POSITIVE STATEMENT

Surgical management of obstructive sleep apnoea: A position statement of the Australasian Sleep Association

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INTRODUCTION

Surgery for adult obstructive sleep apnoea (OSA) plays a key role in contemporary management paradigms, most frequently as either a second-line treatment or in a facilitatory capacity. This committee, comprising two sleep surgeons and three sleep physicians, was established to give clarity to that role and expand upon its appropriate use in Australasia. This position statement has been reviewed and approved by the Australasian Sleep Association (ASA) Clinical Committee.

Key words: airway, clinical sleep medicine, nasendoscopy, sleep apnoea, surgery.

ABSTRACT

Surgery for adult obstructive sleep apnoea (OSA) plays a key role in contemporary management paradigms, most frequently as either a second-line treatment or in a facilitatory capacity. This committee, comprising two sleep surgeons and three sleep physicians, was established to give clarity to that role and expand upon its appropriate use in Australasia. This position statement has been reviewed and approved by the Australasian Sleep Association (ASA) Clinical Committee.

Key words: airway, clinical sleep medicine, nasendoscopy, sleep apnoea, surgery.

INTRODUCTION

Surgery for adult obstructive sleep apnoea (OSA) has an important role, particularly as a salvage treatment when patients are unable to tolerate or adhere to devices (such as continuous positive airway pressure (CPAP) or mandibular advancement splint (MAS)), and as an adjunctive/facilitatory treatment to aid in device use (as with pre-phase nasal surgery or operations to lower CPAP requirements). In children, surgery such as adenotonsillectomy is considered the first-line therapy.

The role of surgery becomes even more important when one considers the significant burden of untreated disease. OSA has long been recognized as a ‘tip of the iceberg’ condition, with many cases undiagnosed, many diagnosed but remaining untreated, and many only partially treated due to compliance issues. Up to 50% of patients will abandon device therapy in the first week after prescription. This carries significant community impact: health and economic burden relate to short- and long-term medical consequences, work and social injury and accident risk, and far-reaching reduction in an individual’s quality of life.

Results of a recently completed Australian multicentre NHMRC-funded clinical trial1 in multilevel airway surgery in adults with OSA, who could not comply with device use, have recently been published. Future research is planned to enable refinement of the identification and selection of appropriate patients and surgeries in order to reduce the burden of disease. Development of tailored approaches in order to offer salvage surgery or even earlier surgery to appropriate anatomical/phenotypic candidates is also required.

CURRENT UNDERSTANDING OF THE ROLE OF SURGERY IN ADULT OSA

The ENT surgeon involved in adult OSA surgery has an obligation to promote benefit and mitigate risk based on the best available evidence. Indications for airway surgery may include:

i. Failed compliance with/intolerance of device therapy
ii. Significant complications of device therapy
iii. Patient favours surgery, declining all other options
iv. Patient has particularly favourable anatomy for surgery
It should be noted that (iii) and (iv) are open to debate dependent upon expert opinion and patient preference.

More recently, modified uvulopalatopharyngoplasty and submucosal insertions of a radiofrequency-in saline wand to reduce tongue volume have been tested at the highest level of evidence, demonstrating a key role for surgical intervention based on a range of primary and secondary outcomes in the trial. Existing international literature supports a role for surgery across many domains including:

- Function/Quality of Life (QOL)
- Cardiovascular risk
- Mortality
- Motor vehicle accident (MVA) risk
- Polysomnographic parameters of disease
- Cost-effectiveness

These publications are at Level I (individual randomized controlled trial (RCT) and also systematic reviews/meta-analyses, see Appendix S1 under ‘A’ (Supplementary Information)) and Level II (large individual cohort and observational or multicentre studies, see Appendix S1 under ‘B’ (Supplementary Information)), studies supported by the International Surgical Sleep Society as providing sufficient evidence of effect, at the time of publication (see Appendix S1 under ‘C’ (Supplementary Information)) and finally literature regarding the philosophy and judgement of sleep apnoea surgery (see Appendix S1 under ‘D’ (Supplementary Information)). Under ‘E’ is to what degree consensus statements are supported in this document.

It is also noted by the committee that adult OSA treatment can no longer have a ‘one-size-fits-all approach’ and the future of personalized medicine in OSA will require an integrated approach by marrying anatomical, physiological and other information to formulate a tailored plan for the individual patient.

PREOPERATIVE ASSESSMENT

Essential, preferred and optional components

Assessment is defined as the summation of clinical history, examination, formal polysomnography (PSG; for patients at risk of OSA as per MBS Guidelines) and completion of a range of predictive or treatment questionnaires.

There is no precise airway examination or assessment tool that can provide a perfect predictor of surgical outcome; it can be considered a skilled art form rather than an exact science.

In the assessment of excessive daytime sleepiness (EDS), other sleep disorders need consideration, such as narcolepsy, and medical and psychological comorbidities, such as depression, prior to committing to OSA surgery.

The essential, preferred and optional assessment components are explained in Figure 1 and Tables 1–5.

**Figure 1** Clinical assessment and evaluation: essential, preferred and optional components. Also consider pre-anaesthesia studies. CT, computed tomography; ESS, Epworth Sleepiness Scale; FOSQ, Functional Outcomes of Sleep Questionnaire; MRI, magnetic resonance imaging; OPG, orthopantomogram; OSA, obstructive sleep apnoea; RAST, radioallergosorbent test; SPT, skin prick testing; SSS, Snoring Severity Scale. STOP-BANG sleep apnoea questionnaire: Snoring Tired Observed (choking/gasping) Pressure (hypertension) Body mass index (>35) Age (>50) Neck size (>40 cm) Gender (male).
Desirable components: Collaboration with other professionals in OSA management

The committee notes that the following professionals treating OSA and associated conditions require different exposures for maintenance of skills and qualifications and that adult OSA is often a chronic progressive condition and may require complex combination therapy.4

Dental
- Trained in Twin-Block titratable MAS
- (Preferred) Member of the ASA/National/International Society

Orthodontist
- Trained in Twin-Block titratable MAS
- (Preferred) Member of the ASA/National/International Society
- Trained in pre-maxillofacial surgery orthodontics and expansion orthodontics

Maxillofacial
- Trained in bi-maxillary advancement surgery, genioglossal advancement and high sliding genioplasty
- (Preferred) Member of the ASA/National/International Society

Sleep psychology
- Trained in insomnia, distorted sleep architecture and multidisciplinary care
- (Preferred) Member of the ASA/National/International Society

Surgeon
- Trained in contemporary sleep surgery and multidisciplinary care
- (Preferred) Member of the ASA/International Surgical Sleep Society (ISSS)/ASOHNS/other

Dietician/personal trainer (exercise physiologist)
- Extended primary care healthcare plan compatible professionals

PRE-ANAESTHESIA STUDIES

OSA carries increased perioperative risk. A discussion with anaesthesiologists is recommended preoperatively with regards to characteristics of OSA phenotype, such as:

- Features of underactivity
- Prior blood/evaluation
- Prior treatment

- Prior PSG
- Prior CPAP/MAS/device use
- Prior/current downloads
- OTC/non-prescribed medication
- Changes since prior evaluation

CPAP, continuous positive airway pressure; MAS, mandibular advancement splint; MVA, motor vehicle accident; OSA, obstructive sleep apnoea; OTC, over the counter; PSG, polysomnography.

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Table 1 Essential components in clinical assessment in OSA—history

| History regarding the likelihood of OSA | Snoring |
|---|---|
| • Loudness | • Duration |
| • Average night/week | • Partner description |
| • Audio/visual recordings | • Social/partner disruption |
| Apnoea |
| • Partner witnessed | • Choking/gasping/pauses |
| • Self-waking episodes |

| History regarding sleep architecture and hygiene | Sleep hygiene |
|---|---|
| • Sleep onset/offset | • In bed times |
| • Nocturnal urination | • Vivid dreams |
| • Difficulty initiating/maintaining sleep | • Hypnopomnic/hypnogonic phenomenon |

| History regarding consequences of OSA | Waking/daytime |
|---|---|
| • Refreshed/unrefreshed | • Tired |
| • Sleepy | • Headaches |
| • Function | • MVA/work issues |

| History regarding associated or adjunctive conditions | Weight |
|---|---|
| • Weight gain/progression | • Weight fluctuation |
| • Prior treatment |

| Cardiovascular/other conditions | Personal history of risk factors |
|---|---|
| Family history of risk factors | Other medications/supplements |

| Nasal symptoms | • Nasal obstruction |
|---|---|
| • Sneez/itch/other | • Fixed vs fluctuating |
| • Smell | • Coloured mucus/discharge |
| • Treatments (medical, surgical and immunological) |

Table 1 Continued

| History regarding previous treatment and assessments | Thyroid symptoms |
|---|---|
| • Features of underactivity | • Prior blood/evaluation |
| • Prior treatment |

| History regarding previous treatment and assessments | Prior PSG |
|---|---|
| Prior CPAP/MAS/device use | Prior/current downloads |
| OTC/non-prescribed medication | Changes since prior evaluation |

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as arousal threshold and ventilatory stability, and also degree of arterial oxygen desaturation on polysomnogram, particularly oxygen nadir and duration of time spent below an peripheral oxygen saturation measured by pulse oximetry (SpO2) of 90%.

In obese patients and suggestive hypnogram, concurrent obesity hypoventilation syndrome (OHS) should be suspected in patients with resting hypoxaemia, spirometry demonstrative of a restrictive ventilatory defect or elevated serum bicarbonate level (≥27 mEq/L). In selected cases, arterial blood gas (ABG) sampling may be useful to establish daytime hypercapnia (arterial partial pressure of carbon dioxide (PaCO2) ≥ 45 mm Hg).

General pre-anaesthetic evaluation should be carried out as per routine societal guidelines.

**PERIOPERATIVE MANAGEMENT FOLLOWING OSA SURGERY**

**Ambulatory versus inpatient management**

OSA is an established risk factor for increased incidence of perioperative complications, especially cardio-pulmonary complications. Preoperative evaluation of patient characteristics can assist with risk stratification and decision-making regarding inpatient versus ambulatory management.

Optimal strategy for the preoperative identification of patients at high risk of complications remains uncertain. In addition to upper airway anatomical and neuromuscular factors, individual OSA phenotypic diversity encompasses arousal threshold and ventilatory stability, with specific OSA phenotypes potentially conferring increased perioperative vulnerability.

Perioperative risk stratification is required to balance patient safety and required location and intensity of post-operative monitoring against cost and hospital resources, and should encompass patient characteristics, extent of upper airway surgery, requirement for opioid therapy and pain-sedation mismatch.

Patients with elevated body mass index (BMI), higher AHI or presence of multiple medical comorbidities have been identified as being at higher risk of early post-operative complications following UPPP and, hence, should be recommended for overnight monitoring. Preoperative AHI and extent of arterial oxygen desaturation are predictive of immediate post-operative desaturation and respiratory compromise following

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**Table 2** Essential components in clinical assessment in OSA—examination

| Examination                  | General                      |
|------------------------------|------------------------------|
|                              | Weight, height, BMI          |
|                               | Neck                         |
|                               | Blood pressure               |
| Oral/ oropharyngeal/dental    | Transoral                    |
|                               | Friedman stage/ modified Mallampati |
|                               | Occlusion                    |
|                               | Maxilla/mandible             |
|                               | Craniofacial                 |
|                               | Tonsil/palate/tongue         |
| Nasal                        | Anterior                     |
|                               | Nasal tip, nasal valve       |
|                               | Mucosal disease              |
|                               | Pathology                    |
| Nasendoscopy                 | Structural/pathology         |
|                               | Modified Mueller manoeuvre   |
|                               | Woodson’s hypotonic method   |
|                               | Erect and supine             |
|                               | Jaw thrust/Esmarch           |

BMI, body mass index; OSA, obstructive sleep apnoea.
isolated UPPP surgery. Patients with a BMI >30 kg/m² and/or AHI ≥22/h are more likely to subsequently require supplemental oxygen therapy after transfer to the ward, and should receive more intensive monitoring.

The incidence of early post-operative complications following isolated UPPP surgery is generally low. Importantly, reviews have consistently recognized that the majority of serious complications are identified within 3 h of surgery, highlighting the importance of careful observation during the immediate post-operative period. Generally, ongoing respiratory assessment in a post-anaesthesia care unit (PACU) for at least 3 h can assist in early identification of upper airway instability or ventilatory vulnerability and requirement for a monitored bed and continuous pulse oximetry. For ward-based care, continued vigilance is encouraged across the initial 12–24-h post-operative period where risk of respiratory compromise is greatest.

Following ambulatory UPPP surgery, primary indications for unscheduled representations were primarily identified as haemorrhage (38.3%) and uncontrolled pain (21.2%). Importantly, multilevel surgery for OSA, now considered standard practice, is associated with higher rates of complications compared to isolated UPPP, and more research is required to guide inpatient versus ambulatory management decisions.

### Post-operative CPAP therapy

Post-operative disruption in sleep architecture is generally low. Importantly, reviews have consistently recognized that the majority of serious complications are identified within 3 h of surgery, highlighting the importance of careful observation during the immediate post-operative period. Generally, ongoing respiratory assessment in a post-anaesthesia care unit (PACU) for at least 3 h can assist in early identification of upper airway instability or ventilatory vulnerability and requirement for a monitored bed and continuous pulse oximetry. For ward-based care, continued vigilance is encouraged across the initial 12–24-h post-operative period where risk of respiratory compromise is greatest.

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### Table 3 Essential components in clinical assessment in OSA—PSG

| PSG | Sleep physician assessment | Joint |
| --- | --- | --- |
| • Formal Level I or II (with accredited sleep physician reporting) | • Formal Level I or II (with accredited sleep physician reporting) | • Represented the IDEAL scenario² |
| • Comprehensive, reliable report | • Comprehensive, reliable report | • One airway clinic |
| • Assessment of: | • Assessment of: | • Multidisciplinary clinic |
| o TST | o TST | o Discussion/comprehensive case review |
| o Sleep efficiency | o Sleep efficiency | |
| o REM/NREM/stages | o REM/NREM/stages | |
| o Positional data | o Positional data | |
| o Apnoea/hypopnoea (≥RERA)³ | o Apnoea/hypopnoea (≥RERA)³ | |
| o ODI³ | o ODI³ | |
| o Nadir oxygen saturation³ | o Nadir oxygen saturation³ | |
| o Full available hypnogram³ | o Full available hypnogram³ | |

If patients have high probability of OSA, they should have PSG prior to any pre-phase nasal surgery.

If patients have a low probability of OSA, and demonstrable nasal pathology, it may be reasonable to perform nasal surgery without PSG.

Assessment of severity.

LMO, Local Medical Officer; NREM, non-REM; ODI, oxygen desaturation index; OHS, obesity hypoventilation syndrome; OSA, obstructive sleep apnoea; PSG, polysomnography; REM, rapid eye movement; RERA, respiratory effort-related arousal; TST, total sleep time.

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Post-operative CPAP therapy

Post-operative disruption in sleep architecture is greatest across the first night, with a reduction in sleep efficiency, slow wave sleep and rapid eye movement (REM) sleep occurring in both patients with and without OSA. A significant increase in post-operative AHI from baseline also occurs in patients with OSA, peaking on post-operative night 3, which temporally corresponded to recovery in REM sleep.

The Society of Anaesthesia and Sleep Medicine (SASM) Practice Guidelines recommends that patients compliant with CPAP therapy should continue CPAP in the post-operative period unless a specific contraindication is identified. Whilst there is a paucity of evidence pertaining specifically to post-operative CPAP management following corrective airway surgery for OSA, the ASA advises to assume the patient remains at heightened risk of
perioperative OSA complications in the absence of a repeat normal PSG and resolution of symptoms.\textsuperscript{11}

**Post-operative analgesia**
Multimodal analgesia should be considered standard of care following surgical treatment of OSA.
Within the first 12–24 h post-operatively, use of systemic opioid therapy is associated with increased incidence of respiratory depression.\textsuperscript{25} Most of the morbidity and mortality related to perioperative opioid-induced respiratory depression relates to pain–sedation mismatch and insufficient monitoring, and are considered preventable.\textsuperscript{19,20} Age, female gender and medical comorbidities are identified as risk factors for post-operative opioid-induced respiratory depression.\textsuperscript{20} Certain OSA phenotypes with an elevated arousal threshold and reduced ventilatory response may be more vulnerable to opioid-induced respiratory depression.\textsuperscript{26}

A multimodal strategy across classes and administration methods should be employed, inclusive of regional analgesia with local anaesthetic and systemic non-opioid analgesia, such as paracetamol, non-steroidal anti-inflammatory drugs (NSAID), cyclooxygenase-2 (COX-2) inhibitors, pregabalin and gabapentin.\textsuperscript{11}

When opioids are administered, line-of-sight nursing care and continuous pulse oximetry monitoring are recommended with vigilance of pain–sedation mismatch.\textsuperscript{11}

**Role of oxygen therapy**
To manage early post-operative hypoxaemia, continuous targeted supplemental oxygen can be utilized as an adjuvant to effective CPAP. Patients with high loop gain in particular can benefit from oxygen therapy, significantly reducing AHI and assisting ventilatory stability.\textsuperscript{27}

When oxygen therapy is utilized to treat early post-operative hypoxaemia, flow rate should be titrated to a specified therapeutic range and continuous pulse oximetry monitoring is recommended.\textsuperscript{11}

In the setting of suspected or confirmed concurrent OHS, cautious administration of supplemental oxygen therapy is required to avoid hypventilation and worsening of hypercapnia.\textsuperscript{28}

**Patient position**
Supine predominant or isolated OSA occurs in between 20% and 60% of individuals.\textsuperscript{29} Post-operatively, AHI is significantly elevated during supine sleep compared to non-supine sleep.\textsuperscript{30}

Non-supine positioning is preferred throughout the recovery period to limit positional worsening of OSA.\textsuperscript{11}

**Fluid management**
Cautious use of perioperative intravenous fluid is encouraged. Significant increase in both neck circumference and post-operative AHI has been demonstrated in males aged ≥40 years with infusion of normal saline (0.9% NaCl).\textsuperscript{31} The combination of excessive intravenous fluid and rostral fluid shifts from immobilization, supine positioning and compression stockings can exacerbate post-operative OSA.\textsuperscript{32}

**Concluding remarks**
Further research is required to guide the post-operative management of patients following OSA surgery, particularly in the context of the transition from isolated to multilevel surgical procedures.

**OVERALL THERAPY OUTLINE IN ADULT OSA MANAGEMENT**

This overall therapy outline describes adjunctive, mainstream, combination and clinical trial pathways for Adult OSA patients (Fig. 2). Each treatment in these categories is described in detail below, with the exception of clinical trials. Where available and patient preference/clinician awareness dictates, clinical trial options of new or evolving treatment are encouraged.

**Nasal treatments: Pre-phase (facilitatory)**
In general, the committee recognizes the three main reasons why nasal treatments (below) should ideally precede other/subsequent interventions:

- **Reason 1:** There may be a higher complication rate associated with concomitant nasal surgery (involving bony and cartilaginous work) and other airway surgery.
- **Reason 2:** Nasal treatments may facilitate a return to device use/trial of devices again.
- **Reason 3:** One may achieve a fortuitous outcome from nasal therapy alone, especially in milder forms of snoring and OSA, obviating the need for larger interventions.

The possible nasal treatments, to be applied singularly or in combination, as clinically indicated are listed below:

- **(i) Modifications for Management of Allergens**
  - House dustmite (e.g. removal of bedroom carpets, high temperature bedding washes, etc.)
  - Grasses/pollens (e.g. protective masks during lawn-mowing, etc.)
  - Moulds (e.g. cleaning environmental moulds, etc.)
  - Animal mix/dander (e.g. avoidance of specific household pets, etc.)

- **(ii) Medical**
  - Preventer medication (e.g. Topical Corticosteroid Spray, Montelukast Inhibitor)
  - Reliever medication (e.g. Antihistamines, Saltwater Douche)
  - Preventer/reliever medication (e.g. Topical corticosteroid/Antihistamine spray)

- **(iii) Surgical**
  - Septoplasty/septal reconstruction
  - Turbinate reduction
  - Functional endoscopic sinus surgery
  - Nasal valve surgery/(or ‘dilators’)

- **(iv) Immunological**
  - Immunomodulatory medication
  - Sublingual immunotherapy

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Injection immunotherapy

Weight loss treatment (adjunctive)
Given that obesity is the major risk factor for OSA, weight loss is an important treatment strategy that is relevant for the majority of patients with OSA. The relationship between weight loss and OSA (and other OSA treatments) is complex and bi-directional. A number of studies have demonstrated that weight loss via various methods can have an important impact on OSA, although even dramatic weight loss may not completely resolve OSA. In this context, following weight loss, patients with residual OSA who desire additional treatment may be considered as candidates for airway surgery or other therapy.

The potential weight loss strategies, singularly or in combination, in adult OSA patients are listed below:

- Dietary interventions
- Advice
- Dietician
- Concomitant/metabolic disease
- Exercise interventions
- Advice
- Exercise physiologist
- Concomitant/metabolic disease
- Surgical interventions
- Minimal
- Laparoscopic/sleeve
- Bypass
- Medical/hormonal
- Medicines
- Hormonal/endocrine

Positional treatment/therapy
Positional therapy is a cost-effective and low-risk alternative (or adjunctive) treatment for OSA. Up to 20% of patients with OSA experience respiratory events exclusively in the supine sleeping position and therefore may achieve resolution of OSA when they avoid supine sleep. The preferred method of supine position avoidance is with the use of vibratory warning devices which allow patients to move freely when asleep and deliver warning vibrations when the patient has adopted the supine sleeping position. Devices that use discomfort to prompt avoidance of the supine position (such as the 'tennis ball technique') have poor long-term adherence whilst bolster or pillow arrangements...
can leave patients stuck on one side all night increasing the chance of hip and shoulder discomfort.

The potential positional therapy options and strategies in adult OSA patients are listed below:

- Advice/self-manufacturable
  - Advice
  - Blocks or prods
  - Tennis ball
  - Positional devices (vibratory)
  - Nightshift (downloadable data available)
  - BuzzPOD
  - Sleep Position Trainer
  - Positional devices (non-vibratory)

- Advice
- Blocks or prods
- Tennis ball
- Positional devices (vibratory)
- Nightshift (downloadable data available)
- BuzzPOD
- Sleep Position Trainer
- Positional devices (non-vibratory)

- Zzoma
- Rematee
- Other

**Combination therapy**

As many of the non-CPAP therapies for OSA are often only partially effective in treating the disease, there has been a focus on combining treatments to improve efficacy. The rationale is that because OSA has many contributory mechanisms including unfavourable airway anatomy, poor upper airway dilator muscle response, respiratory control instability and low respiratory flow.
arousal threshold; combining treatments that target one or more of these mechanisms could result in improved treatment results. For example, the combination of upper airway surgery and supine position avoidance (both anatomical treatments) is frequently recommended based on the observation that upper airway surgery for OSA preferentially reduces the lateral AHI and that positional avoidance can be used to further improve symptoms. A similar approach may be efficacious in patients who have undergone significant weight loss with a concomitant improvement in lateral AHI. Further research is exploring the possibility of targeting different OSA mechanistic pathways. For example, upper airway surgery does not alter respiratory control instability and treatments that improve respiratory control stability could be utilized to further improve the AHI in patients who have had upper airway surgery with residual OSA symptoms.

The potential combination therapy options and strategies in adult OSA patients are listed below:

Combination pre-phase/adjunctive treatments

- Nasal treatment + weight loss + positional therapy
- Nasal treatment + weight loss + nasal treatment + positional therapy
- Weight loss + positional therapy

Combination adjunctive and mainstream treatment

- Weight loss + surgery
- Weight loss + MAS
- Nasal treatment + surgery
- Nasal treatment + MAS

‘Mainstream’ therapy

Continuous positive airway pressure

CPAP is the gold standard treatment for OSA. A number of guidelines exist that describe the management of OSA with CPAP therapy. The position paper of the ASA on CPAP therapy can be found at https://www.sleep.org.au/documents/item/66. RCT evidence exists to support the positive effect of CPAP on mood and cognition; however, the cardiovascular benefits of this treatment remain in doubt. Certainly, CPAP is limited in its application by a high number of patients who cannot comply with the therapy long term. For those patients encountering difficulties acclimatizing to CPAP secondary to nasal obstruction, nasal surgery can be an important intervention to facilitate increased CPAP compliance. Counter to this, some of the older forms of palatal surgery are associated with difficulty subsequently using CPAP therapy. We recommend that patients being considered for upper airway (UA) surgery to reduce OSA severity have an adequate trial of CPAP therapy prior to surgery. We consider a 3–6-month trial of supervised CPAP treatment mandatory except where patients have very favourable anatomy with a high probability of improvement with operative intervention.
The potential CPAP therapy options in adult OSA patients are listed below:
- Nasal CPAP
- Nasal pillows CPAP
- Full face mask CPAP
- Oral mask CPAP

Mandibular advancement splint
Twin-Block titratable MAS are an efficacious treatment for OSA. A number of society guidelines exist for the implementation of these treatments. However, the treatment is not universally successful and comes with potential side effects such as temporomandibular joint pain and bite misalignment. As with surgery, selecting the correct patients for this anatomical treatment remains an ongoing issue.

Surgery
The next section of this consensus statement contains key algorithms, as guidance for practicing sleep surgeons in Australasia, in the assessment and execution of operative (and other) interventions.

The algorithms have been designed specifically to assist sleep surgeons in approaches to commonly faced scenarios. However, heterogeneity/complexity of anatomy, physiology, airway dynamics, surgical skill and patient preference mean that these algorithms are a guide, not prescriptive.

The algorithms are based on the assimilation of all available levels of evidence, predominately in adult airway surgery, recognizing that RCT are rarely done in surgery, but that those available have been considered.

Multiple other non-randomized controlled publications have been taken into account, as defined acceptable by the Consensus Writing Committee (with experienced sleep surgeons and sleep physicians involved) and the ASA Clinical Committee, and categorized into A, B, C, D and E in Appendix S1 (Supplementary Information).

It is noted that the effect sizes on AHI and other parameters in many of these papers, particularly the
systematic review/meta-analyses, are large. Such large effect sizes are seen to justify the categorization and weightings applied to them in Appendix S1 (Supplementary Information).

Despite this, surgery carries risk (see Complications of pharyngeal surgery for snoring/OSA section) and further longer term studies in the field remain warranted.

It should also be noted that many newer areas in the field, particularly hypoglossal nerve stimulator implantation, are in evolution and increased access and availability are anticipated beyond 2020 in Australasia.

In Figures 3–7, suggested algorithms with surgical options (each figure based upon differing anatomical variations) are outlined for adult patients with predominantly moderate to severe OSA. In Figure 8, options for mild OSA/snoring are provided. It is accepted there may be exceptional circumstances under which mild OSA/snoring patients are sufficiently symptomatic to warrant following Figures 3–7.

COMPLICATIONS OF PHARYNGEAL SURGERY FOR SNORING/OSA

The known post-operative complications related to pharyngeal/airway surgeries are listed below. It is recommended that surgeons performing any of the interventions in this position statement familiarize themselves with the ‘early’ and ‘late’ complications, and adhere to the follow-up/outcomes guide listed below.

Early post-operative
1. Bleeding
2. Airway compromise: swelling ± opioid effect. Steroids (i.v.) are beneficial in the first 48–72 h. If patient is still using CPAP prior to surgery, immediate post-operative use is suggested in patients with an elevated BMI
3. Infection
4. Wound dehiscence: partial dehiscence of the UPPP incision is common, and usually heals well by secondary intention
5. Complications of all surgeries: (pulmonary embolism (PE), myocardial infarction (MI), anaphylaxis, etc.)

Late post-operative
1. Secondary haemorrhage: typically days 7–10 post-operatively
2. Velopharyngeal incompetence: rare with newer modified UPPP variants. Swallowing exercises (e.g. Mendelsohn manoeuvre) usually resolve this
3. Palatal fistula: uncommonly seen after transpalatal advancement. Usually heals with conservative management. May require a temporary splint. Rarely, a local flap may be needed
4. Change in taste: this is usually subtle, and often slowly resolves over 12 months
5. Change in swallowing: very subtle changes in swallowing are fairly common (e.g. to dry crumbly food). As with taste changes, these often resolve over a year, but may persist to a very subtle degree long term.

**Follow-up/outcomes assessment**

1. PSG: 3–4 months post-operatively, 12 months post-operatively, then as indicated
2. Epworth and snoring severity scale: 3–4 months, 12 months, then annually. Preoperative assessments should be repeated post-operatively.
3. Other symptomatic assessment: Functional Outcomes of Sleep Questionnaire (FOSQ), 10 or 30: pre- and post-operatively as described above
4. Annual clinical review is recommended

It is advised that resection or ablative procedures involving Laser are avoided as unpredictable scar, pain and many of the above-listed risks are of greater likelihood.

**FUTURE DIRECTIONS**

The committee recognizes the following four important future directions:

1. **Hypoglossal nerve stimulation**
   This is a surgically implantable, medically titratable device. Upper airway stimulation (UAS) is a surgically implanted device that induces neuromuscular augmentation of the hypoglossal nerve and genioglossus muscle timed with ventilation or set off a duty cycle. UAS
Figure 7  Surgery #5. Algorithm for adult OSA surgery in patients with predominantly moderate to severe OSA (and anatomy as per this figure). BMI, body mass index; CPAP, continuous positive airway pressure; HGNS, hypoglossal nerve stimulation; MAS, mandibular advancement splint; OSA, obstructive sleep apnoea.

Figure 8  Surgery #6. Algorithm for adult OSA surgery in patients with predominantly mild OSA or ‘snoring without OSA’. CPAP, continuous positive airway pressure; MAS, mandibular advancement splint; OSA, obstructive sleep apnoea.
reduces multilevel collapse to increase retropalatal and retrolingual dimensions.\textsuperscript{60} It is commercially available internationally, but remains in clinical trial phase in Australasia. UAS has been incorporated into the German guideline for management of sleep-disordered breathing.\textsuperscript{61} The American Academy of Sleep Medicine (AASM) has yet to incorporate UAS into their guideline recommendations.

Evaluation of the evidence for UAS

The STAR multicentre prospective cohort study evaluated patients with a BMI \(\leq 32\) kg/m\(^2\) with moderate to severe OSA and intolerance or poor compliance with CPAP therapy treated with a unilateral hypoglossal nerve implant (Inspire Medical Systems, Minneapolis, MN).\textsuperscript{62} The 5-year follow-up of the STAR study indicated that patients treated with hypoglossal nerve stimulation (HGNS) maintained improvements in PSG parameters (AHI and oxygen desaturation index (ODI)) and patient-focused measures (Epworth Sleepiness Scale (ESS) and FOSQ) of OSA.\textsuperscript{63} The median AHI decreased from a baseline value of 29.3 to 6.2 and median ODI from 25.4 to 4.6. Median ESS decreased from 11 at baseline to 6 and median FOSQ increased from 14.6 to 18.7. Incidence of device-related adverse events were low at 6% and all related to lead or device adjustments.

The multicentre single-arm German post-market study enrolled patients with a BMI \(\leq 15\) and \(\leq 65\) kg/m\(^2\) who received the UAS system (Inspire Medical Systems).\textsuperscript{64} At 12 months, median (interquartile range (IQR)) AHI had reduced from 28.6 (21.6–40.1) to 9.5 (4.6–18.6), ESS had reduced from 13 (9.3–17) to 6.5 (3–10), and FOSQ had increased from 13.7 (11.3–16.7) to 18.6 (16.1–19.7).

Results from the retrospective and prospective ADHERE Registry of 10 tertiary care hospitals in Germany and the USA (no BMI limit) showed significant improvement in both objective and patient-reported OSA outcomes, demonstrating a decrease from baseline to the post-titration review in mean AHI (±SD) of 35.2 ± 19.9 to 10.2 ± 12.9 (\(P < 0.0001\)), and a decrease in ESS score from 11 (9.5) to 7.5 (\(P = 0.0001\)).\textsuperscript{65}

In Australia, the Genio-Nyxoah system offering bilateral nerve stimulation with an implantable device, triggered by an external stimulator set off a duty cycle, has recent publications to support a role in OSA therapy.\textsuperscript{66} with a further study (‘BETTER SLEEP’) underway.

Further research is required to establish the efficacy of UAS in comparison to the various OSA surgical procedures.

Patient selection for UAS

Patient selection for UAS should encompass assessment for features predictive of likely success.\textsuperscript{67–69} Drug-induced sleep endoscopy (DISE) in the supine position to exclude patients with complete concentric collapse, an unfavourable pattern to UAS success, is recommended, but based on limited data.\textsuperscript{70} Computed tomography imaging has been determined determined to offer limited value to predict responders to UAS and cannot be recommended currently.\textsuperscript{80,71}

2. Robotic upper airway surgery

Appropriately credentialed surgeons with expertise in robotic surgery may intervene with such technology, based on a published systematic review and meta-analysis.

3. Phenotyping/endo-phenotyping and personalized approaches

Selecting patients for surgical intervention based on features such as pharyngeal critical pressure (\(P_{crit}\)) and low loop gain may become a part of future paradigms in Australasia.

4. Standardization and registries for data collection

Future registries via International Surgical Sleep Society, ASA, ASOHNS and New Zealand Society of Otolaryngology Head and Neck Surgery (NZSOHNS) are likely to support the audit and refinement of surgical procedures.

**KEY POINTS**

A comprehensive and targeted history and examination is essential for optimal patient selection in the application of OSA surgery.

Consideration of medical comorbidities and other sleep disorders, such as narcolepsy and depression, is critical prior to commitment to OSA surgery given potential for reversible elements, and in such circumstances, referral for formal sleep physician assessment is preferred.

Formal PSG is deemed necessary prior to consideration of OSA surgery and review of current Medicare guidelines is recommended when requesting PSG.

Questionnaire tools can assist in evaluating ‘before’ and ‘after’ outcomes in OSA surgery, establishing functional impact, and determining perioperative risk attributable to the presence of OSA, and their incorporation in routine assessment is preferred.

Targeted nasal investigations (such as allergy profiling and radiological imaging) are considered optional in the presence of relevant clinical and examination findings.

Sleep nasendoscopy is not considered part of routine clinical assessment, and its role is yet to be validated. Sleep nasendoscopy is therefore considered optional.

Discussion regarding standard non-surgical options to manage OSA is essential. The risks and benefits of each option should be conveyed to the patient.

Collaborative perioperative management is essential, given the presence of OSA confers increased perioperative risk.

Importantly, there is no single airway examination or assessment tool predictive of surgical outcome. Rather, it is a combination of considered and individualized assessment elements.

Nasal surgery can be considered a facilitatory treatment option in select patients.

Awareness of appropriate anatomically directed, multilevel surgical options is recommended in the treatment of adult OSA patients seeking salvage surgery.

**Abbreviations:** ABG, arterial blood gas; AHI, apnoea-hypopnoea index; ASA, Australasian Sleep Association; ASOHNS, Australian Society of Otolaryngology Head and Neck Surgery; CPAP, continuous positive airway pressure; CT, computed tomography; COX-2 inhibitors, cyclooxygenase-2 inhibitors; DISE, drug-induced sleep endoscopy; EDS, excessive daytime sleepiness; ESS, Epworth Sleepiness Scale; FOSQ, Functional...
Outcomes of Sleep Questionnaire; FTG, Friedman tongue position; HGNS, hypoglossal nerve stimulation; ISSS, International Surgical Sleep Society; LASER, leave as is, because it is not an abbreviation; MI, myocardial infarction; MAS, mandibular advancement splint; MBS, Medicare Benefits Schedule; MVA, motor vehicle accident; NZSOHNS, New Zealand Society of Otolaryngology Head and Neck Surgery; ODI, oxygen desaturation index; OHS, obesity hypoventilation syndrome; OPG, orthopantomogram; OSA, obstructive sleep apnoea; PACU, post-anaesthesia care unit; Pcrit, pharyngeal critical pressure; Paco2, arterial partial pressure of carbon dioxide; PE, pulmonary embolism; PSG, polysomnography; RAST, radioallergosorbent test; REM, rapid eye movement; RFTA, radiofrequency tissue ablation; QOL, quality of life; Spo2, peripheral oxygen saturation trial; REM, rapid eye movement; RFTA, radiofrequency tissue ablation; UAS, upper airway stimulation; UPPP, uvulopalatopharyngoplasty.

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**Supplementary Information**

Additional supplementary information can be accessed via the html version of this article at the publisher’s website.

**Appendix S1** Categories of evidence supporting a role for OSA surgery in adults.