**SUMMARY**

Background: Obstructive sleep apnea (OSA) is a very common disorder among adults: the prevalence of mild OSA is 20%, and that of moderate or severe OSA is 6% to 7%. Simple snoring is even more common. Conservative treatments such as nocturnal ventilation therapy and oral appliances are successful as long as the patient actually uses them, but they do not eliminate the underlying obstruction of the upper airway.

Method: The relevant literature up to 2008 on the surgical treatment of OSA was selectively reviewed.

Results: Five types of surgical treatment for OSA are available, each for its own indications: optimization of the nasal airway to support nasal ventilation therapy, (adeno-)tonsillectomy as first-line treatment for OSA in children, minimally invasive surgery for simple snoring and mild OSA, invasive surgery as first- and second-line treatment for mild OSA, and invasive multilevel surgery as second-line treatment of moderate to severe OSA that remains refractory to ventilation therapy.

Conclusion: Surgical treatment for OSA is appropriate for specific indications as a complement to the established conservative treatment methods.

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Pathological changes to the upper airway can result in narrowing and so-called obstructive sleep-related breathing disorders. In addition to central causes the international classification of sleep disorders (e1) distinguishes between simple snoring and obstructive sleep apnea (OSA). OSA itself is subcategorized into an adult and pediatric form.

By definition, simple snoring refers to inspiratory breathing sounds that are neither accompanied by insomnia nor hypersomnia nor by a raised cardiovascular risk. Except for possible social problems as a result of the noise produced by breathing while sleeping, simple snoring has no consequences for those affected. The prevalence is age dependent and is reported to be 60% in men over age 60 and 50% in postmenopausal women (1, e2). Intense snoring can be a sign of OSA (2, e3), and in people with intense and arrhythmic snoring, a differential diagnostic evaluation should be conducted by a sleep physician.

The transition to OSA is fluid. OSA is characterized by repeated obstructions in the upper airway during sleep with resultant apneas and hypopneas with or without arousals. Impaired sleep quality reduces the affected person’s quality of life. The main symptoms are sleepiness during the day, arrhythmic snoring, and reduced intellectual performance (e4). Compared with healthy subjects, patients with sleep apnea have an increased risk for morbidity and mortality (3–6, e5–e9). The main tool for quantifying the severity of OSA is the apnea-hypopnea index (AHI) (Table 1). With regard to current diagnostic procedures we refer our readers to the recent literature (7, e10, e11). In children, as few as two breathing pauses per hour of sleep (AHI >2) is seen as problematic (e12).

Selective literature search

We searched PubMed up to 31 December 2008 using the search terms “sleep apnea” and “snoring”, each in combination with “surgery”. We restricted our search to articles written in the German and English languages. Cross references in the respective reference lists were also included. This review article is based on the data collection of the current S2e guidelines “Therapy of obstructive sleep apnea in adults” of the German Society of Oto-Rhino-Laryngology, Head and Neck Surgery (8). This guideline in turn refers to the S2 guideline “Non-restorative sleep” of the German Society of Oto-Rhino-Laryngology, Head and Neck Surgery.
Society of Sleep Research and Sleep Medicine (DGSM) (e13) by providing additional comments on the surgical treatment options from the perspective of otorhinolaryngological surgery.

Current treatment for obstructive sleep disorders may be conservative, surgical, or device-based. This article aims to assess the importance of surgical therapy; for details on conservative and device-based treatment options we refer our readers to the pertinent literature.

Conservative treatment

Conservative therapeutic measures include weight reduction (4, e14), optimizing sleep hygiene, adopting the correct position for sleeping (e15, e16), and different drug-based approaches (e17). None of these methods tackles the pathological changes that lead to a narrowed upper airway, and for this reason we again refer readers to the relevant specialist literature. Weight loss as well as avoidance of the supine position (lying on one’s back) may be able to support treatment of the obstruction in certain findings.

Device-based therapy

Nasal ventilation, oral and nasal appliances, and electrostimulation are available device-based interventions. A training effect has been found only for muscle stimulation. Because of its effectiveness (e18–e20) and the high quality of the evidence based data, ventilation therapy is the standard treatment for OSA. Long term acceptance, however, depends on aftercare, side effects, and other factors and is often impaired (e21–e24). Among oral appliances, mandibular advancement splints are recommended for moderate to severe OSA (e25–e28). No proof of effectiveness exists thus far for nasal appliances and electrostimulation in OSA (8). For primary snoring, individual case series have shown effectiveness (e29, e30).

Surgical therapy

The current German guideline (8) for obstructive sleep apnea in adults sets out 4 indications for surgery that we will discuss in the following section. An additional indication relates to pediatric OSA.

Distinction has to be made between invasive and minimally invasive surgical approaches. A surgical method is regarded as minimally invasive if the intervention can be delivered under local anesthesia and as an outpatient procedure, and if perioperative and postoperative morbidity is low and complications rare.

Furthermore, distinction is made between primary, secondary, and adjuvant indications for surgery. Surgery as first-line treatment is regarded as equal to ventilation therapy; a second-line treatment should be considered only if device-based therapies have remained unsuccessful; and adjuvant surgery supports a different primary therapeutic option without being sufficiently successful for the obstructive sleep-related breathing disorder all by itself.

The successful surgery for OSA is defined as a reduction of the AHI by at least 50% and to a value below 20 (9); this is in contradiction to the therapeutic criteria for nocturnal ventilation treatment. With regard to these criteria, it has often been critically remarked that reducing the original AHI from 40 to 15, for example, should not be rated as successful treatment. By contrast, device-based therapy works only when appliances are being used, whereas a surgical result yields success every night even without appliances. If in the concrete scenario a reduction of the AHI from 40 to 5 is postulated as a result of continuous positive airway pressure (CPAP), then the corresponding reduction in the AHI as a result of CPAP would be 78%, and 62.5% after surgery. If the CPAP equipment is used only during 80% of nocturnal sleep, however, the results are identical (78 x 0.8 = 62.4). Many definitions of success use far less than 80% use of CPAP for their definition of CPAP compliance. For this reason, the simple comparison of AHI values does not do justice to the differentiated evaluation of the different treatment modalities. Rather, it is desirable that subjective parameters—for example, daytime symptoms and quality of life—and the assessment of the cardiovascular risk be integrated into the evaluation.

Basically, surgical intervention is indicated only if the patient’s general condition allows surgery and a rectifiable pathoanatomical finding has been carefully diagnostically evaluated before the operation.
**TABLE 2**

<table>
<thead>
<tr>
<th>Author (reference)</th>
<th>No</th>
<th>CPAP pre (cm H₂O)</th>
<th>CPAP post (cm H₂O)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mayer-Brix et al. 1989 (e31)</td>
<td>3</td>
<td>9.7</td>
<td>6</td>
<td>None</td>
</tr>
<tr>
<td>Friedman et al. 2000 (e32)</td>
<td>6</td>
<td>9.3</td>
<td>6.7</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Dorn et al. 2001 (e33)</td>
<td>5</td>
<td>11.8</td>
<td>8.6</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Masdon et al. 2004 (e34)</td>
<td>35</td>
<td>9.7</td>
<td>8.9</td>
<td>n.s.</td>
</tr>
<tr>
<td>Nakata et al. 2005 (e35)</td>
<td>5</td>
<td>16.8</td>
<td>12</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Zonato et al. 2006 (e36)</td>
<td>17</td>
<td>12.4</td>
<td>10.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total</td>
<td>71</td>
<td>11</td>
<td>9.1</td>
<td></td>
</tr>
</tbody>
</table>

CPAP, continuous positive airway pressure; pre, preoperatively; post, postoperatively; OSA, obstructive sleep apnea; n.s., non-significant

**Improving nasal air flow**

An exclusive operation on the nose by itself cannot lower the AHI significantly (8). However, surgery can improve sleep quality, the restorative function of sleep, and CPAP compliance as well as reduce therapeutic urgency (e31–e36) (*Table 2*). For this reason, surgical correction of relevant impairments to nasal breathing is indicated primarily in case of subjective problems and as adjuvant treatment in problematic CPAP compliance.

**Adenotonsillectomy in pediatric OSA**

In pediatric OSA, adenotonsillar hyperplasia is the main culprit. The effectiveness of adenotonsillectomy (ATE) has been convincingly shown in recent review articles (10, e37). Our own literature analysis of 24 publications included 653 children and found a surgical success rate for ATE in OSA of 83.6% (e38). Furthermore, oxidative stress was reduced (e39) as was total cholesterol (e40), and cognitive performance improved (e41, e42). ATE is therefore indicated as the primary therapeutic option in pediatric OSA. Risk factors for a lack of success include overweight and a raised AHI at baseline (e43). Follow-up monitoring is always advised in such cases.

Because of the notably reduced postoperative pain and rate of postoperative hemorrhage, tonsillectomy is increasingly used in pediatric OSA—with the volume reduction as large as possible. Initial results have shown comparable efficacy for both procedures (11, 12).

**Minimally invasive surgery in primary snoring and mild OSA**

Interstitial radiofrequency therapy (IRFT) with high-frequency current and soft palate implants are minimally invasive interventions. Because of the substantial postoperative wound pain, resections to the soft palate are somewhat loosely termed minimally invasive.

IRFT is used for the soft palate, palatine tonsils, and the base of the tongue. In the muscles of the soft palate and tongue, tissue stiffening is achieved via postoperative scarring, and in the lymphatic tissue of the tonsils, the volume effect is up to 75% (13). Sparing the mucosa leads to less postoperative pain and fewer complications. Ulcers, hemorrhages, and prolonged odynophagia are the most important complications and occur in less than 1% of cases (14, e44). The soft palate can be stiffened by implanting three cylindrical pillar implants made from polyethylene terephthalate (15).

*Table 3* shows the results for OSA. Several minimally invasive procedures can be combined. For primary snoring, numerous articles have shown the subjective effectiveness of minimally invasive treatment of the soft palate, with success rates of more than 70% in some cases, but the same is not true for the base of the tongue.

For this reason, a primary indication in simple snoring exists only for the soft palate. In OSA, primary use on the soft palate and the base of the tongue is indicated only for mild forms. Data on the treatment of the palatine tonsils are lacking.

**Invasive surgery in OSA**

The most widely established surgical procedure is uvulopalatopharyngoplasty (UPPP) (e45, e46). The principle is a widening of the oropharyngeal valve in the transverse as well as a sagittal direction. Selecting suitable patients is crucial for therapeutic success. The

**TABLE 3**

<table>
<thead>
<tr>
<th>Procedue</th>
<th>No of studies</th>
<th>No (patients)</th>
<th>ESS pre</th>
<th>ESS post</th>
<th>AHI pre</th>
<th>AHI post</th>
<th>Success (%)</th>
<th>EBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRFT soft palate</td>
<td>3 [e56–e58]</td>
<td>61</td>
<td>10.6</td>
<td>7.4</td>
<td>20.3</td>
<td>17.3</td>
<td>30.4</td>
<td>B</td>
</tr>
<tr>
<td>Implant soft palate</td>
<td>8 [e59–e66]</td>
<td>248</td>
<td>10.2</td>
<td>7.5</td>
<td>25.6</td>
<td>19.4</td>
<td>42.4</td>
<td>B</td>
</tr>
<tr>
<td>Resection</td>
<td>18 [e58, e67–e83]</td>
<td>576</td>
<td>10.3</td>
<td>6.1</td>
<td>37.3</td>
<td>25.8</td>
<td>33.2</td>
<td>B</td>
</tr>
<tr>
<td>IRFT base of tongue</td>
<td>6 [e84–e89]</td>
<td>133</td>
<td>10.2</td>
<td>7.3</td>
<td>24.7</td>
<td>16</td>
<td>45.7</td>
<td>B</td>
</tr>
<tr>
<td>Combined therapies</td>
<td>5 [e90–e94]</td>
<td>203</td>
<td>10.2</td>
<td>7.3</td>
<td>24.7</td>
<td>16</td>
<td>45.7</td>
<td>B</td>
</tr>
</tbody>
</table>

ESS, Epworth sleepiness scale; pre, preoperatively; post, postoperatively; AHI, Apnea-hypopnea index; EBM, level of recommendation according to evidence based medicine; IRFT, interstitial radiofrequency therapy
specialist literature provides more detail on the topodiagnostic evaluation of the location of the collapse (16, e47).

A recent meta-analysis of 269 cases of UPPP found an objective treatment success as defined by Sher (9) of 30% without and 59% with simultaneous tonsillectomy (e48). Positive predictors for therapeutic success are hyperplastic tonsils, substantial excess mucosa of the soft palate, a long uvula, longitudinal folds of the mucosa covering the back wall of the pharynx, and an observed obstruction of the soft palate on sleep endoscopy. The long term success rate falls from 60.5% after 3 to 12 months to 47.6% after 3 to 7 years (8).

Subjectively, the success after UPPP is comparable to that of CPAP therapy (e49). With regard to mortality, patients with sleep apnea have been found to have no significant difference in mortality up to 9 years as compared to a matched control cohort (17). The long term survival rate for CPAP and after UPPP is identical, as far is known from research so far (18). UPPP is the only surgical treatment for OSA for which a reduction in the risk of incidents (19, e50) and normalization of raised specific values for serum C-reactive protein (20) have been shown. UPPP with tonsillectomy seems indicated for the treatment of mild to moderate OSA if the pathoanatomical findings justify the method. Whether modifications of UPPP are likely to yield better results is currently not known.

In contrast to the soft palate, no established standard technique exists for surgical treatment of retrolingual and hypopharyngeal obstruction. Most procedures are used in combination with other interventions to the upper airway. Table 4 shows the available data for the isolated use of the respective surgical techniques. With regard to surgical technique, indications, and risks, we refer readers to the literature (21, 22).

Maxillomandibular advancement (MMA) osteotomy simultaneously widens the nasopharynx, oropharynx, and hypopharynx by advancing the soft palate and tongue and tightening the lateral pharyngeal walls. Although MMA is regarded as standard treatment it remains technically demanding and requires full anesthesia and inpatient treatment (23). After tracheotomy, MMA is the most successful surgical approach for treating OSA (8). Compared with CPAP, similar reductions of the AHI are achieved, as are a similar optimization of sleep architecture (24). Treatment effects usually last for a minimum of 50 months (25, e51).

MMA is indicated for patients with suitable anatomical conditions. Morbidity, the complication rate, and cosmetic sequelae should be borne in mind when defining the indication.

Laryngeal or tracheal obstructions will trigger OSA only in rare cases; treatment should be administered according to the underlying impairment (22).

Polysomnographic data from 4 observational studies with a total of 159 patients have shown an average success rate for tracheotomy of 96.2% (8). In spite of this, tracheotomy is the approach of last resort in selected cases because of the substantial impairment to patients’ quality of life.

Multilevel surgery in OSA

Nowadays, invasive surgical procedures are rarely undertaken in isolation but usually in combination. In the following section we will refer to multilevel surgery (MLS) if at least one intervention to the base of the tongue/hypopharynx is combined with at least one intervention to the soft palate/tonsil. Therapeutic schemes for moderate to severe OSA at the level of the soft palate always include tonsillectomy combined with UPPP or one of its numerous modifications. For the treatment of hypopharyngeal narrowing, different methods are recommended.

Currently, 11 controlled studies and 32 case series exist, including a total of 1640 patients (8). The average AHI preoperatively was 43.9 and, postoperatively, 20.3. The success rate according to the Sher criteria was 53.8%. The data situation is sufficient to be able to assume a general effectiveness of MLS in severe OSA (recommendation level B). However, it is not yet clear which combination of procedures will be superior. MLS yielded poorer results than nasal CPAP therapy; an indication therefore only exists as secondary therapy for patients who are not, or no longer, open to ventilation therapy.

### Table 4

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No of studies</th>
<th>No (patients)</th>
<th>AHI pre</th>
<th>AHI post</th>
<th>Success (%)</th>
<th>EBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyoid suspension</td>
<td>3 [e95–e97]</td>
<td>60</td>
<td>36</td>
<td>21.1</td>
<td>49.5</td>
<td>C</td>
</tr>
<tr>
<td>Partial resection of the tongue</td>
<td>5 [e98–e103]</td>
<td>96</td>
<td>49.5</td>
<td>25.4</td>
<td>54.4</td>
<td>B</td>
</tr>
<tr>
<td>Tongue suspension</td>
<td>3 [e104–e106]</td>
<td>37</td>
<td>33.6</td>
<td>19.8</td>
<td>28.6</td>
<td>C</td>
</tr>
<tr>
<td>Genioglossus advancement*</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>D</td>
</tr>
</tbody>
</table>

AHI, apnea-hypopnea index; pre, preoperatively; post, postoperatively; EBM, level of recommendation according to evidence based medicine; *osteosynthetic advancement of the genioglossus muscle
Objective surgical success in sleep surgical interventions for the treatment of obstructive sleep apnea depending on the apnea-hypopnea index (AHI) and body mass index (BMI). Success rate as defined by Sher (9)—that is, reduction of AHI by at least 50% and reduction of AHI to below 20), N = 263 patients; with permission from (22).

**Outlook**

Sleep medicine is a cross sectional discipline to which many specialties contribute; this naturally results in the assessment of any therapeutic measure from different perspectives. Nonetheless, consensus nowadays exist regarding the use of rhinosurgery as an adjuvant measure for ventilation therapy and the benefit of adenotonsillectomy as the primary therapeutic approach in pediatric OSA. Consensus also exists with regard to the fact that patients with severe OSA and/or pathological overweight and/or substantial comorbidities should be given ventilation treatment as the primary measure. Multilevel surgery can be a secondary therapeutic option in this setting. Multimodal therapeutic approaches, such as surgical intervention and wearing an oral appliance, may also be successful in case CPAP proves a therapeutic failure (e52).

Minimally invasive therapies are accepted in primary snoring because of their low rate of complications. The success rates of minimally invasive therapy in snoring seemed to be comparable to the evidence on the efficacy of oral appliances. The advantage of an oral device lies in the fact that the treatment can be interrupted at any time and undesired side effects may reverse. Surgery, on the other hand, has the advantage that the affected person does not require a permanent contraption.

Which intervention should be the primary one for OSA is the subject of controversial discussion. The high success rate and better-quality studies for CPAP treatment militate against using surgery. The potential and sometimes irreversible complications and the difficulty in selecting the adequate surgical approach, or multilevel surgery plan, are further arguments against surgery as the primary treatment modality. However, patients’ acceptance of CPAP therapy in mild OSA without clinical symptoms is particularly low. At the same time, low baseline values for AHI and BMI (body mass index) (Figure) and a lower rate of daytime symptoms are positive predictors for successful surgery. The milder the OSA the less comprehensively and invasively surgery needs to be. This means that perioperative and postoperative morbidity and complications are also a function of baseline AHI values. The subjective success of surgery regarding daytime symptoms, the partner’s acceptance, and the snoring itself are no worse for the surgical approaches than for device-based therapy. This, combined with the fact that after successful surgery patients are not dependent on a technical appliance, explains the popularity of surgical therapy in patients.

Against this background, a general rejection of primary surgery for OSA, such as was postulated in the latest Cochrane review of 2005 and several evidence based analyses (e53–e55) seems not exactly differentiated. Primary use of surgery to eliminate obstruction in OSA may be justified in patients whose obstruction is easy to remove and if the OSA is mild. On the basis of today’s state of research, however, it is difficult to establish precise threshold values for AHI, BMI, or comorbidity that define whether surgery should be the primary or secondary therapeutic approach.

**Conflict of interest statement**

Professor Hörmann declares that no conflict of interest exists.

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**REFERENCES**


The prevalence of mild obstructive sleep apnea (OSA) in adults is 20%; with 6–7% experiencing the severe form.

Device-based therapies, such as nocturnal ventilation and oral devices are successful in patients whose compliance is good.

In children with OSA, adenotonsillectomy has a success rate of 83.6%.

In adults, several operative procedures and a primary treatment are available to treat obstruction in primary snoring.

In severe OSA, surgery should be undertaken only to optimize ventilation treatment or as a secondary option if ventilation treatment fails or patients are non-compliant.


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For eReferences please refer to:
www.aerzteblatt-international.de/ref1311
The Surgical Treatment of Sleep-Related Upper Airway Obstruction

Thomas Verse, Karl Hörmann

eReferences


