneic snoring and the orthodontist: the effectiveness of mandibular advancement splints. J Orthod 31:115–123
72. Fransson AM, Tegelberg A, Svenson BA, Lennartsson B, Isacsson G (2002) Influence of mandibular protruding device on airway passages and dentofacial characteristics in obstructive sleep apnea and snoring. Am J Orthod Dentofac Orthop 122:371–379
73. Kushida CA, Morgenthaler TI, Littner MR, Alessi CA, Bailey D, Coleman J Jr, Friedman L, Hirshkowitz M, Kapen S, Kramer M, Lee-Chiong T, Owens J, Pancer JP (2006) Practice parameters for the treatment of snoring and obstructive sleep apnea with oral appliances: an update for 2005. Sleep 29:240–243
74. Cooke ME, Battagel JM (2006) A thermoplastic mandibular advancement device for the management of non-apnoeic snoring: a randomized controlled trial. Eur J Orthod 28:327–338
75. Johnston CD, Gleadhill IC, Cinnamond MJ, Peden WM (2001) Oral appliances for the management of severe snoring: a randomized controlled trial. Eur J Orthod 23:127–134
76. Vanderveken OM, Boudewyns AN, Braem MJ, Okkerse W, Verbraecken JA, Willemen M, Wuyts FL, De Backer WA, Van de Heyning PH (2004) Pilot study of a novel mandibular advancement device for the control of snoring. Acta Otolaryngol 124:628–633
77. Braem M, Keteleer G, Vanderveken O, Van De Heyning PJ (2009) In-vitro retention of mandibular advancement devices. J Dent Res 88 (Spec Iss A):115773
78. Randerath WJ, Verbraecken J, Andreas S, Bettega G, Boudewyns A, Hamans E, Jalbert F, Paoli JR, Sanner B, Smith I, Stuck BA, Lacassagne L, Marklund M, Maurer JT, Pepin JL, Valipour A, Verse T, Fietze I, Task Force Report ERS (2011) Non-CPAP therapies in obstructive sleep apnoea. Eur Respir J 37:1000–1028
79. Scherr S, Dort L, Almeida F, Bennet K, Blumenstock N, Demko G, Essick G, Katz SG, McLoman P, Phillips KS, Prehn RS, Rogers RR, Schell T, Sheats RD, Sreshta FP. Consensus statement accepted by the Board of the American Academy of Dental Sleep Medicine (2014). Definition of effective oral appliance. Journal of Dental Sleep Medicine (in press)
80. Schwarting S, Hübers U, Heise M, Schlieper J, Hauschild A (2007) Position paper on the use of mandibular advancement devices in adults with sleep-related breathing disorders. A position paper of the German Society of Dental Sleep Medicine (Deutsche Gesellschaft Zahnaerztliche Schlafmedizin, DGZS). Sleep Breath 11:125–126
81. Tosun F, Kemikli K, Yetkin S, Ozgen F, Durmaz A, Gerek M (2009) Impact of endoscopic sinus surgery on sleep quality in patients with chronic nasal obstruction due to nasal polyposis. J Craniofac Surg 20: 446–449
82. Brietzke SE, Mair EA (2001) Injection snoreplasty: how to treat snoring without all the pain and expense. Otolaryngol Head Neck Surg 124:503–510
83. Berger G, Finkelstein Y, Stein G, Ophir D (2001) Laser-assisted uvulopalatoplasty for snoring: medium- to long-term subjective and objective analysis. Arch Otolaryngol Head Neck Surg 127:412–417
84. Iyngkaran T, Kanagalingam J, Rajeswaran R, Georgalas C, Kotecha B (2006) Long-term outcomes of laser-assisted uvulopalatoplasty in 168 patients with snoring. J Laryngol Otol 120:932–938
85. Hultcrantz E, Harder L, Loord H, Käll LG, Ydreborg K, Wallberg S, Svanborg E (2010) Long-term effects of radiofrequency ablation of the soft palate on snoring. Eur Arch Otorhinolaryngol 267:137–142
86. Hicklin LA, Tostevin P, Dasan S (2000) Retrospective survey of long-term results and patient satisfaction with uvulopalatopharyngoplasty for snoring. J Laryngol Otol 114:675–681
87. Levin BC, Becker GD (1994) Uvulopalatopharyngoplasty for snoring: long-term results. Laryngoscope 104:1150–1152
88. Stuck BA, Sauter A, Hörmann K, Verse T, Maurer JT (2005) Radiofrequency surgery of the soft palate in the treatment of snoring. A placebo-controlled trial. Sleep 28:847–850
89. Stuck BA, Starzak K, Verse T, Hörmann K, Maurer JT (2003) Complications of temperature-controlled radiofrequency volumetric tissue reduction for sleep-disordered breathing. Acta Otolaryngol 123:532–535
90. Baisch A, Maurer JT, Hörmann K, Stuck BA (2009) Combined radiofrequency assisted uvulopalatoplasty (RF-UPP) in the treatment of snoring. Eur Arch Otorhinolaryngol 266:125–130
91. Skjöstad KW, Nordgard S (2011) Three-year follow-up of palatal implants for the treatment of snoring. Acta Otolaryngol 131:1299–1302
92. Maurer JT, Hein G, Verse T, Hörmann K, Stuck BA (2005) Long-term results of palatal implants for primary snoring. Otolaryngol Head Neck Surg 133:573–578
93. Welt S, Maurer JT, Hörmann K, Stuck BA (2007) Radiofrequency surgery of the tongue base in the treatment of snoring—a pilot study. Sleep Breath 11:39–43

Guideline report

The current guideline was initiated by the German Society of Otolaryngology Head and Neck Surgery (Deutsche Gesellschaft für Hals-Nasen-Ohrenheilkunde, Kopf- und Hals-Chirurgie e.V., DGHNO), and the first author of the guideline (Stuck) was assigned its development. In order to provide an interdisciplinary approach, all involved societies and interest groups were contacted and asked for participation in May 2012. The following societies and institutions were contacted: German College of General Practitioners and Family Physicians (Deutsche Gesellschaft für Allgemein- und Familienmedizin, DEGAM) German Sleep Society

(Deutsche Gesellschaft für Schlafforschung und Schlafmedizin, DGSM), German Respiratory Society (Deutsche Gesellschaft für Pneumologie, DGP), German Society of Oral and Maxillofacial Surgery (Deutsche Gesellschaft für Mund-, Kiefer- und Gesichtschirurgie, DGMKG), German Occupational Union of Otorhinolaryngologists (Deutscher Berufsverband der Hals-Nasen-Ohrenärzte), German Society of Dental Sleep Medicine (Deutsche Gesellschaft zahnärztliche Schlafmedizin, DGZS), and the Union of Chronic Sleep Disorders (Allgemeiner Verband chronische Schlafstörungen Deutschland e.V., AVSD) as representatives of self-help organizations. These institutions were asked to delegate representatives for the nominal group process and to delegate authors for the guideline in order to achieve an interdisciplinary approach at an early stage of the guideline.

Consecutively, the DGMKG delegated one representative to be an author and a member of the nominal group process. The DEGAM decided not to take part in the process. Initially, the DGSM and the DGP were willing to be part of the process and delegated authors, but both withdrew from the process at a later stage. The DGSZ, the Occupational Union of Otorhinolaryngologists, and AVSD did not delegate authors for the guideline but took part in the nominal group process.

Setting and date of the nominal group process and Delphi process

The nominal group process to revise the existing guideline took place in Mannheim, Germany on February 21, 2013 under the direction of Helmut Sitter (Marburg). The members of this meeting were given a draft of the guideline prior to the meeting. Based on this draft and according to the formal rules of a nominal group process, the content of this draft was discussed and controversial aspects were voted on in order to reach a consensus. A simple majority was enough during voting. The following delegates were part of the group process: Alfred Dreher (DGHNO), Clemens Heiser (DGHNO), Gerald Gronke (German Occupational Union of Otorhinolaryngologists), Michael Herzog (DGHNO), Joachim T. Maurer (DGHNO), Reinhard Müller (AVSD), Hans Pistner (DGMKG), Susanne Schwarting (DGZS), Helmut Sitter (AWMF), Boris A. Stuck (DGHNO), and Thomas Verse (DGHNO).

The revised guideline resulting from the nominal group process was further discussed in a nonanonymized Delphi process. The members of the Delphi process were the authors of the guideline as well as the members of the nominal group process.

In order to provide the recommendations of this guideline, two formal consensus processes were combined: the nominal group process and the Delphi process. In a nominal group process, all members meet in strictly structured conditions under direction of a neutral mediator. The process is subdivided into the following steps:

1. Presentation of the statement to be evaluated.
2. Every member revises the statements and makes comments on the statements and presented algorithms.
3. A neutral mediator collects these revisions and comments. Similar comments are summarized.
4. For every suggestion, there is a vote to determine if there should be a discussion about the topic.
5. Suggestions are ranked for discussion.
6. Discussion takes place according to this ranking.
7. The vote of the majority is recorded and the guideline is revised according to this vote before the next meeting.
8. At the next meeting, all steps (1–6) are repeated.

This process is repeated until consensus is reached. For all questions and suggestions that were ranked as less important, the nonanonymized Delphi process (or Delphi technique) was used. The Delphi process has a similar formal structure, but in contrast to the nominal group process described above, the members do not meet in person to reach consensus but communicate in written form.

Funding and conflict of interests

The guideline was developed with funding from the German Society of Otolaryngology, Head and Neck Surgery (DGHNO) without external funding. All authors revealed potential conflicts of interests (e.g., relationships with the pharmaceutical industry and manufacturers of medical devices). Those potential conflicts of interests were evaluated by a team of coordinators, and it was determined that none should prevent any of the authors' participation in the process. The authors' conflict of interest statements were collected and are presented as a supplement to this guideline.

Validity and update of the guideline

This guideline will be valid until August 2016. At that time, a revision of the content and a potential update to the guideline will take place. If the coordinator of the guideline becomes aware of any new and important findings that require an update to the guideline in the meantime, an update will be made earlier.

Passage of the guideline

After finalization of the Delphi process, the guideline was presented for revision and comment to the headquarters of the involved societies as well as to the German Society of Dental, Oral and Craniomandibular Sciences (Deutsche Gesellschaft für Zahn-, Mund- und Kieferheilkunde, DGZMK). The Occupational Union, the AVSD, the DGMKG, and DGZMK had no further comments. The DGZS required inclusion of a diverging statement concerning treatment with intraoral devices, which can now be found in the corresponding section of the guideline. In July 2013, this version of the guideline was presented to and approved by the initiator of the guideline, the German Society of Otolaryngology Head and Neck Surgery.