HEALTH EVIDENCE REVIEW COMMISSION (HERC) COVERAGE GUIDANCE

# SURGICAL TREATMENTS FOR OBSTRUCTIVE SLEEP APNEA

DRAFT for HERC Meeting June 12, 2025

QUESTION 1

## SHOULD UVULOPALATOPHARYNGOPLASTY (UPPP) BE COVERED FOR ADULTS WITH MODERATE TO SEVERE OBSTRUCTIVE SLEEP APNEA (OSA)?

**We recommend coverage of uvulopalatopharyngoplasty (UPPP) for adults when ALL of the following conditions are met:**

1) **documented obstructive sleep apnea based on a sleep study with an apnea-hypopnea index (AHI4*) of 15 or greater; AND**
2) **inadequate response to continuous positive airway pressure (CPAP) therapy or cannot tolerate CPAP or other appropriate noninvasive non-pharmacologic treatment; AND**
3) **evidence of retropalatal or combination retropalatal and retrolingual obstruction as the cause of the obstructive sleep apnea**

***Apnea is defined as a cessation of airflow for at least 10 seconds. Hypopnea is an abnormal respiratory event lasting at least 10 seconds with at least a 30% reduction in thoraco-abdominal movement or airflow as compared with baseline, and with at least a 4% oxygen desaturation.**

Rationale:

We have low confidence there is a clinically meaningful benefit from UPPP compared with ongoing medical management in adults with moderate to severe OSA. This evidence shows improvement in quality of life, OSA severity, and daytime sleepiness. These benefits likely outweigh the moderate confidence evidence of significant serious adverse events, including death, related to these procedures. There is no evidence on whether this treatment affects the rate of major adverse cardiac events (MACE).

QUESTION 2

## SHOULD TONSILLECTOMY ALONE BE COVERED FOR ADULTS WITH MODERATE TO SEVERE OBSTRUCTIVE SLEEP APNEA (OSA)?

**We recommend coverage of tonsillectomy alone for adults when ALL of the following conditions are met:**

1) **documented obstructive sleep apnea based on a sleep study with an AHI4* of 15 or greater; AND**
2) **inadequate response to continuous positive airway pressure (CPAP) therapy or cannot tolerate CPAP or other appropriate noninvasive non-pharmacologic treatment; AND**
3) **Tonsil size rated as 3 or 4 on the Brodsky scale (rated 0–4); AND**
4) **Determined to not be a candidate for concurrent UPPP**

***Apnea is defined as a cessation of airflow for at least 10 seconds. Hypopnea is defined as an abnormal respiratory event lasting at least 10 seconds with at least a 30% reduction in thoraco-abdominal movement or airflow as compared with baseline, and with at least a 4% oxygen desaturation.**

Rationale:

There is evidence of a similar clinically meaningful benefit from tonsillectomy alone compared with UPPP in selected adult patients with moderate to severe OSA. This is a less invasive procedure and may be appropriate for patients who are not candidates for UPPP.

QUESTION 3

## SHOULD OTHER SURGICAL TREATMENTS BE COVERED FOR ADULTS WITH MODERATE TO SEVERE OBSTRUCTIVE SLEEP APNEA (OSA)?

**We do not recommend coverage of maxillomandibular advancement surgery or other surgical procedures to treat obstructive sleep apnea in adults.**

Rationale:

There is insufficient evidence regarding the impact of maxillomandibular advancement surgery or other surgical procedures on various outcomes of interest.

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# RATIONALE FOR DEVELOPMENT OF COVERAGE GUIDANCES AND MULTISECTOR INTERVENTION REPORTS

Coverage guidances are developed to inform coverage recommendations for public and private health plans in Oregon as plan administrators seek to improve patients' experience of care, population health, and the cost-effectiveness of health care. In the era of public and private sector health system transformation, reaching these goals requires a focus on maximizing the benefits and minimizing the harms and costs of health interventions.

The Health Evidence Review Commission (HERC) uses the following principles in selecting topics for its reports to guide public and private payers:

- Represents a significant burden of disease or health problem
- Represents important uncertainty with regard to effectiveness or harms
- Represents important variation or controversy in implementation or practice
- Represents high costs or significant economic impact
- Topic is of high public interest

HERC bases its reports on a review of the best-available research applicable to the intervention(s) in question. For coverage guidances that focus on diagnostic and clinical interventions, evidence is evaluated using an adaptation of the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) methodology. For more information on coverage guidance methodology, see Appendix A.

Multisector interventions can be effective ways to prevent, treat, or manage disease at a population level. In some cases, HERC has reviewed evidence and identified effective interventions, but has not made formal coverage recommendations when these policies are implemented in settings other than traditional health care delivery systems, as effectiveness could depend on the environment in which the intervention is implemented.

## GRADE

HERC develops recommendations by using the concepts of the GRADE approach. GRADE is a transparent and structured process for developing and presenting evidence and for performing the steps involved in developing recommendations. The tables below list the elements that determine the strength of a recommendation. HERC reviews the evidence and assesses each element, which in turn is used to develop the recommendations presented in the coverage guidance box. Estimates of effect are derived from the evidence presented in this document. Assessments of confidence are from the published systematic reviews and meta-analyses, where available and judged to be reliable. The level of confidence in the estimate is determined by HERC based on the assessment of 2 independent reviewers from the Center for Evidence-based Policy (Center; see Figure 1).

In some cases, no systematic reviews or meta-analyses encompass the most current literature. In those cases, HERC may describe the additional evidence or alter the assessments of confidence in light of all

available information. Such assessments are informed by clinical epidemiologists from the Center. Unless otherwise noted, statements regarding resource allocation, values and preferences, and other considerations are the assessments of HERC, as informed by the evidence reviewed, public testimony, and subcommittee discussion.

FIGURE 1. GRADE TABLE KEY

| OUTCOMES | TABLE KEY | | | | |
|---|---|---|---|---|---|
| Confidence in Estimate: | NO DATA ○○○○ | VERY LOW ●○○○ | LOW ●●○○ | MODERATE ●●●○ | HIGH ●●●● |
| Direction of Effect: | No Data, Unclear, No Effect, Benefit, Harm, Mixed | | | | |

Notes. Recommendations for coverage are based on the balance of benefit and harms, resource allocation, values and preferences, and other considerations. See Appendix A for more details about the factors that constitute the GRADE table.
Abbreviation. GRADE: Grading of Recommendations, Assessment, Development, and Evaluations approach.

# GRADE TABLE

## GRADE TABLE

## SURGICAL TREATMENTS FOR ADULTS WITH MODERATE TO SEVERE OBSTRUCTIVE SLEEP APNEA

### CRITICAL OUTCOMES

#### Quality of Life

BENEFIT

**Evidence summary**

Three studies (2 randomized controlled trials [RCTs] and 1 comparative cohort; N = 339) reported general quality of life measures with 2 of those studies (2 RCTs; N = 173) also reporting sleep-related quality of life. Of all studies reporting quality of life measures, 2 studies (2 RCTs; N = 173) examined uvulopalatopharyngoplasty (UPPP) with tonsillectomy and 1 study (comparative cohort; N = 166) examined airway surgeries done at multiple levels of the airway in a sequential manner (multilevel, multistage surgery, with 100% first receiving a UPPP with tonsillectomy). No eligible studies examined quality of life outcomes for barbed repositioning pharyngoplasty with tonsillectomy (a variation of UPPP) or maxillomandibular advancement (MMA).

Compared with participants on a waitlist (1 RCT; N = 71), participants randomized to UPPP with tonsillectomy had significantly improved sleep-related and general quality of life based on improved Functional Outcomes of Sleep Questionnaire (FOSQ) and Short Form-36 (SF-36) Questionnaire scores. In addition, the improvement exceeded the established minimal clinically important difference (MCID) for FOSQ (≥ 1 point) and for the SF-36 Mental Health Component, but not the Physical Health Component (≥ 3 points).

- SKUP3 RCT (UPPP with tonsillectomy, 6 months): FOSQ, +1.5 vs. –0.2 (change scores); SF-36 Mental Health Component, 48.1 vs. 42.7; SF-36 Physical Health Component, 51.2 vs. 48.3; $P < .05$ for all

Compared with participants who received ongoing medical management or positive airway pressure (PAP) therapy (1 RCT and 1 comparative cohort study; N = 268), participants receiving modified UPPP with minimally invasive tongue volume reduction had significantly improved sleep-related quality of life, based on significantly improved FOSQ scores, and this improvement exceeded the established MCID for FOSQ (≥ 1 point). However, participants receiving modified UPPP with minimally invasive tongue volume reduction or multilevel, multistage surgery did not have significantly improved general quality of life based on European Quality of Life-5 Dimension 5-Level Instrument (EQ-5D-5L) or Glasgow Benefit Inventory (GBI) scores.

- Robinson, 2009 comparative cohort (multilevel multistage surgery, approximately 4 years): Glasgow Benefit Inventory, 19.4 vs. 16.7; $P = .79$
- SAMS RCT (modified UPPP with minimally invasive tongue volume reduction, 6 months): FOSQ, +3.6 vs. +0.1 (change scores); $P < .001$; EQ-5D-5L, +0.06 vs. 0.00 (change scores); $P = .054$

**Confidence rating**

Low confidence that obstructive sleep apnea (OSA) surgery improves quality of life in adults with moderate to severe OSA.

- Risk of bias (downgraded 2 levels): lack of blinding for an intervention with a patient-reported outcome predisposes to biased outcome reporting, lack of information on confounders, lack of clarity on how an outcome measure (GBI) was adapted for the nonsurgical group, lack of funding information
- Other: short follow-up periods relative to intended length of intervention

## Procedure-Related Serious Adverse Events

HARM

**Evidence summary**

Twelve studies (5 RCTs, 1 comparative cohort, 2 registry studies, and 4 systematic reviews [SRs]; N = 15,503) reported procedure-related serious adverse events (SAEs). Of those, 7 studies (3 RCTs, 2 registry studies, and 2 SRs; N = 13,125) examined UPPP with tonsillectomy, 2 studies (1 RCT and 1 SR; N = 1,581) examined barbed repositioning pharyngoplasty with tonsillectomy (a variation of UPPP), 2 studies (1 RCT and 1 SR; N = 631) examined MMA, and 1 study (comparative cohort; N = 166) examined airway surgeries done at multiple levels of the airway in a sequential manner (multilevel, multistage surgery, with 100% first receiving a UPPP with tonsillectomy).

For UPPP with tonsillectomy, total SAEs were reported in 0% to 7.1% of participants, repeat surgery in 2.6% of participants, and death in 0% to 0.2% of participants. Death could not necessarily be attributed to the surgery and was only identified due to being within 30 days of surgery. For some outcomes, seriousness could not precisely be determined, including postoperative bleeding in 0% to 7.8% of participants and velopharyngeal insufficiency (a weakness in the structures separating the nose and the mouth that can lead to swallowing and speech difficulties) in 0.3% to 9.1% of participants. Similarly, infection with unreported seriousness occurred in 3.1% of participants receiving multilevel, multistage surgery (where all participants first received a UPPP with tonsillectomy).

For barbed repositioning pharyngoplasty with tonsillectomy, total SAEs were reported in 0% of participants (specific types of SAEs were not reported).

For MMA, total SAEs were reported in 0% to 18% of participants, repeat surgery in 1.7% of participants, and death in 0% of participants (other specific types of SAEs were not reported).

**Confidence rating**

Studies reported actual harms and there is moderate confidence of the scope and magnitude of the harms of OSA surgery in adults with moderate to severe OSA.

- Indirectness (downgraded 1 level): inability to determine level of seriousness for most adverse events, inability to consistently and precisely identify participants with moderate to severe OSA, differences in classification of adverse events

## IMPORTANT OUTCOMES

## OSA Severity (Polysomnography Outcomes)

**Evidence summary**

Five RCTs (N = 315) reported OSA severity as measured by polysomnography. Of those, 3 studies (3 RCTs; N = 215) examined UPPP with tonsillectomy, 1 study (RCT; N = 50) examined barbed repositioning pharyngoplasty with tonsillectomy (a variation of

BENEFIT

UPPP), and 1 study (RCT; N = 50) examined MMA. No eligible studies examined OSA severity for multilevel, multistage surgery.

Compared with participants on a waitlist (3 RCTs; N = 163), participants randomized to surgery had significantly lower OSA severity, as indicated by significantly lower AHI (AHI3, N = 2 studies; AHI4, N = 1 study) and oxygen desaturation index (ODI3, N = 2 studies). In all 3 studies, the differences in mean follow-up AHI and ODI scores between study groups exceeded the established MCID (≥ 5 events per hour). Of the 2 RCTs that reported respiratory disturbance index (RDI), 1 RCT did not find a significant difference at 3 months.

- SKUP3 RCT (UPPP with tonsillectomy, 6 months): AHI3, 21.1 vs. 46.8; ODI3, 14.0 vs. 35.6; RDI, 25.8 vs. 50.1; $P < .001$ for all
- Sommer, 2016 RCT (UPPP with tonsillectomy, 3 months): AHI4, −18.4 vs. −7.2 (change scores); $P = .036$; RDI, −12.5 vs. −8.1 (change scores); $P = .27$
- Vicini, 2020 RCT (barbed repositioning pharyngoplasty with tonsillectomy, 6 months): AHI3, −15.8 vs. −5 (change scores); ODI3, −15.1 vs. −2.8 (change scores); $P = .01$ for both

Compared with participants who received ongoing medical management or PAP therapy (2 RCTs; N = 152), participants randomized to modified UPPP and minimally invasive tongue volume reduction, but not MMA, had a significant reduction in OSA severity. In addition, the reduction in AHI and ODI for modified UPPP with minimally invasive tongue volume reduction exceeded the established MCID (≥ 5 events per hour).

- SAMS RCT (modified UPPP with minimally invasive tongue volume reduction, 6 months): AHI3, −27.4 vs. −9.8 (change scores); ODI3, −17.7 vs. −4.2 (change scores); ODI4, −15.3 vs. −4.3 (change scores); $P < .01$ for all
- Vicini, 2010 RCT (MMA, 12 months): AHI (blood oxygen desaturation threshold for hypopneas NR), 8.1 vs. 6.3; $P = .21$

**Confidence rating**

Low confidence that OSA surgery reduces OSA severity in adults with moderate to severe OSA.

- Risk of bias (downgraded 1 level): lack of blinding, inadequate or inadequately described allocation concealment, inadequate or inadequately described randomization, lack of funding information, author COI
- Indirectness (downgraded 1 level): some studies used a different definition of AHI than OHP, which may overestimate the effect of surgery (OHP uses the same definition as Medicare) and the alternate definition of AHI may have led to enrollment of patients with less severe OSA at baseline
- Other: short follow-up periods relative to intended length of intervention

## Daytime Sleepiness

**Evidence summary**

Six studies (5 RCTs, 1 comparative cohort; N = 481) reported daytime sleepiness as measured by the Epworth Sleepiness Scale (ESS). Of those, 3 studies (3 RCTs; N = 215) examined UPPP with tonsillectomy, 1 study examined barbed repositioning pharyngoplasty with tonsillectomy (a variation of UPPP) (RCT; N = 50), 1 study

# GRADE TABLE

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examined maxillomandibular advancement (MMA) (RCT; N = 50), and 1 study (comparative cohort; N = 166) examined airway surgeries done at multiple levels of the airway in a sequential manner (multilevel, multistage surgery, with 100% first receiving a UPPP with tonsillectomy).

Compared with participants on a waitlist (3 RCTs; N = 163), participants randomized to surgery experienced significantly reduced daytime sleepiness, as indicated by significantly lower ESS scores. The differences in mean follow-up ESS scores between study groups exceeded the established MCID (≥ 2 points).

- SKUP3 RCT (UPPP and tonsillectomy, 6 months): 6.8 vs. 12.5; *P* < .001
- Sommer, 2016 RCT (UPPP and tonsillectomy, 3 months): −4.4 vs. −0.6 (change scores); *P* = .01
- Vicini, 2020 RCT (barbed repositioning pharyngoplasty with tonsillectomy, 6 months): −5.5 vs. +0.4 (change scores); *P* = .00

Compared with participants who received ongoing medical management or PAP therapy (2 RCTs, 1 comparative cohort; N = 318), participants who received modified UPPP with minimally invasive tongue volume reduction, but not multilevel, multistage surgery or MMA, reported a significant improvement in daytime sleepiness. In addition, the improvement in daytime sleepiness for modified UPPP with minimally invasive tongue volume reduction exceeded the established MCID (≥ 2 points).

- Robinson, 2009 comparative cohort (multilevel, multistage surgery; approximately 4 years): 4.0 vs. 4.0 (median); *P* = .78
- SAMS RCT (modified UPPP and minimally invasive tongue volume reduction, 6 months): −7.2 vs. −0.5 (change scores); *P* <.001
- Vicini, 2010 RCT (MMA, 12 months): 7.7 vs. 5.9; *P* = .20

**Confidence rating**

Low confidence that OSA surgery reduces daytime sleepiness in adults with moderate to severe OSA.

- Risk of bias (downgraded 2 levels): lack of blinding for an intervention with a patient-reported outcome predisposes to biased outcome reporting, lack of information on confounders, inadequate or inadequately described allocation concealment, lack of funding information, author COI
- Other: short follow-up periods relative to intended length of intervention

**Major Adverse Cardiac Events**

NO DATA

There were no eligible studies that reported major adverse cardiac events (MACE) outcomes.

**Balance of benefits and harms**

We have low confidence there is a clinically significant benefit for 3 outcomes (sleep-related quality of life, OSA severity, daytime sleepiness) associated with UPPP compared with ongoing medical management in adults with moderate to severe OSA. It is likely these benefits outweigh the moderate confidence evidence of significant serious adverse events related to this surgery. There was also evidence that tonsillectomy alone resulted in similar outcomes as compared with UPPP in selected patients. There were insufficient data to inform a balance statement for MMA or other procedures.

**Resource allocation**

These surgeries involve significant cost, access to specialty care, and recovery time for the patient. Diagnosis of OSA requires a sleep study. The proposed criteria of coverage for UPPP will likely require coverage of drug-induced sleep endoscopy (DISE), which adds costs and anesthesia risk. Some patients may be able to stop using CPAP after UPPP or tonsillectomy alone, which may be cost-saving in the longer term; however, some patients would continue to need CPAP therapy after surgery. Coverage of MMA would also require coverage of corrective dental treatments, which is currently outside of the Oregon Medicaid benefits package for adults.

**Values and preferences**

Many patients who do not have a sufficient response to CPAP, are unable to tolerate CPAP, or have an insufficient response to other medical management of OSA would value an intervention that would improve their quality of life and reduce OSA symptoms. Some patients would prefer a one-time intervention over nightly use of CPAP. Many patients would be concerned about a surgery with significant possible adverse effects. There are few other treatment options for adults with moderate to severe sleep apnea who have inadequate response to or are unable to tolerate CPAP. These assessments are based on staff and expert judgment.

**Other considerations**

UPPP and MMA are only available in certain areas of the state with sufficiently trained surgical subspecialists.

Notes. GRADE table elements are described in Appendix A; a corresponding GRADE Evidence Profile is in Appendix B.
Abbreviations. AHI4: Apnea-Hypopnea Index with 4% blood oxygen desaturation threshold for hypopneas; AHI3: Apnea-Hypopnea Index with 3% blood oxygen desaturation threshold for hypopneas; COI: conflict of interest; CPAP: continuous positive airway pressure; EQ-5D-5L: European Quality of Life-5 Dimension 5-Level Instrument; ESS: Epworth Sleepiness Scale; FOSQ: Functional Outcomes of Sleep Questionnaire; GBI: Glasgow Benefit Inventory; MACE: major adverse cardiac events; MCID: minimal clinically important difference; MMA: maxillomandibular advancement; NR: not reported; ODI4: Oxygen Desaturation Index with 4% blood oxygen desaturation threshold; ODI3: Oxygen Desaturation Index with 3% blood oxygen desaturation threshold; OHP: Oregon Health Plan; OSA: obstructive sleep apnea; PAP: positive airway pressure; RCT: randomized controlled trial; RDI: respiratory disturbance index; RoB: risk of bias; SAE(s): serious adverse event(s); SF-36: Short Form-36; SRs: systematic reviews; UPPP: uvulopalatopharyngoplasty; US: United States; vs.: versus.

# BACKGROUND

Obstructive sleep apnea (OSA) is the most common sleep-related breathing disorder.[1] OSA is caused by recurrent partial or complete collapse of the upper airway, which interferes with the flow of air during sleep.[2] This leads to interrupted sleep, a low oxygen level in the blood, or both.[2] Untreated or undertreated OSA can contribute to poor quality of life, is associated with chronic illnesses such as heart disease, and can cause life-threatening complications.[3-6] OSA is a common condition, affecting an estimated 9% to 38% of the general population.[7,8]

## Causes and Consequences of OSA

### Anatomy of OSA

The upper airway (i.e., pharynx) is mostly surrounded by soft tissues and is not supported by a bony structure, making it especially vulnerable to collapse.[2] Many factors can contribute to upper airway collapse during sleep, including irregularities in anatomical structures and loss of neuromuscular control.[2]

### Symptoms and Complications

Signs and symptoms of OSA may include excessive daytime sleepiness, early morning headaches, and snoring, choking, or gasping during sleep.[9] Due to the frequent interruptions in sleep, excessive daytime sleepiness is the most common symptom reported by individuals with OSA.[8] Excessive daytime sleepiness from OSA is associated with impaired work performance[10,11] and increased risk of motor vehicle crashes while driving.[12] OSA is also associated with other medical complications including cardiovascular complications such as high blood pressure, congestive heart failure, coronary artery disease, stroke, pulmonary hypertension, atrial fibrillation and other irregular heart rhythms, and sudden cardiac death.[2,5,6,9]

## OSA Diagnosis

### Diagnostic Testing

Sleep apnea testing is required for a diagnosis of OSA.[9] The American Academy of Sleep Medicine (AASM) recommends testing for OSA in individuals with excessive daytime sleepiness and other clinical features of OSA, such as loud snoring or gasping.[13] Home sleep apnea testing and in-laboratory polysomnography are the most common diagnostic tests for OSA.[1] Home sleep apnea testing typically involves a respiratory effort band around the chest, a nasal cannula with a pressure transducer to measure airflow and snoring, and an oximeter to measure oxygen saturation.[1] In-laboratory polysomnography generally also involves measures of sleep stages and arousals using electroencephalogram (EEG), electrocardiogram results, body position, and leg movements.[8] The diagnosis of OSA depends on the presence of sleep-associated conditions such as fatigue, insomnia, snoring, or breathing interruptions as well as counts of obstructive respiratory events during sleep.[9]

### Defining Obstructive Respiratory Events

With sleep apnea testing, there are 2 main types of obstructive respiratory events: apneas (complete obstruction) and hypopneas (partial obstruction).[1] An apnea is an event defined as the complete

cessation of airflow for 10 seconds or longer.[2] A hypopnea is an event characterized by a partial reduction in airflow.[2]

There is variation in the definition of hypopnea. A common definition of a hypopnea is evidence of a reduction in airflow of 30% or more for 10 seconds or longer accompanied by either an arousal or oxygen desaturation of 3% or more (this definition is abbreviated as AHI3a).[1] A stricter definition of a hypopnea (abbreviated as AHI4) uses an oxygen desaturation threshold of 4% instead of 3% and does not consider arousals.[1]

The Centers for Medicaid & Medicare Services (CMS) uses the AHI4 criteria to define a hypopnea.[14] The decision of which hypopnea definition to use has implications for the prevalence of OSA diagnoses and severity of OSA classification.[15,16] After changes adopted in 2023, the AASM Scoring Manual 3 recommends every accredited sleep center score hypopneas with the AHI3a definition due to evidence that hypopneas with a 3% oxygen desaturation or arousal are associated with health and quality of life deficits.[17] However, the current scoring manual allows sleep centers to also report AHI scores according to the AHI4 criteria for patients insured by a payer that requires it for treatment coverage.[17]

### The Apnea-Hypopnea Index and Other Measures of OSA Severity

The apnea-hypopnea index (AHI) is a measure of the total number of apneas and hypopneas per hour of sleep.[1] Advantages of the AHI are that it is fairly objective and reproducible across a standardized context.[2] Generally, severity of OSA is defined by AHI thresholds, with greater than or equal to 5 obstructive events per hour characterized as mild OSA, greater than or equal to 15 events per hour as moderate OSA, and greater than or equal to 30 events per hour as severe OSA (Table 1; Appendix D, Table D1).[2]

TABLE 1. CLASSIFICATION OF OSA SEVERITY

| CLASSIFICATION | AHI SCORE |
|---|---|
| Mild | ≥ 5 and < 15 events per hour |
| Moderate | ≥ 15 and < 30 events per hour |
| Severe | ≥ 30 events per hour |

Source. Johnson, 2023.[1]
Abbreviations. AHI: apnea-hypopnea index; OSA: obstructive sleep apnea.

Limitations of AHI as a measure of OSA severity include:

(1) It equates apneas and hypopneas, even though the severity of physiological effects differ[18]

(2) Individual characteristics, such as age, obesity, and cardiopulmonary disease, can be additional factors that affect the degree of oxygen desaturation[2]

(3) AHI is a continuous measure and the discrete thresholds used to define OSA severity may contribute to misclassification of overall OSA severity when scores are near a threshold[2]

(4) It is unclear whether AHI scores correspond closely to the severity of clinical symptoms of OSA or whether these are useful in predicting morbidity, mortality, or response to treatment[1,2]

Other measures of severity of OSA include the respiratory disturbance index (RDI), the respiratory event index (REI), and the oxygen desaturation index (ODI).[1] The RDI differs from the AHI because it accounts for the number of apneas, hypopneas, and arousals per hour of sleep.[1] The REI is commonly used in home sleep testing and reports the number of apneas and hypopneas per hour of monitoring time, since home sleep tests without EEG cannot account for the total time asleep.[1,19] As such, the REI is sometimes an underestimation of the AHI; in contrast, the RDI is often higher than the AHI because it accounts for arousals separately.[19] The ODI counts the number of oxygen desaturations (typically either the AHI3a ≥ 3% standard or the AHI4 ≥ 4% standard) per hour of sleep time or monitoring time.[20]

### Patient-Reported Measures of OSA Severity

Beyond measures based on sleep apnea, hypopnea, and desaturation testing, several patient-reported assessments help evaluate the severity of OSA, including the response to therapy. These instruments include the Epworth Sleepiness Scale (ESS), which measures daytime sleepiness, and the Functional Outcomes of Sleep Questionnaire (FOSQ), which measures sleep-related quality of life (QoL) impairments (Appendix D, Table D1).[8,21]

## OSA Treatment

The aim of OSA treatment is to reduce AHI score, improve symptoms, and increase patient quality of life.[22] Complete remission of OSA is rare and lifelong treatment is usually necessary, with the exception of sustained weight loss in the setting of obesity-related OSA.[8,22]

Continuous positive airway pressure (CPAP) therapy is considered the standard first-line therapy for most adults with OSA.[22] CPAP devices work by creating a constant flow of air through a mask to support breathing.[2] The positive air pressure generated by the CPAP device helps to maintain an open airway during sleep.[2]

## Surgery for OSA

Surgery can be a second-line treatment aimed at correcting or reducing abnormalities in the structure or function of the upper airway.[23] Surgery can be performed to remove or reposition the soft tissues of the upper airway or to reposition the jaw bones to expand the upper airway and reduce apneas and hypopneas during sleep.[23] In the upper airway, surgeries can target the nose, soft tissues of the upper or lower pharynx (throat cavity), or larynx (voice box).[23]

Surgeons can use drug-induced sleep endoscopy (DISE) to evaluate a patient's airway anatomy and guide their approach.[24] DISE involves examination of the airway with a flexible camera while the patient receives light sedation to mimic sleep.[24] It allows direct visualization of the various anatomical structures that can contribute to obstruction during sleep.[24]

### What are Common OSA Surgeries?

Nasal surgeries aim to reduce nasal obstruction typically for the purpose of improving outcomes with CPAP or other treatments.[23] Because nasal surgery alone is not a sufficient treatment for moderate to severe OSA,[23] it was excluded in the scope for this evidence review by the HERC.

In the upper pharynx, uvulopalatopharyngoplasty (UPPP) is a common surgery.[23] The purpose of UPPP is to remove or reposition soft tissue of the upper pharynx to expand the upper airway.[23] The surgical technique of UPPP has evolved over the years and there have been several modifications developed (e.g., expansion sphincter pharyngoplasty, lateral pharyngoplasty, and others).[23] Surgery to remove the tonsils (tonsillectomy), adenoids (adenoidectomy), or both can also be performed as part of UPPP or separately.[23]

In the lower pharynx, surgeries can reduce the volume of the tongue, reposition the tongue to open the airway, or correct abnormalities of the epiglottis (the tissue that protects the larynx to aid in swallowing).[23] Surgeries can be combined at different levels of the upper airway (multilevel surgery) and can be done at one time (single stage) or sequentially (multistage).[23]

In the jaw, surgeries can change the shape and position of the maxilla (upper jaw bone), mandible (lower jaw bone), or both.[23] The most common jaw surgery for OSA is maxillomandibular advancement surgery (MMA).[23] In this surgery, both the maxilla and mandible are moved forward, opening the airway at multiple points.[23]

## Access and Equity

Although clinicians of many specialties can play a role in identifying and referring patients for diagnostic testing for OSA, the AASM recommends that follow-up be under the supervision of a physician trained in sleep medicine.[13] However, there is an anticipated national shortage of sleep medicine specialists in the US.[25] This shortage is especially pronounced in federally designated Health Professions Shortage Areas, which may contribute to sleep health disparities for individuals with lower socioeconomic status and those from racial and ethnic minority groups.[26]

### Differences and Disparities in OSA Prevalence and Diagnosis

The prevalence of OSA varies by sex, with men having higher rates of OSA than women.[9] When excluding mild OSA, US-specific estimates indicate approximately 13% of men and 6% of women have moderate or severe OSA.[27] However, the prevalence of OSA also increases among menopausal and pregnant people due to changes in hormone levels.[28]

Furthermore, the prevalence and severity at diagnosis of OSA may vary by race and ethnicity (as categorized by the study authors) although the precise relationship is unclear. Some studies suggest that African American young adults experience a higher prevalence of OSA than White young adults, independent of body weight.[29] Other studies reveal a racial disparity in higher OSA prevalence for African American children, though evidence of a disparity is less robust for middle-aged populations.[30] At the time of diagnosis, OSA tends to be more severe among African American individuals compared with White individuals.[31,32] Another study found that South Asian individuals with severe obesity had higher prevalence and severity of OSA than White Europeans with severe obesity.[33] However, other study evidence indicates that rates of OSA are similar or lower among Asian individuals and Asian Americans compared with White individuals.[30]

### Disparities in Treatment Coverage and Availability

Evidence on disparities in OSA surgery is limited. A 2020 study found significant geographic variation in the distribution of otolaryngologists (the physicians that typically perform OSA surgery).[34] The number

of otolaryngologists was higher in areas with more subspecialist physicians generally and increased along with income and education in the regional population.[34] A 2022 study of patients with OSA found that, compared with White people, Black people were less likely, Hispanic people were similarly likely, and Asian people were more likely to receive OSA surgery.[35] In that study, the likelihood of OSA surgery also decreased with age.[35]

# METHODS

The following section summarizes the overall scope of the evidence review, including Key Questions (KQs) and Contextual Questions (CQs), inclusion and exclusion criteria, and a brief overview of the methods used to conduct the review. Additional information regarding methods can be found in Appendix C.

## Key Questions

KQ1. What is the effectiveness of surgical versus nonsurgical treatments for OSA in adults?
KQ2. What are the harms of surgical treatments for OSA?
KQ3. How does the effectiveness and harms of these interventions vary by:
- a. Intervention characteristics
- b. Patient characteristics
  - i. Severity of OSA
  - ii. Race, ethnicity, culture, or language
  - iii. Gender or sex
  - iv. Age
  - v. Comorbidities
  - vi. Response to prior interventions

## Contextual Questions

CQ1. What is the evidence for effectiveness of surgical interventions for OSA on outcomes (e.g., all-cause mortality, major adverse cardiac events, motor vehicle crashes) from systematic reviews that include observational and nonrandomized studies?
CQ2. What is the comparative effectiveness of surgical interventions for OSA from randomized controlled trials?
CQ3. What is the cost effectiveness of surgical interventions for OSA?

## Study Eligibility Criteria

Table 2 summarizes the criteria used to inform study selection for the evidence review. See Appendix C for more detailed selection criteria.

TABLE 2. EVIDENCE REVIEW CRITERIA OVERVIEW

| CATEGORY | INCLUDED | EXCLUDED |
|---|---|---|
| POPULATION | ■ Adults with moderate to severe OSA | ■ Children and adolescents (i.e., aged < 18 years) with OSA<br>■ Adults with mild OSA |

| CATEGORY | INCLUDED | EXCLUDED |
|---|---|---|
| | | ■ Adults with central sleep apnea |
| INTERVENTIONS | **Surgical airway (i.e., oropharyngeal) interventions including but not limited to:**<br>■ Upper pharyngeal procedures (e.g., uvulopalatopharyngoplasty [UPPP], tonsillectomy, adenoidectomy)<br>■ Lower pharyngeal and laryngeal procedures (e.g., tongue reduction procedures, tongue advancement or stabilization procedures, epiglottis correction procedures)<br>■ Maxillomandibular advancement [MMA] or expansion surgery | ■ Hypoglossal nerve stimulation devices (separate HERC coverage guidance)[36]<br>■ Nasal surgeries alone<br>■ Airway surgeries no longer used in contemporary practice (e.g., laser-assisted uvulopalatoplasty [LAUP])<br>■ Tracheotomy or tracheostomy (salvage procedures)<br>■ Mandibular advancement devices<br>■ Noninvasive positive pressure ventilation (e.g., bilevel positive airway pressure, continuous positive airway pressure<br>■ Intensive weight loss interventions (e.g., bariatric surgery, medications) |
| COMPARATORS | ■ Nonsurgical OSA interventions (including noninvasive PAP therapy)<br>■ No treatment | ■ Other surgical airway interventions |
| OUTCOMES | **Critical**<br>■ Procedure-related serious adverse events<br>■ Quality of life<br><br>**Important**<br>■ Change in OSA severity (as measured by specific polysomnography indices: AHI, RDI, REI, or ODI)<br>■ Daytime sleepiness<br>■ Major adverse cardiac events | **Considered by HERC but not selected for review:**<br>■ All-cause mortality<br>■ Change in A1c<br>■ Remission of hypertension or diabetes<br>■ Fatigue-related injury<br>■ Other polysomnography outcomes<br>■ General harms |
| STUDY DESIGNS | **KQ1 (effectiveness)**<br>■ RCTs of any size<br>■ Comparative prospective cohort studies (N > 100)<br><br>**KQ2 (harms)**<br>■ RCTs and prospective cohort studies (as defined above)<br>■ Systematic reviews including nonrandomized studies<br>■ Single-arm prospective NRS (N > 100)<br>■ Registry studies | ■ Studies conducted in non-very-high-HDI countries<br>■ Individual retrospective cohort studies (including, cross-sectional studies, case series, or case reports) |

Note. See Appendix C for complete inclusion and exclusion criteria. See Appendix D, Table D1 for information regarding outcome scale interpretation.

Abbreviations. A1c: glycated hemoglobin; AHI: apnea-hypopnea index; HERC: Health Evidence Review Commission; HDI: Human Development Index;

KQ: key question; NRS: nonrandomized study; ODI: oxygen desaturation index; OSA: obstructive sleep apnea; PAP: positive airway pressure; RCTs: randomized controlled trials; RDI: respiratory disturbance index; REI; respiratory event index.

## Methods Overview

To answer the Key Questions (KQs), researchers from the Center for Evidence-based Policy (Center) searched multiple clinical evidence databases (e.g., Ovid MEDLINE, Cochrane CENTRAL) for published randomized controlled trials (RCTs), prospective nonrandomized studies (NRS), systematic reviews (SRs) of NRS, and registry studies, evaluating the effectiveness and harms of surgery for adults with moderate to severe OSA. In addition to the eligibility criteria described in Table 2, primary studies had to be available in English, include follow-up of at least 12 weeks for RCTs and 6 months for NRS and registry studies, be conducted in very-high Human Development Index (HDI) countries,[37] and be published in 2000 or later (2014 for SRs).

- We included surgery for OSA as defined by the study authors. In instances where procedures were not explicitly defined as surgery, we applied the American Medical Association's definition of surgery.[38]
- We included procedure-related adverse events when defined as "severe" or "serious" by the study authors. In instances where the severity of adverse events was not explicitly defined, we applied US Food and Drug Administration (FDA) definitions of serious adverse events (SAEs), which include: death, life-threatening events, inpatient hospitalization or prolongation of an existing hospitalization, persistent or significant incapacity or substantial disruption of the ability to conduct normal life functions, or congenital abnormalities and birth defects.[39]
- We included additional, quantitative procedure-related SAE evidence (KQ2) from registry studies and systematic reviews only for surgeries for which effectiveness (KQ1) data were available.
- For duplicative studies that included the same or significantly overlapping source data, we only included the most comprehensive study.

Two reviewers independently examined abstracts and full-text articles for eligibility using the systematic review software platform DistillerSR[40] and assessed the risk of bias of included studies. Disagreements were primarily resolved through consensus and were referred to a third reviewer when consensus could not be achieved. We assessed the overall strength of evidence using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) method, the results of which are presented in the previously described GRADE table.

We identified evidence for contextual questions (CQs) using results of the KQ database searches and performing targeted searches of relevant English-language sources as needed. Evidence regarding the CQs is summarized by question following the KQ review.

For the Policy Landscape section, we conducted targeted searches in Ovid MEDLINE, websites of relevant professional societies and guideline groups, and DuckDuckGo to identify relevant clinical practice guidelines (CPGs) published since 2014 and key payer policies regarding surgical airway interventions for adults with moderate to severe OSA. Two reviewers independently assessed the quality of the included CPGs; disagreements were primarily resolved through consensus and were referred to a third reviewer when consensus could not be achieved. Relevant position statements from professional societies were also included for contextual purposes and were considered to have high risk of bias.

# EVIDENCE REVIEW

The following results section organizes findings on the effectiveness and harms of surgery for adults with moderate to severe OSA by outcomes:

- Quality of life (QoL)
- Procedure-related serious adverse events (SAEs)
- OSA severity as measured by key polysomnography indices
- Daytime sleepiness
- Major adverse cardiac events (MACE)

Within each section, information is briefly summarized, and results are displayed in table(s). Additional tables can be found in Appendix D.

We screened 2,390 records for eligibility and identified 13 studies[41-53] in 16 publications[41-56] assessing the effectiveness and harms of surgery for adults with moderate to severe OSA (Table 3; Appendix D, Figure D1, Tables D2 and D3).

TABLE 3. CHARACTERISTICS OF INCLUDED STUDIES OF ADULTS WITH OSA

| AUTHOR, YEAR<br>STUDY[a] NAME, TRIAL NUMBER<br>COUNTRY<br>ROB | ELIGIBLE OSA SEVERITY<br>MEAN BASELINE AHI[b]<br>AHI CRITERIA[c] | SAMPLE SIZE<br>TOTAL FOLLOW-UP | SURGERY TYPE(S) | COMPARATOR | OUTCOMES |
|---|---|---|---|---|---|
| **RCTs** | | | | | |
| Browaldh, 2013[43,54-56]<br>SKUP3 Trial, NCT01659671<br>Sweden<br>Moderate | ■ Moderate<br>■ Severe<br>Severe: 53<br>AHI3 | N = 71<br>6 months | UPPP with tonsillectomy | Waitlist[d] | ■ Daytime sleepiness<br>■ OSA severity<br>■ QoL<br>■ SAEs |
| MacKay, 2020[46]<br>SAMS Trial, ACTRN12614000338662<br>Australia<br>Moderate | ■ Moderate<br>■ Severe<br>Severe: 47.9 (surgery); 45.3 (comparator)<br>AHI3 | N = 102<br>6 months | mUPPP and minimally invasive tongue volume reduction | Ongoing medical management[e] | ■ Daytime sleepiness<br>■ OSA severity<br>■ QoL<br>■ SAEs |
| Sommer, 2016[48]<br>Germany<br>High | ■ Moderate<br>■ Severe<br>Severe: 34.7 | N = 42<br>3 months | UPPP with tonsillectomy | Waitlist[d] | ■ Daytime sleepiness<br>■ OSA severity |

| | | | | | |
|---|---|---|---|---|---|
| | AHI4 | | | | ■ SAEs |
| Vicini, 2010[51]<br>Italy<br>High | ■ Severe<br>Severe: 56.8 (surgery); 50.3 (comparator)<br>NR | N = 50<br>12 months | MMA | APAP | ■ Daytime sleepiness<br>■ OSA severity<br>■ SAEs |
| Vicini, 2020[52]<br>Italy<br>High | ■ Moderate<br>■ Severe<br>Moderate: 25.6 (surgery)<br>Severe: 36.8 (comparator)<br>AHI3 | N = 50<br>6 months | Barbed repositioning pharyngo-plasty with tonsillectomy | Waitlist[f] | ■ Daytime sleepiness<br>■ OSA severity<br>■ SAEs |
| **COMPARATIVE COHORT STUDIES** | | | | | |
| Robinson, 2009[47]<br>Australia<br>High | ■ Moderate<br>■ Severe<br>Severe (RDI): 44 (surgery); 46.5 (comparator) | N = 166<br>~4 years | Multilevel multistage surgery[g] | CPAP | ■ Daytime sleepiness<br>■ QoL<br>■ SAEs |
| **REGISTRY STUDIES** | | | | | |
| Baker, 2016[41]<br>ACS-NSQIP database<br>US<br>Moderate | NA | N = 1,079 reports (UPPP alone)[h]<br>Data collection: 2008–2013 | UPPP[i] | NA | ■ SAEs |
| Brietzke, 2017[42]<br>Truven Health Analytics MarketScan Research Databases<br>US<br>Moderate | NA | N = 7,559 participants (UPPP alone)[j]<br>Data collection: 2010–2012 | UPPP | NA | ■ SAEs |
| Kerizian, 2004[45]<br>VA-NSQIP database<br>US<br>High | NA | N = 3,130 reports<br>Data collection: 1991–2001 | UPPP | NA | ■ SAEs *(KQ3 only)* |

| | | | | | |
|---|---|---|---|---|---|
| **SYSTEMATIC REVIEWS** | | | | | |
| Iannella, 2022[44]<br>High | NR | N = 15 studies (1,531 participants)<br>2–56 months | Barbed repositioning pharyngo-plasty with tonsillectomy | NA | ■ SAEs |
| Stuck, 2018[49]<br>Moderate | NR | N = 48 studies (1,919 participants)<br>1 month–15.75 years | UPPP[k] | NA | ■ SAEs |
| Tang, 2017[50]<br>High | NR | N = 24 studies (2,353 participants)<br>1 week–20 years | UPPP and mUPPP | NA | ■ SAEs |
| Zhou 2022[53]<br>Moderate | NR | N = 30 studies (1,610 participants)<br>6 months–12.5 years | MMA | NA | ■ SAEs |

Notes. [a] Or registry. [b] Evaluated as a events per hour and reported as in mean (SD). Indicates mean baseline AHI at study initiation for entire study cohort unless otherwise specified. [c] For studies reporting on OSA severity outcomes that meet eligibility for KQ1. [d] No other treatment for OSA permitted. [e] CPAP, MAD, behavioral interventions (low uptake of MAD or CPAP). [f] Not specified by the study authors if other treatment for OSA was permitted. [g] UPPP with or without tonsillectomy (100%), geniotubercle advancement (88%); if failure: palatal advancement (67%), hyoid suspension (66%); if failure: midline radiofrequency ablation of the tongue (41%) or submucosal glossectomy techniques (12.5%). [h] N = 1,692 total. [i] With or without tonsillectomy and adenoidectomy. [j] N = 14,633 total. [k] With or without tonsillectomy.

Abbreviations. ACS-NSQIP: American College of Surgeons National Surgical Quality Improvement Program; ACTRN: Australian Clinical Trials Registry Number; AHI: apnea-hypopnea index; AHI4: AHI with 4% blood oxygen desaturation threshold for hypopneas; AHI3: AHI with 3% blood oxygen desaturation threshold for hypopneas; APAP: auto-titrating positive airway pressure; CPAP: continuous positive airway pressure; KQ: key question; MAD: mandibular advancement device; MMA: maxillomandibular advancement; mUPPP: modified UPPP; NA: not applicable; NCT: National Clinical Trial; NR: not reported; OSA: obstructive sleep apnea; QoL: quality of life; RCT: randomized controlled trial; RDI: respiratory disturbance index; RoB: risk of bias; SAEs: serious adverse events; SD: standard deviation; UPPP: uvulopalatopharyngoplasty; US: United States; VA-NSQIP: Veterans Administration National Surgical Quality Improvement Program.

## QoL

Three studies (2 moderate RoB RCTs[43,46] and 1 high RoB comparative cohort study[47]) reported eligible QoL outcomes.

- Both RCTs reported on sleep-related QoL using the validated FOSQ (Table 4).[43,46]
- All 3 studies reported on general QoL using the validated European Quality of Life-5 Dimension 5-Level Instrument (EQ-5D-5L), Short Form-36 Questionnaire (SF-36) Mental Health Component (MHC) and Physical Health Component (PHC), or the Glasgow Benefit Inventory (GBI) (Table 5).[43,46,47]
- Additional information is available in Appendix D, Table D4.

## Sleep-Related QoL

TABLE 4. COMPARATIVE SLEEP-RELATED QOL OUTCOMES

| AUTHOR, YEAR<br>STUDY NAME<br>SAMPLE SIZE | STUDY DESIGN<br>SURGERY TYPE<br>CONTROL | TIME POINT | MEASURE | SURGERY VS. NO SURGERY<br>BETWEEN-GROUP ESTIMATE | *P* VALUE |
|---|---|---|---|---|---|
| **FUNCTIONAL OUTCOMES OF SLEEP QUESTIONNAIRE (SCORE RANGE, 5–20 POINTS; HIGHER SCORES ARE BETTER; MCID ≥ 1 POINT)[21]** | | | | | |
| Browaldh, 2013[43,56]<br>SKUP3 Trial<br>N = 71 | RCT<br>■ UPPP and tonsillectomy<br>■ Waitlist (7 mos)[a] | 6 mos | Change from baseline | +1.5 vs. −0.2 | *P* < .001[b] |
| MacKay, 2020[46]<br>SAMS Trial<br>N = 102 | RCT<br>■ mUPPP and minimally invasive tongue volume reduction<br>■ Ongoing medical management[c] | 6 mos | Mean | 18.6 vs. 16.3 | NR |
| | | | Change from baseline | +3.6 vs. +0.1<br>MD, 3.4 (95% CI, 2.5 to 4.4) | *P* < .001 |

Notes. [a] No treatment at all. [b] ITT analysis did not change the results of this per protocol analysis. [c] This included a range of evidence-based treatments as appropriate (e.g., weight loss, alcohol reduction, sleep posture modification, medical management of nasal obstruction) and assistance with retrial of CPAP or mandibular advancement device therapies if participants were willing. However, there was low uptake of MAD or CPAP (only n = 8 participants in total) as well as minimal weight loss in either study group or change in health behaviors.

Abbreviations. CI: confidence interval; CPAP: continuous positive airway pressure; ITT: intention to treat; MAD: mandibular advancement device; MCID: minimum clinically meaningful difference; MD: mean difference; mos: months; mUPPP: modified UPPP; NR: not reported; PHC: physical health component; RCT: randomized controlled trial; UPPP: uvulopalatopharyngoplasty.

## General QoL

TABLE 5. COMPARATIVE GENERAL QOL OUTCOMES

| AUTHOR, YEAR<br>STUDY NAME<br>SAMPLE SIZE | STUDY DESIGN<br>SURGERY TYPE<br>CONTROL | TIME POINT | MEASURE | SURGERY VS. NO SURGERY BETWEEN-GROUP ESTIMATE | *P* VALUE |
|---|---|---|---|---|---|
| **EUROPEAN QUALITY OF LIFE-5 DIMENSION 5-LEVEL INSTRUMENT (SCORE RANGE, 0 TO 1; HIGHER SCORES INDICATE BETTER HEALTH UTILITY; NO MCID FOR OSA)[46,57,58]** | | | | | |
| MacKay, 2020[46]<br>SAMS Trial<br>N = 102 | RCT<br>■ mUPPP and minimally invasive tongue volume reduction<br>■ Ongoing medical management[a] | 6 mos | Mean | 0.93 vs. 0.86 | NR |
| | | | Change from baseline | +0.06 vs. 0.00<br>MD, 0.06 (95% CI, −0.00 to 0.12) | *P* = .054 |
| **SHORT FORM-36 QUESTIONNAIRE: PHYSICAL HEALTH COMPONENT (SCORE RANGE 0 TO 100; HIGHER SCORES INDICATE A BETTER HEALTH-RELATED QoL; MCID ≥ 3 POINTS)[54,59]** | | | | | |
| Browaldh, 2013[43,54]<br>SKUP3 Trial<br>N = 71 | RCT<br>■ UPPP and tonsillectomy<br>■ Waitlist[b] | 6 mos | Mean | 51.2 vs. 48.3 | *P* = .007[c] |
| **SHORT FORM-36 QUESTIONNAIRE: MENTAL HEALTH COMPONENT (SCORE RANGE 0 TO 100; HIGHER SCORES INDICATE A BETTER HEALTH-RELATED QoL; MCID ≥ 3 POINTS)[54,59]** | | | | | |
| Browaldh, 2013[43,54]<br>SKUP3 Trial<br>N = 71 | RCT<br>■ UPPP and tonsillectomy<br>■ Waitlist[b] | 6 mos | Mean | 48.1 vs. 42.7 | *P* = .03[c] |
| **GLASGOW BENEFIT INVENTORY (SCORE RANGE, -100 TO +100; 0 MEANS NO BENEFIT, HIGHER SCORES INDICATE A BETTER OUTCOME; NO MCID)[46,60,61]** | | | | | |
| Robinson, 2009[47]<br>N = 166 | Comparative cohort<br>■ Multilevel, multistage surgery[d]<br>■ CPAP | ~4 yrs | Median | 19.4 vs. 16.7 | *P* = .79 |

Notes. [a] This included a range of evidence-based treatments as appropriate (e.g., weight loss, alcohol reduction, sleep posture modification, medical management of nasal obstruction) and assistance with retrial of CPAP or mandibular advancement device therapies if participants were willing. However, there was low uptake of MAD or CPAP (only n = 8 participants in total) as well as minimal weight loss in either study group or change in health behaviors. [b] No treatment at all. [c] ITT analysis did not change the results of this per protocol analysis. [d] UPPP with or without tonsillectomy (100%), geniotubercle advancement (88%); if failure: palatal advancement (67%), hyoid suspension (66%); if failure: midline radiofrequency ablation of the tongue (41%) or submucosal glossectomy techniques (12.5%).

Abbreviations. CI: confidence interval; CPAP: continuous positive airway pressure; ITT: intention to treat; MAD: mandibular advancement device; MCID: minimum clinically meaningful difference; MD: mean difference; mos: months; mUPPP: modified UPPP; NR: not reported; OSA: obstructive sleep apnea; QoL: quality of life; RCT: randomized controlled trial; UPPP: uvulopalatopharyngoplasty; yrs: years.

## Procedure-Related SAEs

Twelve studies (2 moderate RoB RCTs,[43,46] 3 high RoB RCTs,[48,51,52] 1 high RoB comparative cohort study,[47] 2 moderate RoB registry studies,[41,42] 2 moderate RoB systematic reviews,[49,53] and 2 high RoB systematic reviews[44,50]) reported procedure-related SAEs. Reported follow-up time for most clinically important procedure-related SAEs (Table 6) was up to 6 months.[41-43,45-48,50-52]

- 1 additional high RoB registry study[45] included in an eligible systematic review reported on procedure-related SAEs by participant age.
- Clinically important procedure-related SAEs are reported in Table 6. Additional result information is available in Appendix D, Table D5.

TABLE 6. CLINICALLY IMPORTANT PROCEDURE-RELATED SAES

| PROCEDURE-RELATED SAE | UPPP[a] | BARBED REPOSITIONING PHARYNGOPLASTY WITH TONSILLECTOMY | MMA |
|---|---|---|---|
| Total SAE, overall complication,[b] or major complication[c] | 0% to 7.1%[41,43,46,c] | 0%[44,52] | 0% to 18%[51,53] |
| Postoperative bleeding[b] | 0% to 7.8%[42,48] | NR | NR |
| Repeat surgery | 2.6%[48] | NR | 1.7%[53,d] |
| Aspiration[b] | 4.7%[47] | NR | NR |
| Problems swallowing (dysphagia)[b] | 1.7% to 10.9%[42,47] | NR | NR |
| Velopharyngeal insufficiency[b,e] | 0.3% to 9.1%[42,49,50] | NR | NR |
| Death[f] | 0% to 0.2%[41,42,45] | NR | 0%[53] |
| Infection[b] | 3.1%[47] | NR | NR |

Notes. [a] With or without tonsillectomy, adenoidectomy, minimally invasive tongue volume reduction, or part of a staged treatment plan (multilevel, multistage surgery). [b] Severity not or not consistently reported. [c] 1 systematic review also reported major complications for UPPP in 8 studies with more than 50 participants each but did not summarize event rates. [d] From systematic review (n = 10 participants). [e] Velopharyngeal insufficiency is a disorder of the sphincter separating the oral and pharyngeal cavities, which can result in speech and swallowing abnormalities. [f] Unclear if all reported deaths (n = 8) were procedure related.
Abbreviations. SAE: serious adverse event; UPPP: uvulopalatopharyngoplasty; MMA: maxillomandibular advancement; NR: not reported.

### Procedure-Related SAEs by Subgroup

1 high RoB registry study[45] using data from the VA-NSQIP evaluated 30-day incidence of procedure-related SAEs by participant age for UPPP (Table 7).

TABLE 7. PROCEDURE-RELATED SAES BY PARTICIPANT AGE FOR UPPP

| AUTHOR, YEAR<br>REGISTRY NAME<br>SAMPLE SIZE | OUTCOME | AGE RANGE<br>< 29 | 30–39 | 40–49 | 50–59 | 60–69 | 70+ |
|---|---|---|---|---|---|---|---|
| | | TOTAL N, N (%) | | | | | |
| Kerizian, 2004[45]<br>VA-NSQIP<br>N = 3,130 | Serious complications other than death[a] | n = 99<br>0 (0) | n = 414<br>8 (1.9) | n = 1,051<br>17 (1.6) | n = 979<br>9 (0.9) | n = 454<br>12 (2.6) | n = 133<br>1 (0.8) |
| | Death | n = 99<br>0 (0) | n = 414<br>1 (0.2) | n = 1,051<br>2 (0.2) | n = 979<br>1 (0.1) | n = 454<br>3 (0.7) | n = 133<br>0 (0.0) |

Notes. [a] Could include: respiratory events, including reintubation, pneumonia, prolonged ventilation (>48 hours), emergent tracheotomy, or pulmonary edema; cardiovascular events, including cardiac arrest, myocardial infarction, cerebrovascular accident, or pulmonary embolism; and other complications, including hemorrhage greater than 4 units of packed erythrocytes, coma, wound infection.
Abbreviations. SAE: serious adverse event; UPPP: uvulopalatopharyngoplasty; VA-NSQIP: Veterans Affairs Surgical Quality Improvement Program.

## OSA Severity

Five studies (2 moderate RoB RCTs[43,46] and 3 high RoB RCTs[48,51,52]) assessed OSA severity outcomes as measured by select polysomnography indices, specifically AHI, RDI, and ODI (Table 8).

- No studies reported on REI.
- Additional information is available in Appendix D, Table D6.

TABLE 8. COMPARATIVE OSA SEVERITY OUTCOMES

| AUTHOR, YEAR<br>STUDY NAME<br>SAMPLE SIZE | STUDY DESIGN<br>SURGERY TYPE<br>CONTROL | TIME POINT | MEASURE | SURGERY VS. NO SURGERY<br>BETWEEN-GROUP ESTIMATE | *P* VALUE |
|---|---|---|---|---|---|
| APNEA-HYPOPNEA INDEX (EVENTS PER HOUR; LOWER SCORES ARE BETTER; MCID ≥ 5 EVENTS PER HOUR)[59] | | | | | |
| **AHI3** | | | | | |
| Browaldh, 2013[43]<br>SKUP3 Trial<br>N = 71 | RCT<br>■ UPPP and tonsillectomy<br>■ Waitlist[a] | 6 mos | Mean | 21.1 vs. 46.8<br>MD, −26 (95% CI, −37 to −16) | *P* < .001[b] |
| MacKay, 2020[46]<br>SAMS Trial<br>N = 102 | RCT<br>■ mUPPP and minimally invasive tongue volume reduction<br>■ Ongoing medical management[c] | 6 mos | Mean | 20.8 vs. 34.5 | NR |
| | | | Change from baseline | −27.4 vs. −9.8<br>MD, −17.6 (95% CI, −26.8 to −8.4) | *P* < .001 |

| AUTHOR, YEAR<br>STUDY NAME<br>SAMPLE SIZE | STUDY DESIGN<br>SURGERY TYPE<br>CONTROL | TIME POINT | MEASURE | SURGERY VS. NO SURGERY BETWEEN-GROUP ESTIMATE | *P* VALUE |
|---|---|---|---|---|---|
| Vicini, 2020[52]<br>N = 50 | RCT<br>■ Barbed repositioning pharyngoplasty with tonsillectomy<br>■ Waitlist[d] | 6 mos | Mean | 9.8 vs. 31.9 | NR |
| | | | Change from baseline | −15.8 vs. −5 | *P* = .01 |
| **AHI4** | | | | | |
| Sommer, 2016[48]<br>N = 42 | RCT<br>■ UPPP and tonsillectomy<br>■ Waitlist[a] | 3 mos | Mean | 15.4 vs. 28.6 | NR |
| | | | Change from baseline | −18.4 vs. −7.2<br>MD, −12.8 (95% CI, −18 to −7.5) | *P* = .036 |
| **NR** | | | | | |
| Vicini, 2010[51]<br>N = 50 | RCT<br>■ MMA<br>■ APAP | 12 mos | Mean | 8.1 vs. 6.3 | NR |
| | | | Change from baseline | NR | *P* = .21 |
| **OXYGEN DESATURATION INDEX (EVENTS PER HOUR; LOWER SCORES ARE BETTER; MCID ≥ 5 EVENTS PER HOUR)[59]** | | | | | |
| **ODI3** | | | | | |
| Browaldh, 2013[43]<br>SKUP3 Trial<br>N = 71 | RCT<br>■ UPPP and tonsillectomy<br>■ Waitlist[a] | 6 mos | Mean | 14.0 vs. 35.6<br>MD, −25 (95% CI, −36 to −15) | *P* < .001[b] |
| MacKay, 2020[46]<br>SAMS Trial<br>N = 102 | RCT<br>■ mUPPP and minimally invasive tongue volume reduction<br>■ Ongoing medical management[c] | 6 mos | Mean | 11.4 vs. 21.6 | NR |
| | | | Change from baseline | −17.7 vs. −4.2<br>MD, −13.5 (95% CI −20.0 to −7.1) | *P* = .001 |
| Vicini, 2020[52]<br>N = 50 | RCT<br>■ Barbed repositioning pharyngoplasty with tonsillectomy<br>■ Waitlist[d] | 6 mos | Mean | 9.3 vs. 32.4 | NR |
| | | | Change from baseline | −15.1 vs. −2.8 | *P* = .01 |
| **ODI4** | | | | | |

| AUTHOR, YEAR<br>STUDY NAME<br>SAMPLE SIZE | STUDY DESIGN<br>SURGERY TYPE<br>CONTROL | TIME POINT | MEASURE | SURGERY VS. NO SURGERY BETWEEN-GROUP ESTIMATE | *P* VALUE |
|---|---|---|---|---|---|
| MacKay, 2020[46]<br>SAMS Trial<br>N = 102 | RCT<br>■ mUPPP and minimally invasive tongue volume reduction<br>■ Ongoing medical management[c] | 6 mos | Mean | 8.1 vs. 15.9 | NR |
| | | | Change from baseline | −15.3 vs. −4.3<br>MD, −11.0 (95% CI, −17.2 to −4.7) | *P* = .003 |
| **RESPIRATORY DISTURBANCE INDEX (EVENTS PER HOUR; LOWER SCORES ARE BETTER; MCID ≥ 5 EVENTS PER HOUR)[62]** | | | | | |
| Browaldh, 2013[43]<br>SKUP3 Trial<br>N = 71 | RCT<br>■ UPPP and tonsillectomy<br>■ Waitlist[a] | 6 mos | Mean | 25.8 vs. 50.1<br>MD, −25 (95% CI, −36 to −15) | *P* < .001[b] |
| Sommer, 2016[48]<br>N = 42 | RCT<br>■ UPPP and tonsillectomy<br>■ Waitlist[a] | 3 mos | Mean | 21.8 vs. 28.7 | NR |
| | | | Change from baseline | −12.5 vs. −8.1<br>MD, −10.3 (95% CI, −18 to −2.8) | *P* = .27 |

Notes. [a] No treatment at all. [b] ITT analysis did not change the results of this per protocol analysis. [c] This included a range of evidence-based treatments as appropriate (e.g., weight loss, alcohol reduction, sleep posture modification, medical management of nasal obstruction) and assistance with retrial of CPAP or mandibular advancement device therapies if participants were willing. However, there was low uptake of MAD or CPAP (only n = 8 participants in total) as well as minimal weight loss in either study group or change in health behaviors. [d] Not specified by the study authors if other treatment for OSA was permitted.

Abbreviations. AHI: Apnea-Hypopnea Index; AHI4: AHI with 4% blood oxygen desaturation threshold for hypopneas; AHI3: AHI with 3% blood oxygen desaturation threshold for hypopneas; CI: confidence interval; CPAP: continuous positive airway pressure; ITT: intention to treat; MAD: mandibular advancement device; MCID: minimum clinically meaningful difference; MD: mean difference; mos: months; mUPPP: modified UPPP; NR: not reported; ODI4: oxygen desaturation of 4%; ODI3: oxygen desaturation of 3%; OSA: obstructive sleep apnea; RCT: randomized controlled trial; UPPP: uvulopalatopharyngoplasty.

## Daytime Sleepiness

Six studies (2 moderate RoB RCTs,[43,46] 3 high RoB RCTs,[48,51,52] and 1 high RoB comparative cohort study[47]) reported eligible daytime sleepiness outcomes.

- All studies reported on daytime sleepiness outcomes using the validated Epworth Sleepiness Scale (ESS) (Table 9).[43,46-48,51,52]
- Additional information is available in Appendix D, Table D7.

TABLE 9. COMPARATIVE DAYTIME SLEEPINESS OUTCOMES

| AUTHOR, YEAR<br>STUDY NAME<br>SAMPLE SIZE | STUDY DESIGN<br>SURGERY TYPE<br>CONTROL | TIME POINT | MEASURE | SURGERY VS. NO SURGERY BETWEEN-GROUP ESTIMATE | *P* VALUE |
|---|---|---|---|---|---|
| **EPWORTH SLEEPINESS SCALE (SCORE RANGE, 0–24 POINTS; LOWER SCORES ARE BETTER; MCID ≥ 2 POINTS)[59,63]** | | | | | |
| Browaldh, 2013[43]<br>SKUP3 Trial<br>N = 71 | RCT<br>■ UPPP and tonsillectomy<br>■ Waitlist[a] | 6 mos | Mean | 6.8 vs. 12.5 | NR |
| | | | Change from baseline | −5.7 vs. NR | *P* < .001[b] |
| MacKay, 2020[46]<br>SAMS Trial<br>N = 102 | RCT<br>■ mUPPP and minimally invasive tongue volume reduction<br>■ Ongoing medical management[c] | 6 mos | Mean | 5.3 vs. 10.5 | NR |
| | | | Change from baseline | −7.2 vs. −0.5<br>MD, −6.7 (95% CI, −8.2 to −5.2) | *P* < .001 |
| Robinson, 2009[47]<br>N = 166 | Comparative cohort<br>■ Multilevel, multistage surgery[d]<br>■ CPAP | ~4 yrs | Median | 4.0 vs. 4.0 | *P* = .78 |
| Sommer, 2016[48]<br>N = 42 | RCT<br>■ UPPP and tonsillectomy<br>■ Waitlist[a] | 3 mos | Mean | 6.2 vs. 9.6 | NR |
| | | | Change from baseline | −4.4 vs. −0.6<br>MD, −2.5 (95% CI, −3.9 to −1.1) | *P* = .01 |
| Vicini, 2010[51]<br>N = 50 | RCT<br>■ MMA<br>■ APAP | 12 mos | Mean | 7.7 vs. 5.9 | NR |
| | | | Change from baseline | NR | *P* = .20 |
| Vicini, 2020[52]<br>N = 50 | RCT<br>■ Barbed repositioning pharyngoplasty with tonsillectomy<br>■ Waitlist[e] | 6 mos | Mean | 3.8 vs. 10.9 | NR |
| | | | Change from baseline | −5.5 vs. +0.4 | *P* = .00 |

Notes. [a] No treatment at all. [b] ITT analysis did not change the results of this per protocol analysis. [c] This included a range of evidence-based treatments as appropriate (e.g., weight loss, alcohol reduction, sleep posture modification, medical management of nasal obstruction) and

assistance with retrial of CPAP or mandibular advancement device therapies if participants were willing. However, there was low uptake of MAD or CPAP (only n = 8 participants in total) as well as minimal weight loss in either study group or change in health behaviors. [d] UPPP with or without tonsillectomy (100%), geniotubercle advancement (88%); if failure: palatal advancement (67%), hyoid suspension (66%); if failure: midline radiofrequency ablation of the tongue (41%) or submucosal glossectomy techniques (12.5%). [e] Not specified by the study authors if other treatment for OSA was permitted.

Abbreviations. APAP: auto-titrating positive airway pressure; CI: confidence interval; CPAP: continuous positive airway pressure; ITT: intention to treat; MAD: mandibular advancement device; MCID: minimum clinically meaningful difference; MD: mean difference; MMA: maxillomandibular advancement; mos: months; mUPPP: modified UPPP; NR: not reported; OSA: obstructive sleep apnea; RCT: randomized controlled trial; UPPP: uvulopalatopharyngoplasty; yrs: years.

### Major Adverse Cardiac Events

No eligible studies reported comparative MACE outcomes.

## Review Summary and Limitations

We identified 13 eligible studies[41-53] that assessed the effectiveness and harms of surgery for adults with moderate to severe OSA. Please refer to the GRADE Table for a summary of the evidence and Appendix B for additional details on the limitations that influenced GRADE ratings.

## Contextual Questions

### CQ1. Key Clinical Endpoints from SRs of Surgical Airway Interventions for OSA

We identified 3 systematic reviews of OSA surgery that examined mortality, cerebrovascular disease (stroke or transient ischemic attack), and cardiac arrhythmia outcomes.[49,64,65] Systematic reviews only reported relevant data for UPPP.[49,64,65] For mortality, the 3 systematic reviews found inconsistent results, with some included studies finding a significant difference in mortality between UPPP and comparators and other included studies finding no significant difference.[49,64,65] The most recent included cohort study in the systematic reviews found that, compared with CPAP alone, UPPP was associated with lower mortality among US veterans.[66] For cerebrovascular disease, 1 systematic review included a cohort study finding a reduced risk of cerebrovascular disease with UPPP, compared with no intervention.[64] For cardiac arrhythmia, 1 systematic review included a study that did not find a difference in cardiac arrhythmias.[64]

### CQ2. Comparative Effectiveness of Surgical Airway Interventions for OSA

We identified 5 RCTs that compared the effectiveness of different OSA surgeries, including UPPP and UPPP variants (Table 10).[67-71] Studies of UPPP and UPPP variants typically found similar results between intervention and comparison arms, with the exception that expansion sphincter pharyngoplasty had improved AHI, compared with UPPP.[67]

TABLE 10. RANDOMIZED CONTROLLED TRIALS COMPARING THE EFFECTIVENESS OF DIFFERENT OSA SURGERIES

| STUDY AUTHOR (YEAR)<br>LOCATION<br>TOTAL N | INTERVENTION<br>N | COMPARISON<br>N | QOL | SAE | AHI | ESS |
|---|---|---|---|---|---|---|
| Pang (2007)[67]<br>Singapore<br>45 | Expansion sphincter pharyngoplasty<br>23 | UPPP<br>22 | – | None | Improved[a] | – |
| Fernandez-Julian (2009)[68]<br>Spain<br>57 | UPPP + tongue base radiofrequency<br>29 | UPPP + tongue base suspension<br>28 | – | 2[b] | NS | NS |
| Shin (2009)[69]<br>South Korea<br>32 | mUPPP[c]<br>16 | Classic UPPP<br>16 | – | – | NS | NS |
| Neruntarat (2010)[70]<br>Thailand<br>51 | Palatal suspension<br>25 | UPPP<br>26 | – | None | NS | NS |
| Sundman (2022)[71]<br>Sweden<br>93 | Tonsillectomy alone<br>46 | mUPPP<br>47 | – | – | Improved[a] | NS |

Table Key. A hyphen indicates the outcome was not reported in the study.
Notes. [a] The improvement in AHI with the intervention surgery versus the comparison surgery was statistically significant and met the established minimal clinically important difference (≥ 5 events per hour). [b] N = 2 participants developed submandibular sialadenitis requiring antibiotics. [c] Modified to preserve uvula mucosa and partial resection of the musculus uvula.
Abbreviations. AHI: apnea-hypopnea index; ESS: Epworth sleepiness scale; mUPPP: modified UPPP; NS: not statistically significant; QoL: quality of life; UPPP: uvulopalatopharyngoplasty.

### CQ3. Cost-Effectiveness of Surgical Airway Interventions for OSA

We prepared this section in compliance with Senate Bill 1508 of the 2024 Oregon legislative session, effective January 1, 2025.[72] As such, we did not consider any measures of cost-effectiveness based on or derived from quality adjusted life years (QALY).[72] We did not identify any US-based cost-effectiveness studies that included measures of cost-effectiveness other than QALY or QALY-derived measures.

## Ongoing Studies

We did not identify any ongoing studies that met eligibility criteria based on searches of the ClinicalTrials.gov registry conducted in September 2024.

# POLICY LANDSCAPE

**In the following section, we summarize evidence-based clinical guildelines about surgeries for OSA from professional societies and governmental health agencies and report on payer policies from select public and private organizations.**

In this section, we summarize policies with guidance on surgery for OSA. For this evidence review, we identified 6 relevant clinical guidelines[73-78] and 2 relevant position statements.[79,80] Payer coverage policies from 6 relevant payers are also summarized.[81-86]

## Evidence-Based Recommendations

### Clinical Guidelines with Recommendations on Surgery for the Treatment of OSA

We identified 6 clinical guidelines from 6 distinct professional organizations (see methods in Appendix C).[73-78]

- Guidelines from the Department of Veterans Affairs and the Department of Defense (VA/DoD),[74] the National Institute for Health and Care Excellence (NICE),[77] and the American Academy of Sleep Medicine (AASM)[76] had good methodological quality.
- The updated guideline from the German Sleep Society (GSS) had fair methodological quality.[78] Concerns included lack of clarity regarding potential connections between the recommendations and supporting evidence.[78]
- Guidelines from the European Respiratory Society (ERS)[75] and the Japanese Respiratory Society (JRS)[73] had fair methodological quality; concerns were guideline author conflicts of interest.

The identified guidelines typically included various recommendations pertaining to the diagnosis and assessment of OSA, as well as treatment and management of OSA. Treatment recommendations were for PAP, oral appliances, and various surgeries (including oropharyngeal and skeletal).[73-78] Clinical guideline recommendations are summarized here and in Table 11.

Soft tissue surgeries:

- 2 guidelines included characteristics of patients with OSA who may be candidates for referral for soft-tissue procedures (including tonsillectomy, UPPP, and oropharyngeal [palatal] surgery)[77,78]
- 1 guideline indicated otorhinolaryngological surgery (including but not limited to UPPP) is not recommended for OSA, related to a lack of published reports on the side effects of otorhinolaryngological surgery[73]
- 1 task force omitted soft-tissue surgery from the guideline, citing limited new evidence[75]

Skeletal surgeries:

- 3 guidelines included characteristics of patients with OSA who may be candidates for referral for MMA[73,74,78]
- 1 guideline indicated that *either* MMA or CPAP could be recommended, noting the differential benefits between MMA and CPAP were "trivial"[75]

- 1 guideline included skeletal surgery (e.g., MMA or mandibular osteotomy) in the evidence review; however, the committee did *not* make skeletal framework surgery recommendations, citing a lack of sufficient evidence[77]

A sixth guideline did *not* include an evaluation of specific soft tissue or skeletal surgeries, and was only on characteristics of patients with OSA who may be candidates for referral to a sleep surgeon.[76]

TABLE 11. CLINICAL GUIDELINES WITH RECOMMENDATIONS ON SURGERY FOR OSA

| VA/DOD[74] 2019 | | NICE[77] 2021 | GSS[78] 2022 | ERS[75] 2021 | JRS[73] 2020 | AASM[76] 2021 |
|---|---|---|---|---|---|---|
| Methodological Quality[a] | Good | Good | Fair | Fair | Fair | Good |
| Soft Tissue Surgeries (including UPPP and Tonsillectomy) | [Outside VA/DoD review scope][b] | ✓ Consider referral for assessment for **oropharyngeal (palatal) surgery** in people with severe OSAHS who have been unable to tolerate CPAP and a customized MAS<br>✓ Consider **tonsillectomy** for people with OSAHS who have large obstructive tonsils and a BMI of less than 35 kg/m$^2$ | ✓ In the case of oropharyngeal obstruction due to tonsillar hyperplasia, **tonsillectomy with UPPP** should be considered, particularly if other treatments (CPAP, MAD) are not possible or not sufficiently tolerated | [The ERS task force omitted soft-tissue surgery from the guideline, citing limited new evidence] | **X Otorhino-laryngological surgery** (including but not limited to **UPPP**) is not recommended as a treatment for OSA | Discuss referral to a sleep surgeon with adults with OSA and BMI < 40 kg/m$^2$ who are intolerant or unaccepting of PAP (strong recommend-ation) or have persistent inadequate PAP adherence (conditional recommend-ation)[a] |
| Skeletal Surgeries (including MMA) | ✓ Evaluate patients with severe OSA, who cannot tolerate or are not appropriate candidates for other recommended therapies, for | [The NICE committee did not make skeletal framework surgery recommendations, citing a lack of sufficient evidence] | ✓ If anatomical findings are appropriate (i.e., small mandible and narrow craniofacial structure), **MMA** should be considered, particularly if | ✓ Conditional recommend-dation for ***either* MMA or CPAP** (based on very low quality evidence)[a] | ✓ **MMA** is recommended as a treatment for OSA; (Weak for based on very low quality evidence) | |

| VA/DOD[74] 2019 | | NICE[77] 2021 | GSS[78] 2022 | ERS[75] 2021 | JRS[73] 2020 | AASM[76] 2021 |
|---|---|---|---|---|---|---|
| | alternative treatment with **MMA**; (Weak for based on very low quality evidence)[a] | | other treatments (CPAP, MAD) are not possible or not sufficiently tolerated | | | |

Table Key. A check (✓) generally indicates the guideline provided a relevant recommendation pertaining to a specific procedure. An X (X) indicates the guideline explicitly does not recommend a specific procedure as a treatment for OSA.
Notes. [a] The strength of the recommendation was evaluated using GRADE. [b] VA/DoD made a recommendation pertaining to nasal surgery.
Abbreviations. AASM: American Academy of Sleep Medicine; BMI: body mass index; CPAP: continuous positive airway pressure; ERS: European Respiratory Society; GRADE: Grading of Recommendations, Assessment, Development, and Evaluations; GSS: German Sleep Society; JRS: Japanese Respiratory Society; MAD: mandibular advancement device; MAS: mandibular advancement splint; MMA: maxillomandibular advancement; NICE: National Institute for Health and Care Excellence; OSA: obstructive sleep apnea; OSAHS: obstructive sleep apnea-hypopnea syndrome; UPPP: uvulopalatopharyngoplasty; VA/DoD: Department of Veterans Affairs and the Department of Defense.

## Position Statements on Surgery for the Treatment of OSA

### American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNS)

The position of the AAO-HNS is[79]:

- Surgical management should be considered in the management of adult patients with OSA, including for those who have failed PAP or MAD and as an adjunctive therapy to improve adherence to PAP or MAD.

As of 2021, relevant surgeries that the AAO-HNS considers effective and *not* investigational include the following[79]:

- UPPP
- Tonsillectomy (of the lingual or palatine tonsils)
- Palatal Advancement
- Tongue Suspension
- Hyoid Myotomy/Suspension
- Supraglottoplasty
- Maxillary and Mandibular Advancement
- Genioglossus Advancement

In a supplemental 2021 position statement, the AAO-HNS indicated that submucosal radiofrequency tongue base ablation can successfully treat adults with mild to severe OSA and noted the majority of studies demonstrating effectiveness were done on individuals with mild to moderate OSA.[87]

In an another supplemental 2021 position statement, the AAO-HNS indicated that midline partial glossectomy is an effective surgical modality for the treatment of select adult patients with mild to severe OSA and noted midline partial glossectomy can be performed either as a stand-alone procedure or as part of multilevel pharyngeal surgery.[88]

### Australasian Sleep Association (ASA)

The 2020 position of the ASA is[80]:

- Surgery has a key role in contemporary management of adult patients with OSA, particularly as a salvage modality and for patients who are unable to adhere to or tolerate CPAP or MAD; surgery may be used adjunctively with devices, including facilitating a return to device use.

ASA surgical algorithms, as guidance for practicing sleep surgeons in Australasia, include the following relevant interventions[80]:

- Modified variant UPPP
- Tonsillectomy (of the lingual tonsils)
- Transpalatal Advancement
- Radiofrequency Tongue Ablation/Reduction

## Payer Coverage Policies

We summarized policies related to coverage of surgeries for OSA selected from Washington State Health Care Authority (HCA), Medicare, Aetna, Cigna, Moda, and Regence.[81-86,89] As indicated in Table 12, the payers cover select OSA surgeries in members who meet specified coverage criteria.[81-86,89]

Consistent policies among public and private payers included the following:

- All payers described UPPP as potentially covered or medically necessary.[81-86,89]
- 3 of the payers (including Washington HCA and Medicare) indicated tonsil surgery alone (separate from other surgeries, such as UPPP) is potentially covered or medically necessary; most policies specified documentation of enlarged or hypertrophied tonsils is required.[83,84,86]
- All payer policies indicate select jaw surgeries are potentially covered or medically necessary, with 2 payers indicating procedures are subject to additional review. [81,83-86,89]
- All payers indicated palatal advancement is *not* covered due to being experimental, investigational, or unproven (or the policies did not mention palatal advancement).[81-86]
- All payers indicated radiofrequency ablation is *not* covered due to being experimental, investigational, or unproven.[81-86]

TABLE 12. RELEVANT SURGERIES FOR OSA THAT PAYERS DESCRIBE AS EITHER COVERED OR EXPERIMENTAL, INVESTIGATIONAL, OR UNPROVEN

| | WASHINGTON STATE HCA[84] (2012) | MEDICARE (LCD 34526)[86] (2023) | AETNA[83] (2024) | CIGNA[81] (2024) | MODA[82,89] (2023) | REGENCE[85] (2024) |
|---|---|---|---|---|---|---|
| **UPPER PHARYNX** | | | | | | |
| UPPP | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Tonsillectomy (alone) | ✓ | ✓ | ✓ | | X | |
| Palatal Advancement | | | X | X | X | |
| Radiofrequency Ablation[a] | X | X | X | X | X | X |
| **LOWER PHARYNX** | | | | | | |
| Tongue Reduction | ✓ | ✓ | ✓ | | | ✓ |
| Tongue Suspension | | | X | X | X | X |
| Hyoid Myotomy/ Suspension | ✓ | ✓ | ✓[b] | ✓ | | ✓ |
| Radiofrequency Ablation[a] | X | X | X | X | X | X |
| **LARYNX** | | | | | | |
| Supraglottoplasty | | | | X | | |
| **JAW, TONGUE, AND HYOID** | | | | | | |
| Genioglossus Advancement | ✓ | ✓ | ✓[b] | ✓ | ✓[c] | ✓ |

| | WASHINGTON STATE HCA[84] (2012) | MEDICARE (LCD 34526)[86] (2023) | AETNA[83] (2024) | CIGNA[81] (2024) | MODA[82,89] (2023) | REGENCE[85] (2024) |
|---|---|---|---|---|---|---|
| Mandibular Maxillary Osteotomy and Advancement | ✓ | ✓ | | ✓ | ✓[d] | ✓ |
| Mandibular Osteotomy | | | ✓[b] | | ✓[d] | ✓ |

Table Key. A check (✓) indicates the payer policy explicitly describes the procedure as covered or medically necessary in select members who meet coverage criteria. An X (X) indicates the payer policy explicitly describes the procedure as experimental, investigational, or unproven. A blank space generally indicates that coverage of the individual procedure (or lack of coverage) was not explicitly provided in the payer policy.

Notes. [a] Relevant radiofrequency ablation procedures include treatment of the soft palate, the uvula, or the tongue. [b] Procedures may be subject to review by Aetna's Oral and Maxillofacial Surgery Unit to assess medical necessity.[83] [c] Per the Moda procedures and services document, genioplasty may be included as part of orthognathic surgery.[89] [d] A relevant Moda procedures and services document noted that maxillomandibular osteotomy and advancement or mandibular osteotomy may be benefit exclusions or may be covered per Milliman Care Guidelines (MCG).[89]

Abbreviations. HCA: health care authority; LCD: local coverage determination; UPPP: uvulopalatopharyngoplasty.

Detailed public and private payer coverage criteria for a subset of procedures (UPPP, tonsil surgery, and jaw surgery) are summarized in Tables 13, 14, and 15. If specified by the payer, the following information is included in the tables:

- AHI, RDI, or REI criteria
- CPAP, AutoPap, or PAP criteria related to failed response, inadequate response, intolerance, or unwillingness to use the therapy
- Concomitant medical conditions (such as hypertension, ischemic heart disease, congestive heart failure [CHF], impaired cognition, mood disorders, insomnia, excessive daytime sleepiness, atrial fibrillation, or obesity) or history of stroke
- Documentation of the source of airway obstruction
- Previous failure of UPPP to correct the OSA
- Previous failure of a mandibular repositioning appliance or a tongue-retaining appliance

TABLE 13. UPPP AND RELATED SURGERIES FOR OSA PAYER COVERAGE CRITERIA

| | WASHINGTON STATE HCA[84] | MEDICARE (LCD 34526)[86] | AETNA[83] | CIGNA[81] | MODA[82] | REGENCE[85] |
|---|---|---|---|---|---|---|
| Potentially Covered or Medically Necessary | ■ UPPP[a] | ■ UPPP[a] | ■ UPPP[a]<br>■ Uvulopharyngo-plasty<br>■ Uvulopalatal flap<br>■ Expansion pharyngoplasty<br>■ Lateral pharyngoplasty<br>■ Transpalatal advancement pharyngoplasty<br>■ Relocation pharyngoplasty | ■ UPPP[a] | ■ UPPP[a] | ■ UPPP[a]<br>■ Uvulopharyngo-plasty |
| AHI, RDI, or REI Criteria | ■ RDI ≥ 15 events per hour | ■ RDI ≥ 15 events per hour | ■ AHI or RDI ≥ 15 events per hour with a minimum of 30 events<br>■ Or AHI or RDI ≥5 and less than 15 events per hour with a minimum of 10 events and at least 1 of the following:<br>■ History of stroke<br>■ Hypertension | ■ AHI > 15 events per hour | ■ AHI ≥ 15 events per hour<br>■ Or AHI 5 to 14 events per hour and at least 1 of the following:<br>■ History of stroke<br>■ Hypertension<br>■ Ischemic heart disease<br>■ Impaired cognition<br>■ Mood disorders<br>■ Insomnia | ■ AHI ≥ 15 events per hour<br>■ Or AHI > 5 events per hour and at least 1 of the following:<br>■ History of stroke<br>■ Hypertension<br>■ Ischemic heart disease or CHF<br>■ Excessive daytime sleepiness<br>■ Atrial fibrillation<br>■ Obesity |

| | WASHINGTON STATE HCA[84] | MEDICARE (LCD 34526)[86] | AETNA[83] | CIGNA[81] | MODA[82] | REGENCE[85] |
|---|---|---|---|---|---|---|
| | | | ■ Ischemic heart disease<br>■ Impaired cognition<br>■ Mood disorders<br>■ Insomnia<br>■ Excessive daytime sleepiness<br>■ Greater than 20 episodes of oxygen desaturation during a full night sleep study, or any 1 episode of oxygen desaturation | | ■ Excessive daytime sleepiness | ■ Diabetes and glucose intolerance |
| CPAP, AutoPap, or PAP Criteria | ■ Failed to respond to CPAP or cannot tolerate CPAP | ■ Failed to respond to CPAP or cannot tolerate CPAP | ■ Had an inadequate response or are intolerant to CPAP or AutoPAP | ■ Failed to respond to PAP or cannot tolerate PAP or unwillingness to use PAP | ■ Adequate response to CPAP therapy but unable to tolerate CPAP device | ■ Failed PAP usage or not an appropriate PAP candidate |
| Documented Source of Airway Obstruction (if specified) | ■ Retropalatal or combination retropalatal/ retrolingual obstruction | ■ Retropalatal or combination retropalatal/ retrolingual obstruction | | ■ Narrowing or collapse of the retropalatal region (e.g., soft palate, | ■ Narrowing or collapse of the retropalatal region | ■ Upper airway collapse or obstruction (e.g., palatine tonsils, epiglottis |

| | WASHINGTON STATE HCA[84] | MEDICARE (LCD 34526)[86] | AETNA[83] | CIGNA[81] | MODA[82] | REGENCE[85] |
|---|---|---|---|---|---|---|
| | | | | uvula, tonsils, posterior pharyngeal wall) | | collapse, arytenoid collapse, lateral pharyngeal, craniofacial deficits) |
| Additional Criteria (if specified) | | | | | | ■ An adequate trial of a custom-made mandibular repositioning appliance has failed or the patient is not an appropriate mandibular repositioning appliance candidate |

Note. [a] UPPP usually involves removal of all or part of the palatine tonsils.
Abbreviations. AHI: apnea hypopnea index; AutoPap: automatic positive airway pressure; CHF: congestive heart failure; CPAP: continuous positive airway pressure; HCA: health care authority; PAP: positive airway pressure; RDI: respiratory disturbance index; REI: respiratory event index; UPPP: uvulopalatopharyngoplasty.

TABLE 14. TONSIL SURGERY FOR OSA PAYER COVERAGE CRITERIA

| | WASHINGTON STATE HCA[84] | MEDICARE (LCD 34526)[86] | AETNA[83] | CIGNA[81] | MODA[82] | REGENCE[85] |
|---|---|---|---|---|---|---|
| Potentially Covered or Medically Necessary | ■ Surgery to correct enlarged tonsils | ■ Surgery to correct enlarged tonsils | ■ Lingual tonsillectomy<br>■ Pharyngeal tonsillectomy | ■ Not covered (the policy does not describe tonsillectomy alone) | ■ Not covered (the policy describes lingual tonsillectomy and pharyngeal tonsillectomy as experimental and investigational for OSA) | ■ Not covered (the policy does not describe tonsillectomy alone) |
| Documented Source of Airway Obstruction (if specified) | ■ Enlarged tonsils | ■ Enlarged tonsils | ■ Hypertrophied tonsils comprising the airway space | ■ NA (not covered) | ■ NA (not covered) | ■ NA (not covered) |

Note. This table summarizes criteria for tonsil surgery that is separate from other surgeries (i.e., UPPP).

Abbreviation. HCA: health care authority; LCD: local coverage determination; NA: not applicable; OSA: obstructive sleep apnea; UPPP: uvulopalatopharyngoplasty

TABLE 15. JAW, TONGUE, AND HYOID SURGERY FOR OSA PAYER COVERAGE CRITERIA

| | WASHINGTON STATE HCA[84] | MEDICARE[86] | AETNA[83] | CIGNA[81] | MODA[89] | REGENCE[85] |
|---|---|---|---|---|---|---|
| Potentially Covered or Medically Necessary | ■ Mandibular maxillary osteotomy and advancement and/or genioglossus advancement with or without hyoid suspension | ■ Mandibular maxillary osteotomy and advancement and/or genioglossus advancement with or without hyoid suspension | ■ Jaw realignment surgery (i.e., mandibular osteotomy, genioglossus advancement, hyoid myotomy and suspension[a] | ■ Mandibular maxillary osteotomy and advancement (as a combined procedure or as stepwise multiple procedures)<br>■ Maxillomandibular advancement<br>■ Genioglossus advancement and hyoid myotomy | ■ Maxillomandibular osteotomy and advancement[b]<br>■ Mandibular osteotomy[b]<br>■ Genioplasty[c] | ■ Mandibular osteotomy with or without genioglossus advancement<br>■ Maxillomandibular advancement<br>■ Hyoid myotomy and suspension |
| AHI, RDI, or REI Criteria (if specified) | ■ RDI > 15 events per hour | ■ RDI > 15 events per hour | | ■ AHI > 15 events per hour | | ■ AHI > 15 events per hour<br>■ Or AHI > 5 events per hour and at least 1 of the following:<br>■ History of stroke<br>■ Hypertension<br>■ Ischemic heart disease or CHF<br>■ Excessive daytime sleepiness<br>■ Atrial fibrillation<br>■ Obesity<br>■ Diabetes and glucose intolerance |

| | WASHINGTON STATE HCA[84] | MEDICARE[86] | AETNA[83] | CIGNA[81] | MODA[89] | REGENCE[85] |
|---|---|---|---|---|---|---|
| CPAP or PAP Criteria (if specified) | ■ Failed to respond to CPAP or cannot tolerate CPAP | ■ Failed to respond to CPAP or cannot tolerate CPAP | | ■ Failed to respond to PAP or cannot tolerate PAP or unwillingness to use PAP | | ■ Failed PAP usage or not an appropriate PAP candidate |
| Documented Source of Airway Obstruction (if specified) | ■ Evidence of retrolingual obstruction as the cause of the OSA (or previous failure of UPPP to correct the OSA) | ■ Evidence of retrolingual obstruction as the cause of the OSA (or previous failure of UPPP to correct the OSA) | | | | ■ Upper airway collapse or obstruction (e.g., palatine tonsils, epiglottis collapse, arytenoid collapse, lateral pharyngeal, craniofacial deficits) |
| Additional Criteria (if specified) | | | | ■ A mandibular repositioning appliance or tongue-retaining appliance has been considered and found to be ineffective or undesirable<br>■ Additional criteria for maxillomandib-ular advancement: craniofacial disproportion or deformities | | ■ An adequate trial of a custom-made mandibular repositioning appliance failed or the patient is not an appropriate mandibular repositioning appliance candidate |

Notes. [a]Jaw realignment surgery may be subject to review by Aetna's Oral and Maxillofacial Surgery Unit to assess medical necessity.[83] [b]A relevant Moda procedures and services document noted that maxillomandibular osteotomy and advancement or mandibular osteotomy may be benefit exclusions or may be covered per Milliman Care Guidelines (MCG).[89] [c]Per Moda, genioplasty may be included as part of orthognathic surgery.[89]
Abbreviations. AHI: apnea hypopnea index; CHF: congestive heart failure; CPAP: continuous positive airway pressure; HCA: health care authority; OSA: obstructive sleep apnea; PAP: positive airway pressure; RDI: respiratory disturbance index; REI: respiratory event index; UPPP: uvulopalatopharyngoplasty.

Pertaining to drug-induced sleep endoscopy (DISE), only 1 of the 6 payers indicated DISE may be required when evaluating a patient for upper airway surgery:

- The Cigna policy described DISE as medically necessary for the evaluation of upper airway surgery in an adult with persistent OSA defined as *both* (1) documentation that demonstrates PAP treatment failure, *and* (2) a mandibular repositioning appliance (MRA) or tongue-retaining appliance has been considered and found to be ineffective or undesirable.[81]
- The Aetna policy described DISE as experimental, investigational, or unproven for all indications other than evaluation for hypoglossal nerve stimulation.[83]
- 1 payer (Moda) mentioned DISE in the relevant policy but only in the context of evaluation for hypoglossal nerve stimulation.[82]
- 3 payers (Washington HCA, Medicare, and Regence) did not mention DISE in their policy.[84-86]

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# APPENDIX A. GRADE TABLE ELEMENT DESCRIPTIONS

TABLE A1. GRADE TABLE ELEMENTS

| ELEMENT | DESCRIPTION |
|---|---|
| Balance of benefits and harms | The larger the difference between the desirable and undesirable effects, the higher the likelihood that a strong recommendation is warranted. An estimate that is not statistically significant or has a confidence interval crossing a predetermined clinical decision threshold will be downgraded. |
| Quality of evidence | The higher the quality of evidence, the higher the likelihood that a strong recommendation is warranted. |
| Resource allocation | The higher the costs of an intervention—that is, the greater the resources consumed in the absence of likely cost offsets—the lower the likelihood that a strong recommendation is warranted. |
| Values and preferences | The more values and preferences vary, or the greater the uncertainty in values and preferences, the higher the likelihood that a weak recommendation is warranted. |
| Other considerations | Other considerations include issues about the implementation and operationalization of the technology or intervention in health systems and practices within Oregon. |

Abbreviation. GRADE: Grading of Recommendations, Assessment, Development, and Evaluations approach.

## Confidence in Estimate Rating Across Studies for the Intervention and Outcome

Assessment of confidence in estimate includes factors such as risk of bias, precision, directness, consistency, and publication bias.

***High:*** The subcommittee is very confident that the true effect lies close to that of the estimate of the effect. Typical sets of studies are randomized controlled trials (RCTs) with few or no limitations, and the estimate of effect is likely stable.

***Moderate:*** The subcommittee is moderately confident in the estimate of effect: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Typical sets of studies are RCTs with some limitations or well-performed nonrandomized studies with additional strengths that guard against potential bias and have large estimates of effects.

***Low:*** The subcommittee's confidence in the estimate of effect is limited: The true effect may be substantially different from the estimate of the effect. Typical sets of studies are RCTs with serious limitations or nonrandomized studies without special strengths.

***Very low:*** The subcommittee has very little confidence in the estimate of effect: The true effect is likely to be substantially different from the estimate of effect. Typical sets of studies are nonrandomized studies with serious limitations or inconsistent results across studies.

# APPENDIX B. GRADE EVIDENCE PROFILES

TABLE B1. CERTAINTY ASSESSMENT (CONFIDENCE IN ESTIMATE OF EFFECT) FOR SURGERY IN ADULTS WITH MODERATE TO SEVERE OSA

| NO. OF STUDIES SAMPLE SIZE | RISK OF BIAS | INCONSISTENCY | INDIRECTNESS | IMPRECISION | OTHER FACTORS | LEVEL OF CONFIDENCE |
|---|---|---|---|---|---|---|
| **QOL** | | | | | | |
| 3 studies<br>(2 RCTs and 1 comparative cohort study)<br>N = 339 | **Serious**<br>Downgraded 2 levels:<br>■ 2 RCTs rated as moderate RoB, 1 comparative cohort study rated as high RoB<br>■ Unblinded studies are a major concern when outcome measures are patient-reported (downgraded 1 level)<br>Downgraded 1 level:<br>■ It is unclear in the comparative cohort study that used GBI how the study authors adapted the assessment for the nonsurgical group | **Not serious**<br>■ Consistent direction of effect in FOSQ and SF-36 (favoring surgery)<br>■ Inconsistencies can be explained by the nature of the comparison group | **Not serious**<br>■ Study population concerns: (1) mismatch with current OHP definition for AHI (that aligns with the definition used by Medicare), which may result in enrollment of more participants with milder OSA because AHI3 is a more sensitive definition to detect hypopneas, and (2) Lack of demographic generalizability to Oregon Medicaid population with OSA<br>■ Surgical techniques have evolved over time and studied | **Not serious**<br>■ Although sample sizes were small, the studies were generally well powered to detect differences in QoL<br>■ Some imprecision in confidence intervals | ■ Limited long-term data to assess an ongoing intervention (approximately 4 years is the longest follow-up) | LOW<br>●●○○ |

| NO. OF STUDIES SAMPLE SIZE | RISK OF BIAS | INCONSISTENCY | INDIRECTNESS | IMPRECISION | OTHER FACTORS | LEVEL OF CONFIDENCE |
|---|---|---|---|---|---|---|
| | ■ Details on confounding variables in the comparative cohort study were lacking<br>■ Lack of funding information in the cohort study | | procedures, especially in older studies, may not reflect contemporary practice<br>■ Some heterogeneity in time points for assessment (range is 6 months to 4 years) | | | |
| **PROCEDURE-RELATED SAE** | | | | | | |
| 12 studies<br>(5 RCTs, 1 comparative cohort, 2 registry studies, and 4 SRs)<br>N = 15,503 | **Not serious**<br>■ 6 studies rated as moderate RoB, 6 studies rated as high RoB<br>■ Some author COI concerns and limited funding information | **Not serious**<br>■ Generally consistent findings in terms of reported SAEs<br>■ Generally low rates of SAEs<br>■ Inconsistencies can be explained by the nature of the surgery | **Serious**<br>Downgraded 1 level<br>■ Differences in classification of SAEs and inability to differentiate seriousness of adverse events<br>■ Inability to precisely determine population with moderate to severe OSA in some studies<br>■ Surgical techniques have evolved over time and studied procedures, | **Not serious**<br>■ Few events are reported; studies have generally large sample sizes | ■ None | **Moderate**<br>●●●○ |

| NO. OF STUDIES SAMPLE SIZE | RISK OF BIAS | INCONSISTENCY | INDIRECTNESS | IMPRECISION | OTHER FACTORS | LEVEL OF CONFIDENCE |
|---|---|---|---|---|---|---|
| | | | especially in older studies, may not reflect contemporary practice | | | |
| **OSA SEVERITY (POLYSOMNOGRAPHY INDICES)** | | | | | | |
| 5 studies<br>(5 RCTs)<br>N = 315 | **Serious**<br>Downgraded 1 level<br>■ 2 studies rated as moderate RoB, 3 studies rated as high RoB<br>■ Lack of funding information<br>■ Some concerns with author COI<br>■ Lack of ability to blind<br>■ Issues with adequacy of allocation concealment<br>■ Lack of information on randomization or issues with rigor of randomization methods | **Not serious**<br>■ Generally consistent direction and magnitude of effect<br>■ Inconsistencies can be explained by the nature of the comparison group or differences in the polysomno-graphy measure used (AHI3, AHI4, ODI3, OD4, RDI) | **Serious**<br>Downgraded 1 level<br>■ Mismatch in definition of AHI may overestimate change in AHI (downgraded 1 level)<br>■ Study population concerns: (1) mismatch with current OHP definition for AHI (that aligns with the definition used by Medicare), which may result in enrollment of more participants with milder OSA because AHI3 is a more sensitive definition to detect hypopneas, and (2) Lack of demographic generalizability to | **Not serious**<br>■ Although population sample sizes are small, studies were generally powered to detect changes in OSA severity by AHI<br>■ Confidence intervals are generally indicative of a reduction in OSA severity | ■ Limited long-term data to assess an ongoing intervention (12 months is the longest follow-up) | **Low**<br>●●○○ |

| NO. OF STUDIES SAMPLE SIZE | RISK OF BIAS | INCONSISTENCY | INDIRECTNESS | IMPRECISION | OTHER FACTORS | LEVEL OF CONFIDENCE |
|---|---|---|---|---|---|---|
| | | | Oregon Medicaid population with OSA<br>■ Surgical techniques have evolved over time and studied procedures, especially in older studies, may not reflect contemporary practice | | | |
| **DAYTIME SLEEPINESS** | | | | | | |
| 6 studies<br>(5 RCTs and 1 comparative cohort study)<br>N = 481 | **Serious**<br>Downgraded 2 levels<br>■ 2 RCTs rated as moderate RoB, 4 studies (3 RCTs and 1 comparative cohort study) rated as high RoB<br>■ Unblinded studies are a major concern when outcome measures are patient-reported (downgraded 1 level)<br>■ Downgraded 1 level for: | **Not serious**<br>■ Generally consistent direction and magnitude of effect<br>■ Inconsistencies can be explained by comparison to an active control (PAP treatment), in which there was no difference observed between the 2 groups in terms of daytime sleepiness | **Not serious**<br>■ Study population concerns: (1) mismatch with current OHP definition for AHI (that aligns with the definition used by Medicare), which may result in enrollment of more participants with milder OSA because AHI3 is a more sensitive definition to detect hypopneas, and (2) Lack of demographic generalizability to | **Not serious**<br>■ Although population sample sizes are generally small, the studies are generally well powered to assess ESS (the measure of daytime sleepiness evaluated)<br>■ Confidence intervals generally are showing a reduction in daytime sleepiness | ■ Limited long-term data to assess an ongoing intervention (~4 years is the longest follow-up) | **Low**<br>●●○○ |

| NO. OF STUDIES SAMPLE SIZE | RISK OF BIAS | INCONSISTENCY | INDIRECTNESS | IMPRECISION | OTHER FACTORS | LEVEL OF CONFIDENCE |
|---|---|---|---|---|---|---|
| | ■ Issues with adequacy of allocation concealment for RCTs<br>■ Lack of funding information<br>■ Some concerns with author COI for RCTs<br>■ Details on confounding variables in the cohort study were lacking | | Oregon Medicaid population with OSA<br>■ Surgical techniques have evolved over time and studied procedures, especially in older studies, may not reflect contemporary practice<br>■ Some heterogeneity in time points for assessment (range is 6 months to 4 years) | | | |
| **MAJOR ADVERSE CARDIAC EVENTS** | | | | | | |
| No eligible studies | | | | | | |

Abbreviations. AHI: apnea-hypopnea index; AHI3: evidence of a reduction in airflow of 30% or more for 10 seconds or longer accompanied by either an arousal or oxygen desaturation of 3% or more; COI: conflict of interest; ESS: Epworth Sleepiness Scale; EQ-5D-5L: European Quality of Life-5 Dimension 5-Level Instrument; FOSQ: Functional Outcomes of Sleep Questionnaire; GBI: Glasgow Benefit Inventory; PAP: positive airway pressure; OHP: Oregon Health Plan; OSA: obstructive sleep apnea; QoL: quality of life; RCT: randomized controlled trial; RoB: risk of bias; SAEs: serious adverse events; SF-36: short form-36.

# APPENDIX C. METHODS

## Scope Statement

### Populations

Adults aged 18 years and older with moderate to severe OSA (generally defined as having an AHI ≥ 15 events per hour)

### Interventions

**Surgical airway (i.e., oropharyngeal) interventions including but not limited to:**

- Upper pharyngeal procedures (e.g., uvulopalatopharyngoplasty [UPPP], tonsillectomy, adenoidectomy)
- Lower pharyngeal and laryngeal procedures (e.g., tongue reduction procedures, tongue advancement or stabilization procedures, epiglottis correction procedures)
- Maxillomandibular advancement [MMA] or expansion surgery

### Comparators

- No treatment
- Usual care (i.e., patient education)
- Sham surgery (i.e., placebo)
- Nonsurgical interventions for OSA
    - Noninvasive positive airway pressure therapy (i.e., CPAP, BiPAP)
    - Pharmacotherapy
    - Mandibular advancement devices

### Outcomes

**Critical:**

- Procedure- or device-related serious adverse events
- Overall and sleep-related quality of life (as measured by validated assessment scales)

**Important:**

- Improvement in OSA severity as measured by polysomnography indices (i.e., apnea-hypopnea index, respiratory disturbance index, respiratory event index, oxygen desaturation index)
- Daytime sleepiness (as measured by validated assessment scales)
- Major adverse cardiac events

*Considered, but not selected for GRADE table: All-cause mortality, change in A1c, remission of hypertension, fatigue-related accidents, other polysomnography-related outcomes*

### Study Designs*

**Effectiveness:**

- RCTs of any size
- Prospective comparative cohort studies (N > 100)

**Harms:**

- RCTs (as defined above)
- Prospective comparative cohort studies (as defined above)
- Systematic reviews (including any study design)
- Prospective single-arm cohort studies (N > 100)
- Registry studies (i.e., retrospective studies of data collected from a named centralized database with multisite inputs)

*Studies only eligible if conducted in the US or very-high Human Development Index (HDI) nations.

### Follow-up

**RCTS:** 12 weeks or greater

**Cohort and registry studies:** 6 months or greater

### Publication Date

**Primary studies:** 2000 or later

**Systematic reviews:** 2014 or later

### Key Questions

KQ1. What is the effectiveness of surgical versus nonsurgical treatments for OSA in adults?
KQ2. What are the harms of surgical treatments for OSA?
KQ3. How does the effectiveness and harms of these interventions vary by:
    a. Intervention characteristics
    b. Patient characteristics
        i. Severity of OSA
        ii. Race, ethnicity, culture, or language
        iii. Gender or sex
        iv. Age
        v. Comorbidities
        vi. Response to prior interventions

### Contextual Questions

CQ1. What is the evidence for effectiveness of surgical interventions for OSA on outcomes (e.g., all-cause mortality, major adverse cardiac events, motor vehicle crashes) from systematic reviews that include observational and nonrandomized studies?
CQ2. What is the comparative effectiveness of surgical interventions for OSA from randomized controlled trials?
CQ3. What is the cost effectiveness of surgical interventions for OSA?

## Key Question Search Strategy

We searched bibliographic databases to identify randomized controlled trials (RCTs), systematic reviews (with and without meta-analyses), cohort studies, and clinical practice guidelines including the terms *obstructive sleep apnea,* and a variety of terms to capture surgeries, including, but not limited to:

*adenoidectomy, pharyngectomy, tonsillectomy, uvulopalatopharyngoplasty, tonsillotomy, glossectomy, laryngoplasty, mandibular advancement, uvulopalatal flap, lingualplasty,* and *epiglottidectomy.* We limited records retrieved to studies on adult human subjects and published in the English language after 2000. No additional search limits were applied. Systematic reviews were used for additional reference list searching and citation chaining was conducted on relevant primary studies. Search strategies were built initially for Ovid MEDLINE ALL and then translated with the support of the Polyglot Search Translator for the Cochrane Database of Systematic Reviews (CDSR) and Cochrane CENTRAL.[90] Searches were conducted on August 9, 2024.

## Bibliographic Databases

TABLE C1. BIBLIOGRAPHIC DATABASES SEARCHED FOR THIS REPORT

| DATABASE | PLATFORM | ISSUE/VERSION | TOTAL NUMBER OF RECORDS RETRIEVED |
|---|---|---|---|
| CENTRAL | Wiley | Issue 8 of 12, August 2024 | 793 |
| CDSR | Wiley | Issue 8 of 12, August 2024 | 1 |
| MEDLINE ALL | Ovid | 1946 to August 9, 2024 | 1,979 |

Abbreviations. CDSR: Cochrane Database of Systematic Reviews; CENTRAL: Cochrane Central Register of Controlled Trials.

## Ovid MEDLINE ALL Search Strategy

| | | |
|---|---|---|
| 1 | exp sleep apnea, obstructive/ | 28898 |
| 2 | ((nocturnal or sleep*) adj3 (apn?e* or apn?ea-hypopne* or apn?eic-hypopne* or hypopn?e* or hypo-apn?e*)).ti,ab,kw. | 49342 |
| 3 | osa.ti,ab,kf. | 21469 |
| 4 | osahs.ti,ab,kf. | 1781 |
| 5 | sahs.ti,ab,kf. | 632 |
| 6 | shs.ti,ab,kf. | 3992 |
| 7 | or/1-6 | 59933 |
| 8 | exp pharynx/su | 6808 |
| 9 | exp palate/su | 4614 |
| 10 | tongue/su | 1723 |
| 11 | exp laryngeal cartilages/su | 2741 |
| 12 | hyoid bone/su | 424 |
| 13 | adenoidectomy/ | 5201 |
| 14 | pharyngectomy/ | 1431 |

| | | |
|---|---|---|
| 15 | tonsillectomy/ | 11097 |
| 16 | glossectomy/ | 1192 |
| 17 | laryngoplasty/ | 824 |
| 18 | mandibular advancement/ | 2284 |
| 19 | adenoidectom*.ti,ab,kf. | 3780 |
| 20 | adenotonsil?ectom*.ti,ab,kf. | 3016 |
| 21 | adenotonsil?otom*.ti,ab,kf. | 22 |
| 22 | palatoplast*.ti,ab,kf. | 1512 |
| 23 | pharyngectom*.ti,ab,kf. | 386 |
| 24 | pharyngoplast*.ti,ab,kf. | 820 |
| 25 | uvulopalatal flap*.ti,ab,kw. | 42 |
| 26 | uvulopalatopharyngoplast*.ti,ab,kf. | 1096 |
| 27 | uppp.ti,ab,kf. | 721 |
| 28 | tonsil?ectom*.ti,ab,kf. | 10570 |
| 29 | tonsil?otom*.ti,ab,kf. | 317 |
| 30 | ((adenoid* or palat* or pharyn* or tonsil* or uvula or uvulopalat* or uvulo-palat*) adj3 (ablat* or coblat* or dissect* or excis* or implant* or laser* or operat* or reduc* or remov* or resect* or surg*)).ti,ab,kw. | 10747 |
| 31 | glossectom*.ti,ab,kf. | 1074 |
| 32 | lingualplast*.ti,ab,kf. | 10 |
| 33 | ((geniogloss* or gloss* or lingual* or tongue*) adj3 (ablat* or advance* or coblat* or operat* or reduc* or remov* or resect* or stabiliz* or surg* or suspen*)).ti,ab,kw. | 3494 |
| 34 | epiglottidectom*.ti,ab,kf. | 15 |
| 35 | epiglottopex*.ti,ab,kf. | 62 |
| 36 | epiglottoplast*.ti,ab,kf. | 70 |
| 37 | laryngoplast*.ti,ab,kf. | 998 |

| | | |
|---|---|---|
| 38 | ((epiglott* or laryn*) adj3 (ablat* or coblat* or dissect* or excis* or laser* or operat* or reduc* or remov* or resect* or surg*)).ti,ab,kw. | 8742 |
| 39 | ((mandib* or maxillomandib* or maxillo-mandib*) adj3 (advance* or osteotom* or operat* or setback or surg*)).ti,ab,kw. | 8621 |
| 40 | (hyoid adj3 suspen*).ti,ab,kw. | 145 |
| 41 | (multilevel adj surg*).ti,ab,kw. | 463 |
| 42 | or/8-41 | 58660 |
| 43 | clinical trials as topic/ | 202978 |
| 44 | clinical trials, phase iii as topic/ | 11527 |
| 45 | clinical trials, phase iv as topic/ | 399 |
| 46 | comparative effectiveness research/ | 4054 |
| 47 | controlled clinical trials as topic/ | 5735 |
| 48 | cross-over studies/ | 57202 |
| 49 | double-blind method/ | 179754 |
| 50 | multicenter studies as topic/ | 24572 |
| 51 | random allocation/ | 107485 |
| 52 | exp randomized controlled trials as topic/ | 176479 |
| 53 | single-blind method/ | 33810 |
| 54 | clinical trial.pt. | 540314 |
| 55 | clinical trial, phase iii.pt. | 23127 |
| 56 | clinical trial, phase iv.pt. | 2522 |
| 57 | controlled clinical trial.pt. | 95586 |
| 58 | equivalence trial.pt. | 1314 |
| 59 | multicenter study.pt. | 351754 |
| 60 | pragmatic clinical trial.pt. | 2393 |
| 61 | randomized controlled trial.pt. | 618637 |
| 62 | random*.ti,kf. | 359194 |

| | | |
|---|---|---|
| 63 | ((clinical or controlled or crossover or cross-over or equivalence or noninferior* or non-inferior* or pragmatic or randomi#ed) adj3 trial*).ti,ab,kw. | 954730 |
| 64 | ((single* or double* or triple* or treb* or quad*) adj3 (blind* or mask*)).ti,ab,kw. | 209472 |
| 65 | (2 arm* or two arm* or 3 arm* or three arm* or 4 arm* or four arm* or 5 arm* or five arm*).ti,ab,kw. | 23619 |
| 66 | (phase 3* or phase iii* or phase 4* or phase iv*).ti,ab,kf. | 73880 |
| 67 | (head to head or head-to-head).ti,ab,kw. | 11898 |
| 68 | (compar* adj3 (effectiveness or efficacy)).ti,ab,kw. | 108292 |
| 69 | quasi*.ti,ab,kf. | 92132 |
| 70 | (sham adj3 (operation* or procedure* or surg*)).ti,ab,kw. | 19272 |
| 71 | epidemiologic studies/ | 9567 |
| 72 | exp cohort studies/ | 2636795 |
| 73 | registries/ | 113060 |
| 74 | cohort*.ti,ab,kf. | 966561 |
| 75 | longitudinal*.ti,ab,kf. | 379678 |
| 76 | registr*.ti,ab,kf. | 397673 |
| 77 | or/43-76 | 5238822 |
| 78 | exp "costs and cost analysis"/ | 272263 |
| 79 | economics.fs. | 446507 |
| 80 | medicaid/ | 28649 |
| 81 | dual medicaid medicare eligibility/ | 41 |
| 82 | cost?.ti,kf. | 162377 |
| 83 | economic*.ti,kf. | 103056 |
| 84 | medicaid*.ti,ab,kf. | 37561 |
| 85 | or/78-84 | 681342 |
| 86 | clinical decision rules/ | 972 |
| 87 | exp clinical protocols/ | 195505 |

| | | |
|---|---|---|
| 88 | consensus/ | 23401 |
| 89 | exp consensus development conferences as topic/ | 3011 |
| 90 | critical pathways/ | 8079 |
| 91 | decision making, shared/ | 2319 |
| 92 | exp guidelines as topic/ | 174729 |
| 93 | health planning guidelines/ | 4165 |
| 94 | consensus development conference.pt. | 12480 |
| 95 | consensus development conference, NIH.pt. | 801 |
| 96 | guideline.pt. | 16386 |
| 97 | practice guideline.pt. | 31958 |
| 98 | guideline?.ti,kf. | 115056 |
| 99 | ((committee or executive) adj2 (recommend* or statement or summary)).ti,kw. | 2324 |
| 100 | ((consensus or joint or position) adj2 (recommend* or statement)).ti,kw. | 10780 |
| 101 | ((clinical or critical or practice) adj2 (path* or pathway or standard? or statement)).ti,kw. | 24100 |
| 102 | or/86-101 | 524331 |
| 103 | exp meta-analysis as topic/ | 30490 |
| 104 | systematic reviews as topic/ | 13707 |
| 105 | technology assessment, biomedical/ | 11304 |
| 106 | meta-analysis.pt. | 205870 |
| 107 | systematic review.pt. | 269346 |
| 108 | (metaanaly* or meta-analy* or meta analy*).ti,ab,kf. | 316673 |
| 109 | (systematic adj2 (overview? or review?)).ti,ab,kw. | 355406 |
| 110 | (technology adj assessment?).ti,ab,kw. | 8950 |
| 111 | cinahl.ab. | 51661 |
| 112 | cochrane.ab. | 154448 |
| 113 | embase.ab. | 178964 |

| | | |
|---|---|---|
| 114 | medline.ab. | 182184 |
| 115 | (psychinfo or psycinfo).ab. | 66782 |
| 116 | pubmed.ab. | 245957 |
| 117 | scopus.ab. | 71936 |
| 118 | web of science.ab. | 96805 |
| 119 | or/103-118 | 703404 |
| 120 | and/7,42,77 | 3030 |
| 121 | and/7,42,85 | 72 |
| 122 | or/120-121 | 3055 |
| 123 | limit 122 to yr="2000 -Current" | 2797 |
| 124 | and/7,102 | 869 |
| 125 | limit 124 to yr="2018 -Current" | 313 |
| 126 | and/7,42,119 | 408 |
| 127 | limit 126 to yr="2014 -Current" | 339 |
| 128 | or/123,125,127 | 3274 |
| 129 | exp animals/ not humans/ | 5247134 |
| 130 | 128 not 129 | 3265 |
| 131 | (exp infant/ or exp child/ or adolescent/) not exp adult/ | 2213948 |
| 132 | 130 not 131 | 2158 |
| 133 | limit 132 to english language | 1979 |

## CDSR via the Cochrane Library Search Strategy

Date Run: 09/08/2024 20:11:19

ID Search Hits

#1 [mh "sleep apnea, obstructive"] 3226

#2 (((nocturnal or sleep*) NEAR/3 (apn?e* or apn?ea-hypopne* or apn?eic-hypopne* or hypopn?e* or hypo-apn?e*))):ti,ab,kw 9140

#3 osa:ti,ab,kw 4551

#4 osahs:ti,ab,kw 253

#5 sahs:ti,ab,kw 97

#6 shs:ti,ab,kw 465

#7 #1 OR #2 OR #3 OR #4 OR #5 OR #6 10182

#8 [mh pharynx/su] 257

#9 [mh palate/su] 281

#10 [mh ^tongue] 539

#11 [mh "laryngeal cartilages"/su] 49

#12 [mh ^"hyoid bone"] 52

#13 [mh ^adenoidectomy] 622

#14 [mh ^pharyngectomy] 20

#15 [mh ^tonsillectomy] 1329

#16 [mh ^glossectomy] 26

#17 [mh ^laryngoplasty] 18

#18 [mh ^"mandibular advancement"] 270

#19 adenoidectom*:ti,ab,kw 1183

#20 adenotonsil?ectom*:ti,ab,kw 901

#21 adenotonsil?otom*:ti,ab,kw 11

#22 palatoplast*:ti,ab,kw 181

#23 pharyngectom*:ti,ab,kw 34

#24 pharyngoplast*:ti,ab,kw 58

#25 (uvulopalatal NEXT flap*):ti,ab,kw 7

#26 uvulopalatopharyngoplast*:ti,ab,kw 184

#27 uppp:ti,ab,kw 111

#28 tonsil?ectom*:ti,ab,kw 3034

#29 tonsil?otom*:ti,ab,kw 85

#30 (((adenoid* or palat* or pharyn* or tonsil* or uvula or uvulopalat* or uvulo-palat*) NEAR/3 (ablat* or coblat* or dissect* or excis* or implant* or laser* or operat* or reduc* or remov* or resect* or surg*))):ti,ab,kw 2744

#31 glossectom*:ti,ab,kw 56

#32 lingualplast*:ti,ab,kw 0

#33 (((geniogloss* or gloss* or lingual* or tongue*) NEAR/3 (ablat* or advance* or coblat* or operat* or reduc* or remov* or resect* or stabiliz* or surg* or suspen*))):ti,ab,kw 455

#34 epiglottidectom*:ti,ab,kw 0

#35 epiglottopex*:ti,ab,kw 2

#36 epiglottoplast*:ti,ab,kw 1

#37 laryngoplast*:ti,ab,kw 40

#38 (((epiglott* or laryn*) NEAR/3 (ablat* or coblat* or dissect* or excis* or laser* or operat* or reduc* or remov* or resect* or surg*))):ti,ab,kw 1483

#39 (((mandib* or maxillomandib* or maxillo-mandib*) NEAR/3 (advance* or osteotom* or operat* or setback or surg*))):ti,ab,kw 2494

#40 (hyoid NEAR/3 suspen*):ti,ab,kw 13

#41 (multilevel NEXT surg*):ti,ab,kw 57

#42 OR #8-#41 10105

#43 AND #7, #42 1207

#44 ([mh infant] OR [mh child] OR [mh ^adolescent]) NOT [mh adult] 88490

#45 #43 NOT #44 with Cochrane Library publication date Between Jan 2015 and December 2024 1

## CENTRAL via the Cochrane Library Search Strategy

Date Run: 09/08/2024 20:11:19

ID Search Hits

#1 [mh "sleep apnea, obstructive"] 3226

#2 (((nocturnal or sleep*) NEAR/3 (apn?e* or apn?ea-hypopne* or apn?eic-hypopne* or hypopn?e* or hypo-apn?e*))):ti,ab,kw 9140

#3 osa:ti,ab,kw 4551

#4 osahs:ti,ab,kw 253

#5 sahs:ti,ab,kw 97

#6 shs:ti,ab,kw 465

#7 #1 OR #2 OR #3 OR #4 OR #5 OR #6 10182

#8 [mh pharynx/su] 257

#9 [mh palate/su] 281

#10 [mh ^tongue] 539

#11 [mh "laryngeal cartilages"/su] 49

#12 [mh ^"hyoid bone"] 52

#13 [mh ^adenoidectomy] 622

#14 [mh ^pharyngectomy] 20

#15 [mh ^tonsillectomy] 1329

#16 [mh ^glossectomy] 26

#17 [mh ^laryngoplasty] 18

#18 [mh ^"mandibular advancement"] 270

#19 adenoidectom*:ti,ab,kw 1183

#20 adenotonsil?ectom*:ti,ab,kw 901

#21 adenotonsil?otom*:ti,ab,kw 11

#22 palatoplast*:ti,ab,kw 181

#23 pharyngectom*:ti,ab,kw 34

#24 pharyngoplast*:ti,ab,kw 58

#25 (uvulopalatal NEXT flap*):ti,ab,kw 7

#26 uvulopalatopharyngoplast*:ti,ab,kw 184

#27 uppp:ti,ab,kw 111

#28 tonsil?ectom*:ti,ab,kw 3034

#29 tonsil?otom*:ti,ab,kw 85

#30 (((adenoid* or palat* or pharyn* or tonsil* or uvula or uvulopalat* or uvulo-palat*) NEAR/3 (ablat* or coblat* or dissect* or excis* or implant* or laser* or operat* or reduc* or remov* or resect* or surg*))):ti,ab,kw 2744

#31 glossectom*:ti,ab,kw 56

#32 lingualplast*:ti,ab,kw 0

#33 (((geniogloss* or gloss* or lingual* or tongue*) NEAR/3 (ablat* or advance* or coblat* or operat* or reduc* or remov* or resect* or stabiliz* or surg* or suspen*))):ti,ab,kw 455

#34 epiglottidectom*:ti,ab,kw 0

#35 epiglottopex*:ti,ab,kw 2

#36 epiglottoplast*:ti,ab,kw 1

#37 laryngoplast*:ti,ab,kw 40

#38 (((epiglott* or laryn*) NEAR/3 (ablat* or coblat* or dissect* or excis* or laser* or operat* or reduc* or remov* or resect* or surg*))):ti,ab,kw 1483

#39 (((mandib* or maxillomandib* or maxillo-mandib*) NEAR/3 (advance* or osteotom* or operat* or setback or surg*))):ti,ab,kw 2494

#40 (hyoid NEAR/3 suspen*):ti,ab,kw 13

#41 (multilevel NEXT surg*):ti,ab,kw 57

#42 OR #8-#41 10105

#43 AND #7, #42 1207

#44 ([mh infant] OR [mh child] OR [mh ^adolescent]) NOT [mh adult] 88490

#45 #43 NOT #44 with Cochrane Library publication date Between 2000 and 2024 903*

**Manually removed 110 ClinicalTrials.gov records: 793*

## Ongoing Studies Search Strategy

We searched ClinicalTrials.gov in September 2024 for ongoing studies using the following search strategy:

- **Condition/Disease:** Obstructive Sleep Apnea\(OSA\) OR Sleep Apnea, Obstructive OR Sleep Apnea OR Sleep Disordered Breathing
- **Intervention/treatment:** Surgery OR Uvulopalatopharyngoplasty OR Maxillomandibular Advancement OR tonsillectomy OR adenotonsillectomy OR Adenoidectomy OR Radiofrequency OR Multilevel OR Implant OR tongue reduction OR transoral robotic surgery OR tongue advancement OR tongue stabilization OR tongue suspension OR Epiglottidectomy OR Epiglottopexy OR Hyoepiglottoplasty OR palatal expansion OR maxillary expansion OR suture OR repose system OR AIRVance system OR Advance system OR snoreplasty
- **Status:** Not yet recruiting, Recruiting, Active, not recruiting, Completed, Enrolling by invitation, Unknown status studies
- **Age groups:** Adult (18–64), Older adult (65+)
- **Study type:** Interventional, Observational studies
- **Primary completion:** on or after 01/01/2020

## Policy Landscape Methods

For the Policy Landscape section, we conducted targeted searches in Ovid MEDLINE, websites of relevant professional societies and guideline groups, and DuckDuckGo to identify relevant clinical practice guidelines (CPGs) and key payer policies. Two reviewers independently assessed the quality of the included CPGs; disagreements were resolved through consensus or by a third reviewer. Relevant position statements from professional societies were also included for contextual purposes and were considered to have high risk of bias.

We limited searches for CPGs to those issued by professional societies in the US or other very-high Human Development Index countries published since 2014. We conducted a search for relevant clinical practice guidelines using MEDLINE and the following sources:

- American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNS)
- American Academy of Sleep Medicine (AASM)
- American College of Surgeons (ACS)
- American College of Physicians (ACP)
- American Medical Association (AMA)
- Australasian Sleep Association (ASA)
- Canadian Agency for Drugs and Technologies in Health (CADTH)
- Centers for Disease Control and Prevention (CDC)
- European Respiratory Society (ERS)
- German Sleep Society (GSS)
- German Society of Oto-Rhino-Laryngology, Head and Neck Surgery
- Health Quality Ontario
- The International Sleep Surgery Society (ISSS)
- Japanese Respiratory Society (JRS)
- National Institute for Health and Care Excellence (NICE)
- Obesity Medicine Association (OMA)
- Scottish Intercollegiate Guidelines Network (SIGN)
- United States Preventive Services Task Force (USPSTF)
- Veterans Administration/Department of Defense (VA/DoD)
- The World Sleep Society (WSS)

Guidelines were reviewed for content on oropharyngeal and skeletal surgeries *only.* Recommendations pertaining to bariatric surgery and hypoglossal nerve stimulation were *not* summarized due to being outside of the scope of this evidence review.

We additionally sought payer coverage policies from select public and private payers, including:

- Medicare
- Washington State Health Care Authority (Medicaid)
- Aetna
- Cigna
- Moda
- Regence BlueCross BlueShield of Oregon

## Risk of Bias of Included Studies

We assessed the risk of bias of the included systematic reviews, RCTs, cohort studies, and CPGs using standard instruments developed and adapted by the Center that are modifications of instruments used by several renowned, respected organizations.[91-94] One experienced researcher independently rated the risk of bias of included studies. A second experienced researcher reviewed each assessment. Disagreement was managed by discussion.

## Systematic Reviews

If a meta-analysis or network meta-analysis was conducted, the risk of bias of the analyses was considered in the overall rating for the systematic review. In brief, low risk of bias systematic reviews include a clearly focused question, a literature search sufficiently rigorous to identify all relevant studies, criteria used to assess study quality and select studies for inclusion (e.g., randomized controlled trials), and assessment of similarities between studies to determine whether combining them is appropriate for evidence synthesis. Moderate risk of bias systematic reviews have incomplete information about methods that might mask important limitations or a meaningful conflict of interest. High risk of bias systematic reviews have clear flaws that could introduce significant bias.

## Randomized Controlled Trials

Low risk of bias randomized controlled trials include a clear description of the population, setting, intervention, and comparison groups; a random and concealed allocation of patients to study groups; low dropout rates; and intention-to-treat analyses. Low risk of bias randomized controlled trials also have low potential for bias from conflicts of interest and funding source(s). Moderate risk of bias randomized controlled trials have incomplete information about methods that might mask important limitations or a meaningful conflict of interest. High risk of bias randomized controlled trials have clear flaws that could introduce significant bias.

## Cohort Studies

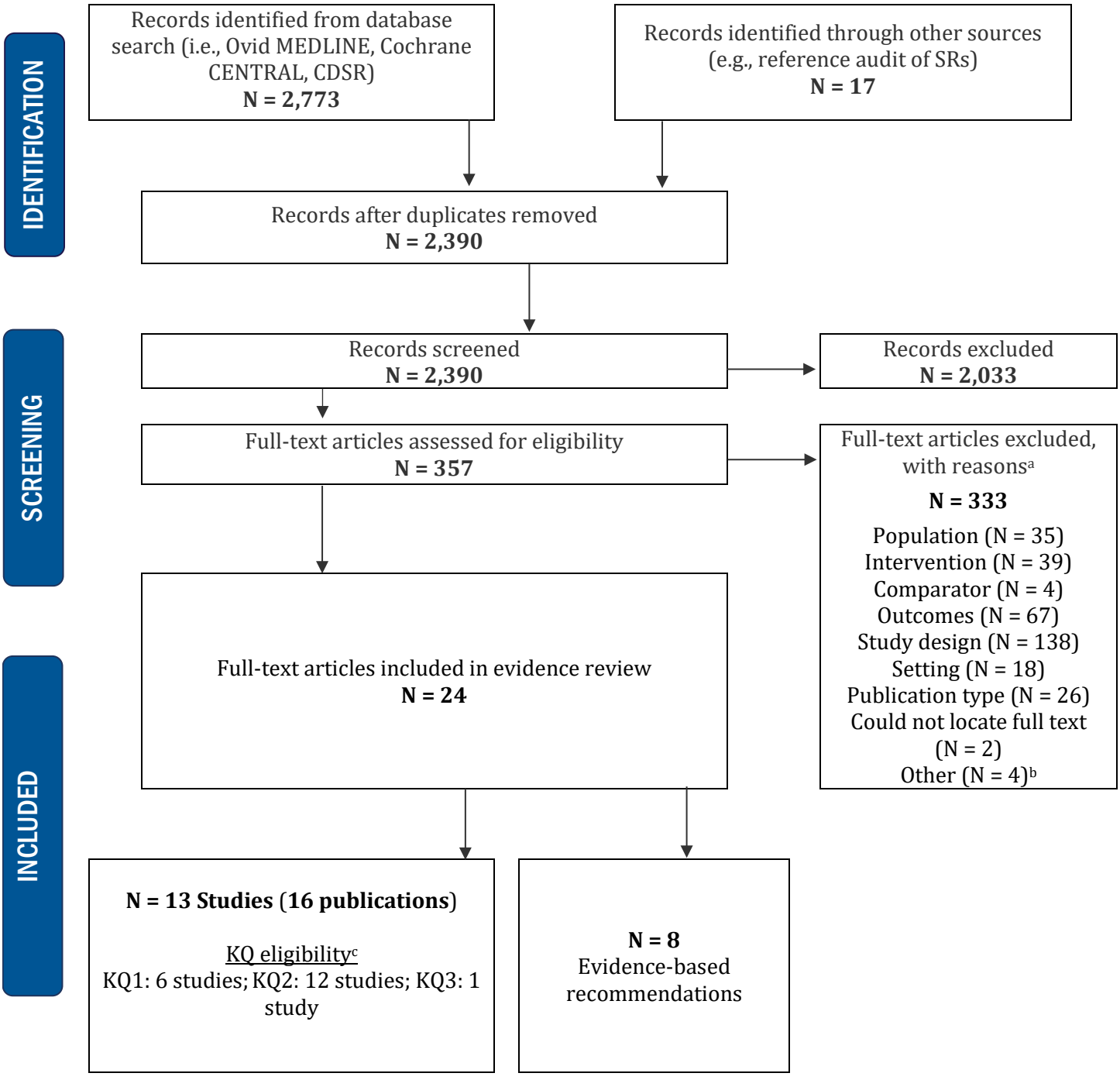
Low risk of bias cohort studies include a sample that is representative of the source population, have low loss to follow-up, and measure and consider relevant confounding factors. Low risk of bias cohort studies also list their funding source(s) and have a low potential of bias from conflicts of interest. Moderate risk of bias cohort studies might not have measured all relevant confounding factors or adjusted for them in statistical analyses, have loss to follow-up that could bias findings, consist of a sample that is not representative of the source population, or have potential conflicts of interest that are not addressed. High risk of bias cohort studies have a clear, high risk of bias that would affect findings.

## Clinical Practice Guidelines

We assessed the methodological quality of the guidelines using an instrument adapted from the Appraisal of Guidelines Research and Evaluation (AGREE) Collaboration.[91,95,96] Each rater assigned the study a rating of good, fair, or poor based on its adherence to recommended methods and potential for biases. A good-quality guideline fulfills all or most of the criteria outlined in the instrument. A fair-quality guideline fulfills some of the criteria, and its unfulfilled criteria are not likely to alter the recommendations. A poor-quality guideline met few or none of the criteria.

# APPENDIX D. ADDITIONAL EVIDENCE TABLES

FIGURE D1. STUDY FLOW DIAGRAM




Notes. [a] No studies were excluded for study duration, publication date, or lack of availability in English. [b] n = 4 registry studies, systematic reviews, or single arm prospective NRS excluded on the basis of significant KQ2 data overlap. [c] There is overlap in the studies with data available for KQ1, KQ2, and KQ3.

Abbreviations. CDSR: Cochrane Database of Systematic Reviews; CPG: clinical practice guideline; KQ: key question; NRS: nonrandomized study.

TABLE D1. OUTCOME MEASURES AND MCIDS

| MEASUREMENT SCALE | ABBREVIATION | MEASURE | SCORE RANGE | SCORE INTERPRETATION | MCID |
|---|---|---|---|---|---|
| **VALIDATED PATIENT-REPORTED OUTCOME SCALES** | | | | | |
| Epworth Sleepiness Scale[63] | ESS | Daytime sleepiness | 0–24 points | Higher scores indicate increased daytime sleepiness | ■ ± 2 points[a, b] |
| EuroQoL-5 Dimension 5-Level Instrument[57,58] | EQ-5D-5L | Generic measure of health | 0–1 | High scores indicate better health utility | ■ No MCID set for OSA[46,c] |
| Functional Outcomes of Sleep Questionnaire[97] | FOSQ | Functional status | 5–20 points | Higher scores indicate improvement in functional status | ■ ± 1 point |
| Glasgow Benefit Inventory[60,61, d] | GBI | Measure of change in health status post-intervention[b] | –100 to +100 | –100 represents the poorest outcome, 0 indicates no change, and +100 represents the best outcome | ■ No reported MCID[46] |
| Short Form-36 Item [Mental Health Component][54,59] | SF-36 [MHC] | Health related QoL | 0 to 100 | Higher scores indicated a better health-related quality of life | ■ ± 3 points |
| Short Form-36 Item [Physical Health Component][54,59] | SF-36 [PHC] | Health related QoL | 0 to 100 | Higher scores indicated a better health-related quality of life | ■ ± 3 points |
| **POLYSOMNOGRAPHY MEASURES[e]** | | | | | |

| MEASUREMENT SCALE | ABBREVIATION | MEASURE | SCORE RANGE | SCORE INTERPRETATION | MCID |
|---|---|---|---|---|---|
| Apnea-Hypopnea Index[62] | AHI | OSA severity | 0–no upper limit | Higher scores indicate greater OSA severity | ■ ± 5 events per hour[b, f] |
| Oxygen Desaturation Index[97] | ODI | OSA severity | 0–no upper limit | Higher scores indicate greater OSA severity | ■ ± 5 events per hour |
| Respiratory Disturbance Index[62] | RDI | OSA severity | 0–no upper limit | Higher scores indicate greater OSA severity | ■ ± 5 events per hour[f] |

Notes. [a] While we used the MCID of 2 points, there is an alternate definition of 3 points.[63] [b] The SAMS trial introduces the concept of sufficiently important difference, which accounts for cost and potential morbidity of surgery. The study authors consider the sufficiently important difference to be a difference of 20 events per hour for AHI and 3 points for ESS.[46] [c] Score changes from 0.03-0.52 are the minimally important differences in other diseases. [d] Designed for otorhinolaryngological interventions specifically and to be administered only once post-intervention. [e] The respiratory event index (REI) was not included in this table as it was not identified in any of the evidence eligible for inclusion in this report. The REI reports the number of apneas and hypopneas per hour of monitoring time and is commonly used in home sleep testing. [f] While we applied the MCID of 5 events per hour, the AASM provides an alternate definition of a 10% change.[97]
Abbreviations. AASM: American Academy of Sleep Medicine; CI: confidence interval; MCID: minimal clinically important difference; OSA: obstructive sleep apnea.

TABLE D2. ADDITIONAL STUDY CHARACTERISTICS: PRIMARY STUDIES

| AUTHOR, YEAR STUDY OR REGISTRY NAME RISK OF BIAS | POPULATION DESCRIPTION | STUDY SETTING | BASELINE CHARACTERISTICS | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | STUDY GROUPS | MEAN AGE | MEAN BMI | CPAP TRIAL REQUIRED BEFORE STUDY | MEAN AHI | MEAN ESS | % FEMALE | % RACE/ ETHNICITY[a] |
| **RCTs** | | | | | | | | | | |
| Browaldh, 2013[43,55]<br>SKUP3 Trial<br>Moderate | N = 71<br>Adults with moderate to severe OSAS | 1 hospital in Sweden | UPPP with tonsillectomy | 41.5 yrs | 28.2 kg/m$^2$ | Yes[c] | 53.3 events/hr | 12.5 | 12.5% | NR |
| | | | Waitlist[b] | 42.9 yrs | 27.7 kg/m$^2$ | Yes[c] | 52.6 events/hr | 12.9 | 12.9% | NR |
| MacKay, 2020[46]<br>SAMS Trial<br>Moderate | N = 102<br>Adults with moderate to severe OSA | 6 Australian academic centers | mUPPP and minimally invasive tongue volume reduction | 42.7 yrs | 30.7 kg/m$^2$ | Yes | 47.9 events/hr | 12.4 | 20% | White: 86.3%<br>Other: 13.7% |
| | | | Ongoing medical management[d] | 46.4 yrs | 29.5 kg/m$^2$ | Yes | 45.3 events/hr | 11.1 | 16% | White: 90.2%<br>Other: 9.8% |
| Sommer, 2016[48]<br>High | N = 42<br>Adults with moderate to severe OSA | 2 hospitals in Germany | UPPP with tonsillectomy | 36.6 yrs | 28.5 kg/m$^2$ | Yes | 33.7 events/hr | 10.6 | 0% | NR |
| | | | Waitlist[b] | 38.4 yrs | 29.2 kg/m$^2$ | Yes | 35.7 events/hr | 10.2 | 26% | NR |
| Vicini, 2010[51]<br>High | N = 50 | 1 hospital in Italy | MMA | 49.1 yrs | 32.7 kg/m$^2$ | No | 56.8 events/hr | 11.6 | 8% | NR |

| AUTHOR, YEAR STUDY OR REGISTRY NAME RISK OF BIAS | POPULATION DESCRIPTION | STUDY SETTING | BASELINE CHARACTERISTICS | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | STUDY GROUPS | MEAN AGE | MEAN BMI | CPAP TRIAL REQUIRED BEFORE STUDY | MEAN AHI | MEAN ESS | % FEMALE | % RACE/ ETHNICITY[a] |
| | Adults with severe OSAHS | | APAP | 48.7 yrs | 30.2 kg/ $m^2$ | No | 50.3 events/hr | 11.2 | 20% | NR |
| Vicini, 2020[52] High | N = 50 Adults with moderate to severe OSA | 1 hospital in Italy | Barbed repositioning pharyngo-plasty with tonsillectomy | 44.6 yrs | 26.5 $kg/m^2$ | Yes | 25.6 events/hr | 9.3 | 12% | NR |
| | | | Waitlist[e] | 50.1 yrs | 27.9 $kg/m^2$ | Yes | 36.8 events/hr | 10.4 | 5% | NR |
| **COMPARATIVE COHORT STUDIES** | | | | | | | | | | |
| Robinson, 2009[47] High | N = 166 Adults with moderate to severe OSA | 1 hospital in Australia | Multilevel multistage surgery[f] | 52.3 yrs | 30.9 $kg/m^2$ | Yes | RDI: 44.0 events/hr | Median: 9.0 | 14.3% | NR |
| | | | CPAP | 60.0 yrs | 32.2 $kg/m^2$ | No | RDI: 46.5 events/hr | Median: 10.5 | 12.4% | NR |
| **REGISTRIES** | | | | | | | | | | |
| Baker, 2016[41] ACS-NSQIP database Moderate | N= 1,692 (UPPP alone: 1,079) Adults with sleep apnea who | US based registry 2008-2013 | UPPP[g] | 44 yrs | 32.4 $kg/m^2$ | NA | NR | NR | 23.8% | Asian or Pacific Islander: 6.2% Black or African |

| AUTHOR, YEAR<br>STUDY OR REGISTRY NAME<br>RISK OF BIAS | POPULATION DESCRIPTION | STUDY SETTING | BASELINE CHARACTERISTICS<br>STUDY GROUPS | MEAN AGE | MEAN BMI | CPAP TRIAL REQUIRED BEFORE STUDY | MEAN AHI | MEAN ESS | % FEMALE | % RACE/ ETHNICITY[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| | underwent UPPP | | | | | | | | | American: 13.3%<br>White: 80.5% |
| Brietzke, 2017[42]<br>Truven Health Analytics MarketScan Research Databases<br>Moderate | N = 14,633 (UPPP alone: 7,559)<br>Adults with OSA | US based registry<br>2010-2012 | UPPP | 44.1 yrs | NR | NA | NR | NR | 31.4% | NR |
| Kerizian, 2004[45]<br>VA-NSQIP database<br>High | N = 3,130<br>All patients undergoing UPPP | US based registry<br>1991-2001 | UPPP | 49.8 yrs | NR | NA | NR | NR | 3% | NR |

Notes. [a] Terminology used is directly from study publications. [b] No other treatment for OSA permitted. [c] Not required if Friedman stage 1 and BMI < 30 kg/m$^2$. [d] (e.g., CPAP, MAD, behavioral interventions), low uptake of MAD or CPAP. [e] Not specified by the study authors if other treatment for OSA was permitted. [f] UPPP with or without tonsillectomy (100%), geniotubercle advancement (88%); if failure: palatal advancement (67%), hyoid suspension (66%); if failure: midline radiofrequency ablation of the tongue (41%) or submucosal glossectomy techniques (12.5%). [g] With or without tonsillectomy and adenoidectomy.

Abbreviations. ACS-NSQIP: American College of Surgeons National Surgical Quality Improvement Program; AHI: apnea hypopnea index; APAP: auto-titrating positive airway pressure; BMI: body mass index; CPAP: continuous positive air pressure; ESS: Epworth Sleepiness Scale; MAD: mandibular advancement device; MMA: maxillomandibular advancement; mUPPP: modified UPPP; NA: not applicable; NR: not reported; OSA: obstructive sleep apnea; OSAS: obstructive sleep apnea syndrome; OSAHS: obstructive sleep apnea-hypopnea syndrome; RCT: randomized controlled trial; RDI: respiratory disturbance index; UPPP: uvulopalatopharyngoplasty; US: United States; VA-NSQIP: Veterans Affairs Surgical Quality Improvement Program.

TABLE D3. ADDITIONAL STUDY CHARACTERISTICS: SYSTEMATIC REVIEWS

| AUTHOR, YEAR<br>SURGERY<br>RISK OF BIAS | REVIEW OBJECTIVE | PUBLICATION DATE RANGE | STUDY INCLUSION CRITERIA | STUDY EXCLUSION CRITERIA | TOTAL INCLUDED STUDIES<br>STUDY DESIGNS | TOTAL PARTICIPANTS |
|---|---|---|---|---|---|---|
| Iannella, 2022[44]<br>Barbed repositioning pharyngoplasty with tonsillectomy<br>High | To present the state of the art and evolution on barbed repositioning pharyngoplasty in velopharyngeal surgery. | 2015 to 2021 | ▪ Prospective and retrospective studies on barbed repositioning pharyngoplasty<br>▪ Snorers and OSA patients<br>▪ Single level procedure and/or as a part of multilevel surgery<br>▪ Studies comparing barbed repositioning pharyngoplasty with other similar velopharyngeal surgical techniques | ▪ Studies not in English<br>▪ Case reports, reviews, meta-analysis, conference abstracts, and letters to the editor<br>▪ Studies with unclear and/or incomplete data<br>▪ Studies concerning other barbed velopharyngeal surgical techniques different than barbed repositioning pharyngoplasty (e.g. barbed expansion sphincter pharyngoplasty (BESP), anterior pharyngoplasty, barbed Roman blinds technique) | N = 15 studies<br>▪ Prospective cohort studies<br>▪ Retrospective cohort studies<br>▪ RCTs | 1,531 participants |

| AUTHOR, YEAR<br>SURGERY<br>RISK OF BIAS | REVIEW OBJECTIVE | PUBLICATION DATE RANGE | STUDY INCLUSION CRITERIA | STUDY EXCLUSION CRITERIA | TOTAL INCLUDED STUDIES<br>STUDY DESIGNS | TOTAL PARTICIPANTS |
|---|---|---|---|---|---|---|
| | | | | ▪ Experimental/trial studies or not clinical studies | | |
| Stuck, 2018<br>UPPP[49,a]<br>Moderate | Assess the effect of isolated UPPP ± TE in adult patients with OSA on clinically relevant endpoints. Secondary outcome measures were morbidity, mortality and complications. | 1987 to 2016 | ▪ Adult patients with OSA diagnosed by PSG or comparative objective measures<br>▪ Studies in English, French, German, or Dutch<br>▪ RCTs, nonrandomized controlled trials, prospective cohort studies<br>▪ Effectiveness data<br>▪ Retrospective studies, case series, and reports that otherwise met inclusion criteria<br>▪ Adverse events,<br>▪ Studies evaluating survival/mortality | ▪ E.g., reviews, guidelines, study protocols, conference proceedings, comments, posters or a letter to the editor<br>▪ Studies evaluating significant surgical variations of UPPP<br>▪ Studies that included patients undergoing concomitant surgery | N = 48 studies<br>▪ Prospective cohort studies<br>▪ RCTs<br>▪ Controlled clinical trials | 1,919 participants |
| Tang, 2017[50]<br>UPPP and mUPPP<br>High | To assess the incidence of long-term VPI and to determine other sequelae following classic and modified | 1984 to 2013 | ▪ Studies in English<br>▪ Discussed the complications of UPPP, specifically reporting the incidence of VPI or another variation of | ▪ Studies not in English<br>▪ Did not mention VPI or any other descriptive form of VPI as a | N = 24 studies<br>▪ NR | 2,353 participants |

| AUTHOR, YEAR<br>SURGERY<br>RISK OF BIAS | REVIEW OBJECTIVE | PUBLICATION DATE RANGE | STUDY INCLUSION CRITERIA | STUDY EXCLUSION CRITERIA | TOTAL INCLUDED STUDIES<br>STUDY DESIGNS | TOTAL PARTICIPANTS |
|---|---|---|---|---|---|---|
| | UPPP for the treatment of OSA. | | VPI such as nasal regurgitation, nasopharyngeal reflux, swallowing reflux, pharyngonasal reflux, palatopharyngeal incompetency, or nasopharyngeal unclosure<br>■ Included only classic or modified UPPP procedures | complication of UPPP<br>■ Other methods of UPPP outside of the classic or modified approach such as laser-assisted or radiofrequency-assisted<br>■ Reported the incidences of VPI in combination with other sequelae such as difficulty swallowing. | | |
| Zhou, 2022[53]<br>MMA<br>Moderate | Comprehensively evaluate and compare the efficacy of MMA and UAS for moderate-to-severe OSA through the assessment of AHI and ESS. Postoperative complications of these 2 therapies | 1997 to 2019 (MMA studies) | ■ Adult patients (> 18 years old)<br>■ Moderate-to-severe OSA (PSG; AHI ≥ 15 events/h)<br>■ Patients underwent MMA or UAS for OSA<br>■ Studies that reported pre- and postoperative PSG data<br>■ Follow-up ≥ 6 months | ■ Sample size < 10 patients<br>■ Patients who underwent other adjunctive surgical at the time of MMA or UAS<br>■ Preliminary studies in which the findings were nested in other studies with larger sample size | N = 30 studies<br>(21 studies on MMA)<br>■ Prospective cohort studies<br>■ Retrospective cohort studies<br>■ RCTs | 1,610 participants<br>(581 participants with MMA) |

| AUTHOR, YEAR<br>SURGERY<br>RISK OF BIAS | REVIEW OBJECTIVE | PUBLICATION DATE RANGE | STUDY INCLUSION CRITERIA | STUDY EXCLUSION CRITERIA | TOTAL INCLUDED STUDIES<br>STUDY DESIGNS | TOTAL PARTICIPANTS |
|---|---|---|---|---|---|---|
| | were also investigated. | | ■ Randomized controlled trials (RCTs), quasi-experimental studies, and cohort studies<br>■ English language | and/or longer follow-up | | |

Notes.[a] With or without tonsillectomy.

Abbreviations. AHI: apnea hypopnea index; BMI: body mass index; ESS: Epworth Sleepiness Scale; MMA: maxillomandibular advancement; mUPPP: modified UPPP; NA: not applicable; NR: not reported; OSA: obstructive sleep apnea; PSG: polysomnography; RCT: randomized controlled trial; TE: tonsillectomy; UAS: upper airway nerve stimulation; UPPP: uvulopalatopharyngoplasty; VPI: velopharyngeal insufficiency.

TABLE D4. QOL OUTCOMES

| STUDY INFO | STUDY DESIGN | TIME POINT | MEASURE | SURGERY N | SURGERY MEAN (SD) | NO SURGERY N | NO SURGERY MEAN (SD) | BETWEEN-GROUP ESTIMATE | *P* VALUE |
|---|---|---|---|---|---|---|---|---|---|
| **FUNCTIONAL OUTCOMES OF SLEEP QUESTIONNAIRE (SCORE RANGE, 5–20 POINTS; HIGHER SCORES ARE BETTER; MCID ≥ 1 POINT)[21]** | | | | | | | | | |
| Browaldh, 2013[43,56]<br>SKUP3 Trial<br>N = 71<br>Moderate RoB | RCT<br>■ UPPP and tonsillectomy<br>■ Waitlist[a] | 6 mos | Change from baseline | 32 | +1.5 (2.6) | 33 | −0.2 (1.2) | NR | *P* <.001[b] |
| MacKay, 2020[46]<br>SAMS Trial<br>N = 102<br>Moderate RoB | RCT<br>■ mUPPP and minimally invasive tongue volume reduction<br>■ Ongoing medical management | 6 mos | Mean | 50 | 18.6 (1.8) | 49 | 16.3 (2.4) | NR | NR |
| | | | Change from baseline | 50 | +3.6 (95% CI, 2.9 to 4.2) | 49 | +0.1 (95% CI, – 0.6 to 0.8) | MD, 3.4 (95% CI, 2.5 to 4.4) | *P* < .001 |
| **EUROPEAN QUALITY OF LIFE-5 DIMENSION 5-LEVEL INSTRUMENT (SCORE RANGE, 0 TO 1; HIGHER SCORES INDICATE BETTER HEALTH UTILITY; NO MCID FOR OSA)[46,57,58]** | | | | | | | | | |
| MacKay, 2020[46] | RCT | 6 mos | Mean | 50 | 0.93 (0.12) | 49 | 0.86 (0.10) | NR | NR |

| STUDY INFO | STUDY DESIGN | TIME POINT | MEASURE | SURGERY N | SURGERY MEAN (SD) | NO SURGERY N | NO SURGERY MEAN (SD) | BETWEEN-GROUP ESTIMATE | *P* VALUE |
|---|---|---|---|---|---|---|---|---|---|
| SAMS Trial<br>N = 102<br>Moderate RoB | ■ mUPPP and minimally invasive tongue volume reduction<br>■ Ongoing medical management | | Change from baseline | 50 | +0.06 (95% CI, 0.02 to 0.11) | 49 | 0.00 (95% CI, −0.03 to 0.04) | MD, 0.06 (95% CI, −0.00 to 0.12) | *P* = .054 |
| **SHORT FORM-36 QUESTIONNAIRE: PHYSICAL HEALTH COMPONENT (SCORE RANGE 0 TO 100; HIGHER SCORES INCDICATE A BETTER HEALTH-RELATED QUALITY OF LIFE; MCID ≥ 3 POINTS)[54 59]** | | | | | | | | | |
| Browaldh, 2013[43,54]<br>SKUP3 Trial<br>N = 71<br>Moderate RoB | RCT<br>■ UPPP and tonsillectomy<br>■ Waitlist[a] | 6 mos | Mean | 31 | 51.2 (8.8) | 31 | 48.3 (9.1) | NR | *P* = .007[b] |
| **SHORT FORM-36 QUESTIONNAIRE: MENTAL HEALTH COMPONENT (SCORE RANGE 0 TO 100; HIGHER SCORES INCDICATE A BETTER HEALTH-RELATED QUALITY OF LIFE; MCID ≥ 3 POINTS)[54,59]** | | | | | | | | | |
| Browaldh, 2013[54]<br>SKUP3 Trial<br>N = 71<br>Moderate RoB | RCT<br>■ UPPP and tonsillectomy<br>■ Waitlist[a] | 6 mos | Mean | 31 | 48.1 (9.7) | 31 | 42.7 (11.5) | NR | *P* = .03[b] |
| **GLASGOW BENEFIT INVENTORY (SCORE RANGE, −100 TO +100; 0 MEANS NO BENEFIT, HIGHER SCORES INDICATE A BETTER OUTCOME; NO MCID)[46,60,61]** | | | | | | | | | |
| Robinson, 2009[47]<br>N = 166<br>High RoB | Comparative cohort<br>■ Multilevel multistage surgery[d]<br>■ CPAP | ~4 yrs | Median | 77 | 19.4 (IQR, 25) | 89 | 16.7 (IQR, 22.2) | NR | *P* = .79 |

Notes [a] No treatment at all. [b] ITT analysis did not change the results of this per protocol analysis. [c] This included a range of evidenced-based treatments as appropriate (e.g., weight loss, alcohol reduction, sleep posture modification, medical management of nasal obstruction) and assistance with retrial of CPAP or mandibular advancement device therapies if participants were willing. However, there was low uptake of MAD or CPAP (only n = 8 ppts in total) as well as minimal weight loss in either study group or change in health behaviors. [d] UPPP with or without tonsillectomy

(100%), geniotubercle advancement (88%); if failure: palatal advancement (67%), hyoid suspension (66%); if failure: midline radiofrequency ablation of the tongue (41%) or submucosal glossectomy techniques (12.5%).

Abbreviations. CI: confidence interval; CPAP: continuous positive airway pressure; IQR: interquartile range; ITT: intention to treat; MAD: mandibular advancement device; MCID: minimum clinically meaningful difference; MD: mean difference; mos: months; mUPPP: modified UPPP; NR: not reported; QoL: quality of life; RCT: randomized controlled trial; RoB: risk of bias; SD: standard deviation; UPPP: uvulopalatopharyngoplasty; yrs: years.

TABLE D5. PROCEDURE-RELATED SERIOUS ADVERSE EVENTS

| STUDY INFO | SURGERY | TIME POINT | MEASURE | OUTCOME | TOTAL N<br>EVENTS |
|---|---|---|---|---|---|
| **RCTs** | | | | | |
| Browaldh, 2013[43]<br>SKUP3 Trial<br>N = 71<br>Moderate RoB | ■ UPPP with tonsillectomy | 6 mos | n (%) | Total SAE | 32<br>0 (0)[a] |
| MacKay, 2020[46]<br>SAMS Trial<br>N = 102<br>Moderate RoB | ■ mUPPP and minimally invasive tongue volume reduction | 6 mos | n (%) | Total SAE | 50<br>2 (4) |
| Sommer, 2016[48]<br>N = 42<br>High RoB | ■ UPPP with tonsillectomy | 3 mos | n (%) | Postoperative hemorrhages[b, c] | 39<br>2 (5.1) |
| | | | n (%) | Repeat surgery[c] | 39<br>1 (2.6) |
| Vicini, 2010[51]<br>N = 50<br>High RoB | ■ MMA | 12 mos | n (%) | Total SAE | 25<br>0 (0) |
| Vicini, 2020[52] | ■ Barbed repositioning | 6 mos | n (%) | Total SAE | 25<br>0 (0) |

| STUDY INFO | SURGERY | TIME POINT | MEASURE | OUTCOME | TOTAL N<br>EVENTS |
|---|---|---|---|---|---|
| N = 50<br>High RoB | pharyngoplasty with tonsillectomy | | | | |
| **COMPARATIVE COHORT** | | | | | |
| Robinson, 2009[47]<br>N = 166<br>High RoB | ■ Multilevel multistage surgery[d] | ~4 yrs | n (%) | Aspiration[b] | 64<br>3 (4.7) |
| | | | n (%) | Dysphagia[b] | 64<br>7 (10.9) |
| | | | n (%) | Infection[b] | 64<br>2 (3.1) |
| | | | n (%) | Wound dehiscence[b] | 64<br>1 (1.6) |
| **REGISTRIES** | | | | | |
| Baker, 2016[41]<br>ACS-NSQIP<br>N = 1,692 (UPPP alone: 1,079)<br>Moderate RoB | ■ UPPP[e] | 30-day post-op | n (%) | Overall complication[b] | 560<br>40 (7.1) |
| | | | n (%) | Medical complication[f] | 1,079<br>8 (0.7) |
| | | | n (%) | Return to operating room | 1,079<br>20 (1.9) |
| | | | n (%) | Readmission[g] | 543<br>15 (2.8) |
| | | | n (%) | Death[h] | 1,079<br>1 (0.1) |

| STUDY INFO | SURGERY | TIME POINT | MEASURE | OUTCOME | TOTAL N<br>EVENTS |
|---|---|---|---|---|---|
| | | | n (%) | Surgical complication[b,i] | 1,079<br>8 (0.7) |
| Brietzke, 2017[42]<br>Truven Health Analytics MarketScan Research Databases<br>N = 14,633 total (7,559 UPPP alone)<br>Moderate RoB | ■ UPPP | 0–14 days post-op | n (%) | Postoperative bleeding[b] | 7,559<br>326 (4.3) |
| | | | n (%) | Postoperative dehydration[b] | 7,559<br>136 (1.8) |
| | | | n (%) | Other complications[b, j] | 7,559<br>115 (1.5) |
| | | | n (%) | Respiratory distress[b] | 7,559<br>835 (11.1) |
| | | | n (%) | Pulmonary edema | 7,559<br>69 (0.9) |
| | | | n (%) | Pulmonary embolism | 7,559<br>12 (0.2) |
| | | | n (%) | Death | 7,559<br>0 (0) |
| | | | n (%) | Tracheostomy | 7,559<br>10 (0.1) |
| | | 15–60 days post-op | n (%) | Tracheostomy | 7,559<br>0 (0) |
| | | 61–183 days post-op | n (%) | Tracheostomy | 7,559<br>1 (0.01) |

| STUDY INFO | SURGERY | TIME POINT | MEASURE | OUTCOME | TOTAL N EVENTS |
|---|---|---|---|---|---|
| | | 15–60 days post-op | n (%) | Dysphagia[b] | 7,559<br>128 (1.7) |
| | | 61–183 days post-op | n (%) | Dysphagia[b] | 7,559<br>187 (2.5) |
| | | 15–60 days post-op | n (%) | Velopharyngeal insufficiency[b] | 7,559<br>21 (0.3) |
| | | 61–183 days post-op | n (%) | Velopharyngeal insufficiency[b] | 7,559<br>20 (0.3) |
| **SYSTEMATIC REVIEWS** | | | | | |
| Iannella, 2022[44]<br>15 studies/n = 1,531<br>High RoB | ■ Barbed repositioning pharyngoplasty with tonsillectomy | NA | Events | Significant intra-operative or post-operative complications | 15 studies<br>0 |
| Stuck, 2018[49]<br>48 studies/n = 1,919<br>Moderate RoB | ■ UPPP[k] | NA | No. studies | Major complication[l] | 48 studies<br>8 studies[l] |
| | | | Rate | Complication Rate "airway" | Out of 8 studies[m]<br>0% to 13.3% |
| | | | Rate | Complication Rate "bleeding"[n] | Out of 8 studies[m]<br>0% to 7.8% |

| STUDY INFO | SURGERY | TIME POINT | MEASURE | OUTCOME | TOTAL N<br>EVENTS |
|---|---|---|---|---|---|
| | | | No. participants with event | Velopharyngeal stenosis requiring surgery | Out of 8 studies [m]<br>1 participant |
| Tang, 2017[50]<br>24 studies; n = 2,353 participants<br>High RoB | ■ UPPP and mUPPP | NA | Rate | Short-term incidence of VPI | NR<br>7.3% |
| | | | | Long-term incidence of VPI | NR<br>9.1% |
| Zhou, 2022[53]<br>30 total studies; n = 1,610 (21 on MMA; n = 581 ppts)<br>Moderate RoB | ■ MMA | NA | Events | Death | 21 studies<br>0 |
| | | | Rate | Major complication | 10 studies<br>0% to 18% |
| | | | No. participants with event | Repeat surgery | 5 studies<br>10[o] |
| | | | No. participants with event | Acute dyspnea | 5 studies<br>1 |

Notes. [a] The authors reported there were no SAEs but there is record of 1 individual in the surgical arm that required a night of hospitalization, 3 days post-surgery. [b] Severity not specified. [c] Everyone who underwent surgery (inclusive of open-label phase of study). [d] UPPP with or without tonsillectomy (100%), geniotubercle advancement (88%); if failure: palatal advancement (67%), hyoid suspension (66%); if failure: midline radiofrequency ablation of the tongue (41%) or submucosal glossectomy techniques (12.5%) [e] With or without tonsillectomy and adenoidectomy. [f] Medical complications included cardiovascular (cardiac arrest, myocardial infarction, or stroke), pulmonary (pneumonia, unplanned reintubation, or ventilator-assisted respiration for >48 hours), neurologic (coma), renal (progressive renal insufficiency or acute renal failure), thromboembolic (deep vein thrombosis or pulmonary embolism), urinary tract infection, and sepsis or septic shock. [g] Data missingness for this outcome was noted by the study authors. [h] NR if related to surgery. [i] Defined as superficial surgical site infection, deep surgical site infection, wound dehiscence, or bleeding requiring blood transfusion. [j] Other complications include unspecified disease of pharynx, other and unspecified diseases of upper respiratory tract, other specified complications of procedures not

elsewhere classified, unspecified complication of procedure not elsewhere classified, and disruption of internal operation (surgical) wound. [k] With or without tonsillectomy. [l] This could be an airway complication, a bleeding complication, or a complication related to velopharyngeal insufficiency. [m] With more than 50 participants each. [n] 1 surgical revision was required due to post-op bleeding. [o] n = 8 ppts had a reoperation for the removal of osteosynthesis screws and plates; n = 2 had reoperations for maxillary non-union.

Abbreviations. ACS-NSQIP: American College of Surgeons National Surgical Quality Improvement Program; APAP: auto-titrating positive airway pressure; MMA: maxillomandibular advancement; mUPPP: modified UPPP; NA: not applicable; NR: not reported; OSA: obstructive sleep apnea; RCT: randomized controlled trial; RoB: risk of bias; SAEs: serious adverse events; UPPP: uvulopalatopharyngoplasty; VA-NSQIP: Veterans Administration National Surgical Quality Improvement Program; VPI: velopharyngeal insufficiency.

TABLE D6. OSA SEVERITY OUTCOMES

| STUDY INFO | STUDY DESIGN | TIME POINT | MEASURE | SURGERY N | SURGERY MEAN (SD) | NO SURGERY N | NO SURGERY MEAN (SD) | BETWEEN-GROUP ESTIMATE | *P* VALUE |
|---|---|---|---|---|---|---|---|---|---|
| **APNEA-HYPOPNEA INDEX (EVENTS PER HOUR; LOWER SCORES ARE BETTER; MCID ≥ 5 EVENTS PER HOUR)[59]** | | | | | | | | | |
| **AHI3** | | | | | | | | | |
| Browaldh, 2013[43]<br>SKUP3 Trial<br>N = 71<br>Moderate RoB | RCT<br>■ UPPP with tonsillectomy<br>■ Waitlist[a] | 6 mos | Mean | 32 | 21.1 (16.7) | 33 | 46.8 (22.8) | MD, −26 (95% CI, −37 to −16) | *P* < .001[b] |
| MacKay, 2020[46]<br>SAMS Trial<br>N = 102<br>Moderate RoB | RCT<br>■ mUPPP and minimally invasive tongue volume reduction<br>■ Ongoing medical management[c] | 6 mos | Mean | 50 | 20.8 (18.4) | 49 | 34.5 (23.0) | NR | NR |
| | | | Change from baseline | 50 | −27.4 (95% CI, −33.8 to −21.0) | 49 | −9.8 (95% CI, −16.5 to −3.1) | MD, −17.6 (95% CI, −26.8 to −8.4) | *P* < .001 |
| Vicini, 2020[51]<br>N = 50<br>High RoB | RCT<br>■ Barbed repositioning pharyngoplasty with tonsillectomy<br>■ Waitlist[d] | 6 mos | Mean | 25 | 9.8 (9.9) | 25 | 31.9 (21.9) | NR | NR |
| | | | Change from baseline | 25 | −15.8 (14.5) | 25 | −5 (13.8) | NR | *P* = .01 |
| **AHI4** | | | | | | | | | |
| | RCT | 3 mos | Mean | 18 | 15.4 (14.1) | 16 | 28.6 (19.3) | NR | NR |

| STUDY INFO | STUDY DESIGN | TIME POINT | MEASURE | SURGERY N | SURGERY MEAN (SD) | NO SURGERY N | NO SURGERY MEAN (SD) | BETWEEN-GROUP ESTIMATE | *P* VALUE |
|---|---|---|---|---|---|---|---|---|---|
| Sommer, 2016[48]<br>N = 42<br>High RoB | ■ UPPP with tonsillectomy<br>■ Waitlist[a] | | Change from baseline | 18 | −18.4 (95% CI, −15.2 to 0.9) | 16 | −7.2 (95% CI, −25.7 to −11.0) | MD, −12.8 (95% CI, −18 to −7.5) | *P* = .036 |
| **NR** | | | | | | | | | |
| Vicini, 2010[51]<br>N = 50<br>High RoB | RCT<br>■ MMA<br>■ APAP | 12 mos | Mean | 25 | 8.1 (7.0) | 25 | 6.3 (1.9) | NR | NR |
| | | | Change from baseline | 25 | NR | 25 | NR | NR | *P* = .21 |
| **OXYGEN DESATURATION INDEX (EVENTS PER HOUR; LOWER SCORES ARE BETTER; MCID ≥ 5 EVENTS PER HOUR)[59]** | | | | | | | | | |
| **ODI3** | | | | | | | | | |
| Browaldh, 2013[43]<br>SKUP3 Trial<br>N = 71<br>Moderate RoB | RCT<br>■ UPPP with tonsillectomy<br>■ Waitlist[a] | 6 mos | Mean | 32 | 14.0 (13.1) | 33 | 35.6 (21.3) | MD, −25 (95% CI, −36 to −15) | *P* < .001[b] |
| MacKay, 2020[46]<br>SAMS Trial<br>N = 102<br>Moderate RoB | RCT<br>■ mUPPP and minimally invasive tongue volume reduction<br>■ Ongoing medical management[c] | 6 mos | Mean | 50 | 11.4 (12.7) | 49 | 21.6 (17.8) | NR | NR |
| | | | Change from baseline | 50 | −17.7 (95% CI, −22.2 to −13.3) | 49 | −4.2 (95% CI, −8.9 to 0.4) | MD, −13.5 (95% CI −20.0 to −7.1) | *P* = .001 |

| STUDY INFO | STUDY DESIGN | TIME POINT | MEASURE | SURGERY N | SURGERY MEAN (SD) | NO SURGERY N | NO SURGERY MEAN (SD) | BETWEEN-GROUP ESTIMATE | *P* VALUE |
|---|---|---|---|---|---|---|---|---|---|
| Vicini, 2020[52]<br>N = 50<br>High RoB | RCT<br>■ Barbed repositioning pharyngoplasty with tonsillectomy<br>■ Waitlist[d] | 6 mos | Mean | 25 | 9.3 (10.2) | 25 | 32.4 (22.6) | NR | NR |
| | | | Change from baseline | 25 | −15.1 (17.9) | 25 | −2.8 (14.6) | NR | *P* = .01 |
| **ODI4** | | | | | | | | | |
| MacKay, 2020[46]<br>SAMS Trial<br>N = 102<br>Moderate RoB | RCT<br>■ mUPPP and minimally invasive tongue volume reduction<br>■ Ongoing medical management[c] | 6 mos | Mean | 50 | 8.1 (11.1) | 50 | 15.9 (16.2) | NR | NR |
| | | | Change from baseline | 49 | −15.3 (95% CI, −19.6 to −11.0) | 49 | −4.3 (95% CI, −8.8 to 0.1) | MD, −11.0 (95% CI, −17.2 to −4.7) | *P* = .003 |
| **RESPIRATORY DISTURBANCE INDEX (EVENTS PER HOUR; LOWER SCORES ARE BETTER; MCID ≥ 5 EVENTS PER HOUR)[62]** | | | | | | | | | |
| Browaldh, 2013[43]<br>SKUP3 Trial<br>N = 71<br>Moderate RoB | RCT<br>■ UPPP with tonsillectomy<br>■ Waitlist[a] | 6 mos | Mean | 32 | 25.8 (17.3) | 33 | 50.1 (23.1) | MD, −25 (95% CI, −36 to −15) | *P* < .001[b] |
| Sommer, 2016[48]<br>N = 42<br>High RoB | RCT<br>■ UPPP with tonsillectomy<br>■ Waitlist[a] | 3 mos | Mean | 17 | 21.8 (21.8) | 16 | 28.7 (19.4) | NR | NR |
| | | | Change from baseline | 17 | −12.5 (95% CI, −25.6 to 0.5) | 16 | −8.1 (95% CI, −16.5 to 0.3) | MD, −10.3 (95% CI, −18 to −2.8) | *P* = .27 |

Notes. [a] No treatment at all. [b] ITT analysis did not change the results of this per protocol analysis. [c] This included a range of evidence-based treatments as appropriate (e.g., weight loss, alcohol reduction, sleep posture modification, medical management of nasal obstruction) and assistance with retrial of CPAP or mandibular advancement device therapies if participants were willing. However, there was low uptake of MAD or CPAP (only n = 8 ppts in total) as well as minimal weight loss in either study group or change in health behaviors. [d] Not specified by the study authors if other treatment for OSA was permitted.

Abbreviations. AHI: Apnea-Hypopnea Index; AHI4: AHI with 4% blood oxygen desaturation threshold for hypopneas; AHI3: AHI with 3% blood oxygen desaturation threshold for hypopneas; CI: confidence interval; CPAP: continuous positive airway pressure; ITT: intention to treat; MAD: mandibular advancement device; MCID: minimum clinically meaningful difference; MD: mean difference; mos: months; mUPPP: modified UPPP; NR: not reported; ODI4: oxygen desaturation of 4%; ODI3: oxygen desaturation of 3%; OSA: obstructive sleep apnea; RCT: randomized controlled trial; SD: standard deviation; UPPP: uvulopalatopharyngoplasty.

TABLE D7. DAYTIME SLEEPINESS OUTCOMES

| STUDY INFO | STUDY DESIGN | TIME POINT | MEASURE | SURGERY N | SURGERY MEAN (SD) | NO SURGERY N | NO SURGERY MEAN (SD) | BETWEEN-GROUP ESTIMATE | *P* VALUE |
|---|---|---|---|---|---|---|---|---|---|
| **EPWORTH SLEEPINESS SCALE (SCORE RANGE, 0–24 POINTS; LOWER SCORES ARE BETTER; MCID ≥ 2 POINTS)[59,63]** | | | | | | | | | |
| Browaldh, 2013[43,54]<br>SKUP3 Trial<br>N = 71 | RCT<br>■ UPPP with tonsillectomy<br>■ Waitlist[a] | 6 mos | Mean | 32 | 6.8 (3.9) | 33 | 12.5 (3.9) | NR | NR |
| | | | Change from baseline | 32 | −5.7 (3.9) | 33 | NR | NR | *P* < .001[b] |
| | | | Median | 32 | 6 (range: 2 to 16) | 33 | 12 (range: 5 to 21) | NR | NR |
| MacKay, 2020[46]<br>SAMS Trial<br>N = 102 | RCT<br>■ mUPPP and minimally invasive tongue volume reduction<br>■ Ongoing medical management[c] | 6 mos | Mean | 50 | 5.3 (3.0) | 49 | 10.5 (4.7) | NR | NR |
| | | | Change from baseline | 50 | −7.2 (95% CI, −8.3 to −6.2) | 49 | −0.5 (95% CI, −1.6 to 0.6) | MD, −6.7 (95% CI, −8.2 to −5.2) | *P* < .001 |
| Robinson, 2009[47]<br>N = 166 | Comparative cohort<br>▪ Multilevel multistage surgery[d]<br>■ CPAP | ~4 yrs | Median | 77 | 4.0 (IQR, 4.0) | 89 | 4.0 (IQR, 6.0) | NR | *P* = .78 |
| Sommer, 2016[48]<br>N = 42 | RCT<br>■ UPPP with tonsillectomy<br>■ Waitlist[a] | 3 mos | Mean | 20 | 6.2 (2.9) | 15 | 9.6 (5.2) | NR | NR |
| | | | Change from baseline | 20 | −4.4 (95% CI, −6.4 to −2.3) | 15 | −0.6 (95% CI, −2.5 to 1.3) | MD, −2.5 (95% CI, −3.9 to −1.1) | *P* = .01 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Vicini, 2010[51]<br>N = 50 | RCT<br>■ MMA<br>■ APAP | 12 mos | Mean | 25 | 7.7 (1.3) | 25 | 5.9 (1.6) | NR | NR |
| | | | Change from baseline | 25 | NR | 25 | NR | NR | *P* = .20 |
| Vicini, 2020[52]<br>N = 50 | RCT<br>■ Barbed repositioning pharyngoplasty with tonsillectomy<br>■ Waitlist[e] | 6 mos | Mean | 25 | 3.8 (4.4) | 25 | 10.9 (3.9) | NR | NR |
| | | | Change from baseline | 25 | −5.5 (4.1) | 25 | +0.4 (1.9) | NR | *P* = .00 |

Notes. [a] No treatment at all. [b] ITT analysis did not change the results of this per protocol analysis. [c] This included a range of evidence-based treatments as appropriate (e.g., weight loss, alcohol reduction, sleep posture modification, medical management of nasal obstruction) and assistance with retrial of CPAP or mandibular advancement device therapies if participants were willing. However, there was low uptake of MAD or CPAP (only n = 8 ppts in total) as well as minimal weight loss in either study group or change in health behaviors. [d] UPPP with or without tonsillectomy (100%), geniotubercle advancement (88%); if failure: palatal advancement (67%), hyoid suspension (66%); if failure: midline radiofrequency ablation of the tongue (41%) or submucosal glossectomy techniques (12.5%). [e] Not specified by the study authors if other treatment for OSA was permitted.

Abbreviations. APAP: auto-titrating positive airway pressure; CI: confidence interval; CPAP: continuous positive airway pressure; ITT: intention to treat; IQR: interquartile range; MAD: mandibular advancement device; MCID: minimum clinically meaningful difference; MD: mean difference; MMA: maxillomandibular advancement; mos: months; mUPPP: modified UPPP; NR: not reported; OSA: obstructive sleep apnea; RCT: randomized controlled trial; SD: standard deviation; UPPP: uvulopalatopharyngoplasty; yrs: years.

# APPENDIX E. APPLICABLE CODES

TABLE E1. APPLICABLE CODES FOR SURGICAL TREATMENTS FOR OBSTRUCTIVE SLEEP APNEA

| CODE | DESCRIPTION |
|---|---|
| **ICD-10-CM CODES** | |
| G47.33 | Obstructive sleep apnea (adult) (pediatric) |
| **CPT CODES** | |
| 21110 | Application of interdental fixation device for conditions other than fracture or dislocation, includes removal |
| 21193 | Reconstruction of mandibular rami, horizontal, vertical, C, or L osteotomy; without bone graft |
| 21194 | Reconstruction of mandibular rami, horizontal, vertical, C, or L osteotomy; with bone graft (includes obtaining graft) |
| 21195 | Reconstruction of mandibular rami and/or body, sagittal split; without internal rigid fixation |
| 21196 | Reconstruction of mandibular rami and/or body, sagittal split; with internal rigid fixation |
| 21198 | Osteotomy, mandible, segmental; |
| 21199 | Osteotomy, mandible, segmental; with genioglossus advancement |
| 21206 | Osteotomy, maxilla, segmental (eg, Wassmund or Schuchard) |
| 42145 | Palatopharyngoplasty (eg, uvulopalatopharyngoplasty, uvulopharyngoplasty) |
| 42299 | Unlisted procedure, palate, uvula |
| 42821 | Tonsillectomy and adenoidectomy; age 12 or over |
| 42825 | Tonsillectomy, primary or secondary; younger than age 12 |
| 42826 | Tonsillectomy, primary or secondary; age 12 or over |
| 42950 | Pharyngoplasty (plastic or reconstructive operation on pharynx) |
| 42975 | Drug-induced sleep endoscopy, with dynamic evaluation of velum, pharynx, tongue base, and larynx for evaluation of sleep-disordered breathing, flexible, diagnostic |
| **HCPCS CODES** | |
| | None reported |

Abbreviations. CPT: Current Procedural Terminology; HCPCS: Healthcare Common Procedure Coding System; ICD-10-CM: International Classification of Diseases, Tenth Revision, Clinical Modification.