

SURGICAL TREATMENTS FOR OBSTRUCTIVE SLEEP APNEA

Approved 8/14/2025

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



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

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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



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 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

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(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



BENEFIT

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 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).

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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

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; OD14: Oxygen Desaturation Index with 4% blood oxygen desaturation threshold; OD13: 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 differ¹⁸
- (2) Individual characteristics, such as age, obesity, and cardiopulmonary disease, can be additional factors that affect the degree of oxygen desaturation²
- (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 threshold²
- (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 \geq 3% standard or the AHI4 \geq 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	<ul style="list-style-type: none"> ■ Adults with moderate to severe OSA 	<ul style="list-style-type: none"> ■ Children and adolescents (i.e., aged < 18 years) with OSA ■ Adults with mild OSA ■ Adults with central sleep apnea

CATEGORY	INCLUDED	EXCLUDED
INTERVENTIONS	<p>Surgical airway (i.e., oropharyngeal) interventions including but not limited to:</p> <ul style="list-style-type: none"> ■ 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 	<ul style="list-style-type: none"> ■ Hypoglossal nerve stimulation devices (separate HERC coverage guidance)³⁶ ■ Nasal surgeries alone ■ Airway surgeries no longer used in contemporary practice (e.g., laser-assisted uvulopalatoplasty [LAUP]) ■ Tracheotomy or tracheostomy (salvage procedures) ■ Mandibular advancement devices ■ Noninvasive positive pressure ventilation (e.g., bilevel positive airway pressure, continuous positive airway pressure) ■ Intensive weight loss interventions (e.g., bariatric surgery, medications)
COMPARATORS	<ul style="list-style-type: none"> ■ Nonsurgical OSA interventions (including noninvasive PAP therapy) ■ No treatment 	<ul style="list-style-type: none"> ■ Other surgical airway interventions
OUTCOMES	<p>Critical</p> <ul style="list-style-type: none"> ■ Procedure-related serious adverse events ■ Quality of life <p>Important</p> <ul style="list-style-type: none"> ■ Change in OSA severity (as measured by specific polysomnography indices: AHI, RDI, REI, or ODI) ■ Daytime sleepiness ■ Major adverse cardiac events 	<p>Considered by HERC but not selected for review:</p> <ul style="list-style-type: none"> ■ All-cause mortality ■ Change in A1c ■ Remission of hypertension or diabetes ■ Fatigue-related injury ■ Other polysomnography outcomes ■ General harms
STUDY DESIGNS	<p>KQ1 (effectiveness)</p> <ul style="list-style-type: none"> ■ RCTs of any size ■ Comparative prospective cohort studies (N > 100) <p>KQ2 (harms)</p> <ul style="list-style-type: none"> ■ RCTs and prospective cohort studies (as defined above) ■ Systematic reviews including nonrandomized studies ■ Single-arm prospective NRS (N > 100) ■ Registry studies 	<ul style="list-style-type: none"> ■ Studies conducted in non-very-high-HDI countries ■ 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 DistillerSR⁴⁰ 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 studies⁴¹⁻⁵³ in 16 publications⁴¹⁻⁵⁶ 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 STUDY ^a NAME, TRIAL NUMBER	ELIGIBLE OSA SEVERITY	SAMPLE SIZE	SURGERY	COMPARATOR	OUTCOMES
COUNTRY	MEAN BASELINE AHI ^b	TOTAL FOLLOW- UP	TYPE(S)		
ROB	AHI CRITERIA ^c				
RCTs					
Browalddh, 2013 ^{43,54-56}	<ul style="list-style-type: none"> ■ Moderate ■ Severe 	N = 71 6 months	UPPP with tonsillectomy	Waitlist ^d	<ul style="list-style-type: none"> ■ Daytime sleepiness ■ OSA severity ■ QoL ■ SAEs
SKUP3 Trial, NCT01659671 Sweden Moderate	Severe: 53 AHI3				
MacKay, 2020 ⁴⁶	<ul style="list-style-type: none"> ■ Moderate ■ Severe 	N = 102 6 months	mUPPP and minimally invasive tongue volume reduction	Ongoing medical management ^e	<ul style="list-style-type: none"> ■ Daytime sleepiness ■ OSA severity ■ QoL ■ SAEs
SAMS Trial, ACTRN1261400 0338662 Australia Moderate	Severe: 47.9 (surgery); 45.3 (comparator) AHI3				
Sommer, 2016 ⁴⁸ Germany High	<ul style="list-style-type: none"> ■ Moderate ■ Severe Severe: 34.7 AHI4	N = 42 3 months	UPPP with tonsillectomy	Waitlist ^d	<ul style="list-style-type: none"> ■ Daytime sleepiness ■ OSA severity

Vicini, 2010 ⁵¹ Italy High	<ul style="list-style-type: none"> ■ Severe Severe: 56.8 (surgery); 50.3 (comparator) NR	N = 50 12 months	MMA	APAP	<ul style="list-style-type: none"> ■ SAEs ■ Daytime sleepiness ■ OSA severity ■ SAEs
Vicini, 2020 ⁵² Italy High	<ul style="list-style-type: none"> ■ Moderate ■ Severe Moderate: 25.6 (surgery) Severe: 36.8 (comparator) AHI3	N = 50 6 months	Barbed repositioning pharyngoplasty with tonsillectomy	Waitlist ^f	<ul style="list-style-type: none"> ■ Daytime sleepiness ■ OSA severity ■ SAEs

COMPARATIVE COHORT STUDIES

Robinson, 2009 ⁴⁷ Australia High	<ul style="list-style-type: none"> ■ Moderate ■ Severe Severe (RDI): 44 (surgery); 46.5 (comparator)	N = 166 ~4 years	Multilevel multistage surgery ^g	CPAP	<ul style="list-style-type: none"> ■ Daytime sleepiness ■ QoL ■ SAEs
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REGISTRY STUDIES

Baker, 2016 ⁴¹ ACS-NSQIP database US Moderate	NA	N = 1,079 reports (UPPP alone) ^h Data collection: 2008–2013	UPPP ⁱ	NA	<ul style="list-style-type: none"> ■ SAEs
Brietzke, 2017 ⁴² Truven Health Analytics MarketScan Research Databases US Moderate	NA	N = 7,559 participants (UPPP alone) ^j Data collection: 2010–2012	UPPP	NA	<ul style="list-style-type: none"> ■ SAEs
Kerizian, 2004 ⁴⁵ VA-NSQIP database US High	NA	N = 3,130 reports Data collection: 1991–2001	UPPP	NA	<ul style="list-style-type: none"> ■ SAEs (KQ3 only)

SYSTEMATIC REVIEWS

Iannella, 2022 ⁴⁴ High	NR	N = 15 studies (1,531 participants) 2–56 months	Barbed repositioning pharyngo- plasty with tonsillectomy	NA	■ SAEs
Stuck, 2018 ⁴⁹ Moderate	NR	N = 48 studies (1,919 participants) 1 month–15.75 years	UPPP ^k	NA	■ SAEs
Tang, 2017 ⁵⁰ High	NR	N = 24 studies (2,353 participants) 1 week–20 years	UPPP and mUPPP	NA	■ SAEs
Zhou 2022 ⁵³ Moderate	NR	N = 30 studies (1,610 participants) 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%), genioglossus 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 study⁴⁷) 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	STUDY DESIGN	TIME	MEASURE	SURGERY VS. NO SURGERY BETWEEN-GROUP ESTIMATE	<i>P</i> VALUE
FUNCTIONAL OUTCOMES OF SLEEP QUESTIONNAIRE (SCORE RANGE, 5–20 POINTS; HIGHER SCORES ARE BETTER; MCID ≥ 1 POINT)²¹					
Browaldh, 2013 ^{43,56} SKUP3 Trial N = 71	RCT <ul style="list-style-type: none"> ■ UPPP and tonsillectomy ■ Waitlist (7 mos)^a 	6 mos	Change from baseline	+1.5 vs. -0.2	<i>P</i> < .001 ^b
MacKay, 2020 ⁴⁶ SAMS Trial N = 102	RCT <ul style="list-style-type: none"> ■ mUPPP and minimally invasive tongue volume reduction ■ Ongoing medical management^c 	6 mos	Mean Change from baseline	18.6 vs. 16.3 +3.6 vs. +0.1 MD, 3.4 (95% CI, 2.5 to 4.4)	NR <i>P</i> < .001

Notes. ^aNo treatment at all. ^bITT analysis did not change the results of this per protocol analysis. ^cThis 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 retrieval 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.

TABLE 5. COMPARATIVE GENERAL QOL OUTCOMES

AUTHOR, YEAR	STUDY DESIGN	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	RCT	6 mos	Mean	0.93 vs. 0.86	NR
SAMS Trial N = 102	<ul style="list-style-type: none"> ■ mUPPP and minimally invasive tongue volume reduction ■ Ongoing medical management^a 		Change from baseline	+0.06 vs. 0.00 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}	RCT	6 mos	Mean	51.2 vs. 48.3	P = .007 ^c
SKUP3 Trial N = 71	<ul style="list-style-type: none"> ■ UPPP and tonsillectomy ■ Waitlist^b 				
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}	RCT	6 mos	Mean	48.1 vs. 42.7	P = .03 ^c
SKUP3 Trial N = 71	<ul style="list-style-type: none"> ■ UPPP and tonsillectomy ■ Waitlist^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	Comparative cohort	~4 yrs	Median	19.4 vs. 16.7	P = .79
N = 166	<ul style="list-style-type: none"> ■ Multilevel, multistage surgery^d ■ CPAP 				

Notes. ^aThis 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 retrieval 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. ^bNo treatment at all. ^cITT 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 study⁴⁵ 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 study⁴⁵ 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	OUTCOME	AGE RANGE					
		< 29	30-39	40-49	50-59	60-69	70+

REGISTRY NAME							
SAMPLE SIZE		TOTAL N, N (%)					
Kerizian, 2004 ⁴⁵ VA-NSQIP N = 3,130	Serious complications other than death ^a	n = 99 0 (0)	n = 414 8 (1.9)	n = 1,051 17 (1.6)	n = 979 9 (0.9)	n = 454 12 (2.6)	n = 133 1 (0.8)
	Death	n = 99 0 (0)	n = 414 1 (0.2)	n = 1,051 2 (0.2)	n = 979 1 (0.1)	n = 454 3 (0.7)	n = 133 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	STUDY DESIGN	TIME	MEASURE	SURGERY VS. NO SURGERY 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 SKUP3 Trial N = 71	RCT ■ UPPP and tonsillectomy ■ Waitlist ^a	6 mos	Mean	21.1 vs. 46.8 MD, -26 (95% CI, -37 to -16)	P < .001 ^b
MacKay, 2020 ⁴⁶ SAMS Trial N = 102	RCT ■ mUPPP and minimally invasive tongue volume reduction ■ Ongoing medical management ^c	6 mos	Mean Change from baseline	20.8 vs. 34.5 -27.4 vs. -9.8 MD, -17.6 (95% CI, -26.8 to -8.4)	NR P < .001
Vicini, 2020 ⁵² N = 50	RCT ■ Barbed repositioning pharyngoplasty with tonsillectomy	6 mos	Mean Change from baseline	9.8 vs. 31.9 -15.8 vs. -5	NR P = .01

AUTHOR, YEAR	STUDY DESIGN	TIME POINT	MEASURE	SURGERY VS. NO SURGERY BETWEEN-GROUP ESTIMATE	P VALUE
	<ul style="list-style-type: none"> ■ Waitlist^d 				
AHI4					
Sommer, 2016 ⁴⁸	RCT	3 mos	Mean	15.4 vs. 28.6	NR
N = 42	<ul style="list-style-type: none"> ■ UPPP and tonsillectomy ■ Waitlist^a 		Change from baseline	-18.4 vs. -7.2 MD, -12.8 (95% CI, -18 to -7.5)	P = .036
NR					
Vicini, 2010 ⁵¹	RCT	12 mos	Mean	8.1 vs. 6.3	NR
N = 50	<ul style="list-style-type: none"> ■ MMA ■ APAP 		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	RCT	6 mos	Mean	14.0 vs. 35.6	P < .001 ^b
SKUP3 Trial	<ul style="list-style-type: none"> ■ UPPP and tonsillectomy ■ Waitlist^a 			MD, -25 (95% CI, -36 to -15)	
N = 71					
MacKay, 2020 ⁴⁶	RCT	6 mos	Mean	11.4 vs. 21.6	NR
SAMS Trial	<ul style="list-style-type: none"> ■ mUPPP and minimally invasive tongue volume reduction ■ Ongoing medical management^c 		Change from baseline	-17.7 vs. -4.2 MD, -13.5 (95% CI -20.0 to -7.1)	P = .001
N = 102					
Vicini, 2020 ⁵²	RCT	6 mos	Mean	9.3 vs. 32.4	NR
N = 50	<ul style="list-style-type: none"> ■ Barbed repositioning pharyngoplasty with tonsillectomy ■ Waitlist^d 		Change from baseline	-15.1 vs. -2.8	P = .01
ODI4					
MacKay, 2020 ⁴⁶	RCT	6 mos	Mean	8.1 vs. 15.9	NR
SAMS Trial					

AUTHOR, YEAR	STUDY DESIGN	TIME POINT	MEASURE	SURGERY VS. NO SURGERY BETWEEN-GROUP ESTIMATE	P VALUE
N = 102	<ul style="list-style-type: none"> mUPPP and minimally invasive tongue volume reduction Ongoing medical management^c 		Change from baseline	-15.3 vs. -4.3 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 SKUP3 Trial N = 71	RCT <ul style="list-style-type: none"> UPPP and tonsillectomy Waitlist^a 	6 mos	Mean	25.8 vs. 50.1 MD, -25 (95% CI, -36 to -15)	P < .001 ^b
Sommer, 2016 ⁴⁸ N = 42	RCT <ul style="list-style-type: none"> UPPP and tonsillectomy Waitlist^a 	3 mos	Mean Change from baseline	21.8 vs. 28.7 -12.5 vs. -8.1 MD, -10.3 (95% CI, -18 to -2.8)	NR P = .27

Notes. ^aNo treatment at all. ^bITT analysis did not change the results of this per protocol analysis. ^cThis 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. ^dNot 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 study⁴⁷) 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	STUDY DESIGN				SURGERY VS. NO SURGERY
STUDY NAME	SURGERY TYPE	TIME	MEASURE	BETWEEN-GROUP	
SAMPLE SIZE	CONTROL	POINT		ESTIMATE	P VALUE
EPWORTH SLEEPINESS SCALE (SCORE RANGE, 0–24 POINTS; LOWER SCORES ARE BETTER; MCID ≥ 2 POINTS)^{59,63}					
Browaldh, 2013 ⁴³	RCT	6 mos	Mean	6.8 vs. 12.5	NR
SKUP3 Trial	<ul style="list-style-type: none"> ■ UPPP and tonsillectomy ■ Waitlist^a 		Change from baseline	–5.7 vs. NR	<i>P</i> < .001 ^b
N = 71					
MacKay, 2020 ⁴⁶	RCT	6 mos	Mean	5.3 vs. 10.5	NR
SAMS Trial	<ul style="list-style-type: none"> ■ mUPPP and minimally invasive tongue volume reduction ■ Ongoing medical management^c 		Change from baseline	–7.2 vs. –0.5 MD, –6.7 (95% CI, –8.2 to –5.2)	<i>P</i> < .001
N = 102					
Robinson, 2009 ⁴⁷	Comparative cohort	~4 yrs	Median	4.0 vs. 4.0	<i>P</i> = .78
N = 166	<ul style="list-style-type: none"> ■ Multilevel, multistage surgery^d ■ CPAP 				
Sommer, 2016 ⁴⁸	RCT	3 mos	Mean	6.2 vs. 9.6	NR
N = 42	<ul style="list-style-type: none"> ■ UPPP and tonsillectomy ■ Waitlist^a 		Change from baseline	–4.4 vs. –0.6 MD, –2.5 (95% CI, –3.9 to –1.1)	<i>P</i> = .01
Vicini, 2010 ⁵¹	RCT	12 mos	Mean	7.7 vs. 5.9	NR
N = 50	<ul style="list-style-type: none"> ■ MMA ■ APAP 		Change from baseline	NR	<i>P</i> = .20
Vicini, 2020 ⁵²	RCT	6 mos	Mean	3.8 vs. 10.9	NR
N = 50	<ul style="list-style-type: none"> ■ Barbed repositioning pharyngoplasty with tonsillectomy ■ Waitlist^e 		Change from baseline	–5.5 vs. +0.4	<i>P</i> = .00

Notes. ^aNo treatment at all. ^bITT analysis did not change the results of this per protocol analysis. ^cThis 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 retrieval 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 studies⁴¹⁻⁵³ 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)							
LOCATION	INTERVENTION	COMPARISON					
TOTAL N	N	N	QOL	SAE	AHI	ESS	
Pang (2007) ⁶⁷ Singapore 45	Expansion sphincter pharyngoplasty 23	UPPP 22	–	None	Improved ^a	–	
Fernandez-Julian (2009) ⁶⁸ Spain 57	UPPP + tongue base radiofrequency 29	UPPP + tongue base suspension 28	–	2 ^b	NS	NS	
Shin (2009) ⁶⁹ South Korea 32	mUPPP ^c 16	Classic UPPP 16	–	–	NS	NS	
Neruntarat (2010) ⁷⁰ Thailand 51	Palatal suspension 25	UPPP 26	–	None	NS	NS	
Sundman (2022) ⁷¹ Sweden 93	Tonsillectomy alone 46	mUPPP 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 guidelines 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 guidelines⁷³⁻⁷⁸ 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 surgery⁷³
- 1 task force omitted soft-tissue surgery from the guideline, citing limited new evidence⁷⁵

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 evidence⁷⁷

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	<p>✓ Consider referral for assessment for oropharyngeal (palatal) surgery in people with severe OSAHS who have been unable to tolerate CPAP and a customized MAS</p> <p>✓ Consider tonsillectomy for people with OSAHS who have large obstructive tonsils and a BMI of less than 35 kg/m²</p>	<p>✓ 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</p>	[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 recommendation) or have persistent inadequate PAP adherence (conditional recommendation) ^a
Skeletal Surgeries (including MMA)	✓ Evaluate patients with severe OSA, who cannot tolerate or are not appropriate candidates for other recommended therapies, for alternative	[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 other treatments	✓ Conditional recommendation 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
	treatment with MMA ; (Weak for based on very low quality evidence) ^a	(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. ^aThe 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 is⁷⁹:

- 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 following⁷⁹:

- 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 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 is⁸⁰:

- 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 interventions⁸⁰:

- 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	<ul style="list-style-type: none"> ■ UPPP^a 	<ul style="list-style-type: none"> ■ UPPP^a 	<ul style="list-style-type: none"> ■ UPPP^a ■ Uvulopharyngo-plasty ■ Uvulopalatal flap ■ Expansion pharyngoplasty ■ Lateral pharyngoplasty ■ Transpalatal advancement pharyngoplasty ■ Relocation pharyngoplasty 	<ul style="list-style-type: none"> ■ UPPP^a 	<ul style="list-style-type: none"> ■ UPPP^a 	<ul style="list-style-type: none"> ■ UPPP^a ■ Uvulopharyngo-plasty
AHI, RDI, or REI Criteria	<ul style="list-style-type: none"> ■ RDI ≥ 15 events per hour 	<ul style="list-style-type: none"> ■ RDI ≥ 15 events per hour 	<ul style="list-style-type: none"> ■ AHI or RDI ≥ 15 events per hour with a minimum of 30 events ■ 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: <ul style="list-style-type: none"> ■ History of stroke ■ Hypertension ■ Ischemic heart disease 	<ul style="list-style-type: none"> ■ AHI > 15 events per hour 	<ul style="list-style-type: none"> ■ AHI ≥ 15 events per hour ■ Or AHI 5 to 14 events per hour and at least 1 of the following: <ul style="list-style-type: none"> ■ History of stroke ■ Hypertension ■ Ischemic heart disease ■ Impaired cognition ■ Mood disorders ■ Insomnia ■ Excessive daytime sleepiness 	<ul style="list-style-type: none"> ■ AHI ≥ 15 events per hour ■ Or AHI > 5 events per hour and at least 1 of the following: <ul style="list-style-type: none"> ■ History of stroke ■ Hypertension ■ Ischemic heart disease or CHF ■ Excessive daytime sleepiness ■ Atrial fibrillation ■ Obesity

	WASHINGTON STATE HCA ⁸⁴	MEDICARE (LCD 34526) ⁸⁶	AETNA ⁸³	CIGNA ⁸¹	MODA ⁸²	REGENCE ⁸⁵
			<ul style="list-style-type: none"> ■ Impaired cognition ■ Mood disorders ■ Insomnia ■ Excessive daytime sleepiness ■ Greater than 20 episodes of oxygen desaturation during a full night sleep study, or any 1 episode of oxygen desaturation 			<ul style="list-style-type: none"> ■ Diabetes and glucose intolerance
CPAP, AutoPap, or PAP Criteria	<ul style="list-style-type: none"> ■ Failed to respond to CPAP or cannot tolerate CPAP 	<ul style="list-style-type: none"> ■ Failed to respond to CPAP or cannot tolerate CPAP 	<ul style="list-style-type: none"> ■ Had an inadequate response or are intolerant to CPAP or AutoPAP 	<ul style="list-style-type: none"> ■ Failed to respond to PAP or cannot tolerate PAP or unwillingness to use PAP 	<ul style="list-style-type: none"> ■ Adequate response to CPAP therapy but unable to tolerate CPAP device 	<ul style="list-style-type: none"> ■ Failed PAP usage or not an appropriate PAP candidate
Documented Source of Airway Obstruction (if specified)	<ul style="list-style-type: none"> ■ Retropalatal or combination retropalatal/retrolingual obstruction 	<ul style="list-style-type: none"> ■ Retropalatal or combination retropalatal/retrolingual obstruction 		<ul style="list-style-type: none"> ■ Narrowing or collapse of the retropalatal region (e.g., soft palate, uvula, tonsils, posterior 	<ul style="list-style-type: none"> ■ Narrowing or collapse of the retropalatal region 	<ul style="list-style-type: none"> ■ Upper airway collapse or obstruction (e.g., palatine tonsils, epiglottis collapse, arytenoid collapse, lateral

WASHINGTON STATE HCA ⁸⁴	MEDICARE (LCD 34526) ⁸⁶	AETNA ⁸³	CIGNA ⁸¹	MODA ⁸²	REGENCE ⁸⁵
			pharyngeal wall)		pharyngeal, craniofacial deficits)
Additional Criteria (if specified)					<ul style="list-style-type: none"> ■ An adequate trial of a custom-made mandibular repositioning appliance has failed or the patient is not an appropriate mandibular repositioning appliance candidate

Note. ^aUPPP 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	<ul style="list-style-type: none"> ■ Surgery to correct enlarged tonsils 	<ul style="list-style-type: none"> ■ Surgery to correct enlarged tonsils 	<ul style="list-style-type: none"> ■ Lingual tonsillectomy ■ Pharyngeal tonsillectomy 	<ul style="list-style-type: none"> ■ Not covered (the policy does not describe tonsillectomy alone) 	<ul style="list-style-type: none"> ■ Not covered (the policy describes lingual tonsillectomy and pharyngeal tonsillectomy as experimental and investigational for OSA) 	<ul style="list-style-type: none"> ■ Not covered (the policy does not describe tonsillectomy alone)
Documented Source of Airway Obstruction (if specified)	<ul style="list-style-type: none"> ■ Enlarged tonsils 	<ul style="list-style-type: none"> ■ Enlarged tonsils 	<ul style="list-style-type: none"> ■ Hypertrophied tonsils comprising the airway space 	<ul style="list-style-type: none"> ■ NA (not covered) 	<ul style="list-style-type: none"> ■ NA (not covered) 	<ul style="list-style-type: none"> ■ 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	<ul style="list-style-type: none"> ■ Mandibular maxillary osteotomy and advancement and/or genioglossus advancement with or without hyoid suspension 	<ul style="list-style-type: none"> ■ Mandibular maxillary osteotomy and advancement and/or genioglossus advancement with or without hyoid suspension 	<ul style="list-style-type: none"> ■ Jaw realignment surgery (i.e., mandibular osteotomy, genioglossus advancement, hyoid myotomy and suspension^a) 	<ul style="list-style-type: none"> ■ Mandibular maxillary osteotomy and advancement (as a combined procedure or as stepwise multiple procedures) ■ Maxillomandibular advancement ■ Genioglossus advancement and hyoid myotomy 	<ul style="list-style-type: none"> ■ Maxillomandibular osteotomy and advancement^b ■ Mandibular osteotomy^b ■ Genioplasty^c 	<ul style="list-style-type: none"> ■ Mandibular osteotomy with or without genioglossus advancement ■ Maxillomandibular advancement ■ Hyoid myotomy and suspension
AHI, RDI, or REI Criteria (if specified)	<ul style="list-style-type: none"> ■ RDI > 15 events per hour 	<ul style="list-style-type: none"> ■ RDI > 15 events per hour 		<ul style="list-style-type: none"> ■ AHI > 15 events per hour 		<ul style="list-style-type: none"> ■ AHI > 15 events per hour ■ Or AHI > 5 events per hour and at least 1 of the following: <ul style="list-style-type: none"> ■ History of stroke ■ Hypertension ■ Ischemic heart disease or CHF ■ Excessive daytime sleepiness ■ Atrial fibrillation ■ Obesity ■ Diabetes and glucose intolerance

	WASHINGTON STATE HCA ⁸⁴	MEDICARE ⁸⁶	AETNA ⁸³	CIGNA ⁸¹	MODA ⁸⁹	REGENCE ⁸⁵
CPAP or PAP Criteria (if specified)	<ul style="list-style-type: none"> Failed to respond to CPAP or cannot tolerate CPAP 	<ul style="list-style-type: none"> Failed to respond to CPAP or cannot tolerate CPAP 		<ul style="list-style-type: none"> Failed to respond to PAP or cannot tolerate PAP or unwillingness to use PAP 		<ul style="list-style-type: none"> Failed PAP usage or not an appropriate PAP candidate
Documented Source of Airway Obstruction (if specified)	<ul style="list-style-type: none"> Evidence of retrolingual obstruction as the cause of the OSA (or previous failure of UPPP to correct the OSA) 	<ul style="list-style-type: none"> Evidence of retrolingual obstruction as the cause of the OSA (or previous failure of UPPP to correct the OSA) 				<ul style="list-style-type: none"> Upper airway collapse or obstruction (e.g., palatine tonsils, epiglottis collapse, arytenoid collapse, lateral pharyngeal, craniofacial deficits)
Additional Criteria (if specified)				<ul style="list-style-type: none"> A mandibular repositioning appliance or tongue-retaining appliance has been considered and found to be ineffective or undesirable Additional criteria for maxillomandibular advancement: craniofacial disproportion or deformities 		<ul style="list-style-type: none"> An adequate trial of a custom-made mandibular repositioning appliance failed or the patient is not an appropriate mandibular repositioning appliance candidate

Notes. ^aJaw realignment surgery may be subject to review by Aetna's Oral and Maxillofacial Surgery Unit to assess medical necessity.⁸³ ^bA 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 ^cPer 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 (2 RCTs and 1 comparative cohort study) N = 339	<p>Serious</p> <p>Downgraded 2 levels:</p> <ul style="list-style-type: none"> 2 RCTs rated as moderate RoB, 1 comparative cohort study rated as high RoB Unblinded studies are a major concern when outcome measures are patient-reported (downgraded 1 level) <p>Downgraded 1 level:</p> <ul style="list-style-type: none"> It is unclear in the comparative cohort study that used GBI how the study authors adapted the assessment for the nonsurgical group Details on confounding 	<p>Not serious</p> <ul style="list-style-type: none"> Consistent direction of effect in FOSQ and SF-36 (favoring surgery) Inconsistencies can be explained by the nature of the comparison group 	<p>Not serious</p> <ul style="list-style-type: none"> 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 Surgical techniques have evolved over time and studied procedures, 	<p>Not serious</p> <ul style="list-style-type: none"> Although sample sizes were small, the studies were generally well powered to detect differences in QoL Some imprecision in confidence intervals 	<ul style="list-style-type: none"> Limited long-term data to assess an ongoing intervention (approximately 4 years is the longest follow-up) 	<p>LOW</p>

NO. OF STUDIES SAMPLE SIZE	RISK OF BIAS	INCONSISTENCY	INDIRECTNESS	IMPRECISION	OTHER FACTORS	LEVEL OF CONFIDENCE
	variables in the comparative cohort study were lacking <ul style="list-style-type: none"> ■ Lack of funding information in the cohort study 		especially in older studies, may not reflect contemporary practice <ul style="list-style-type: none"> ■ Some heterogeneity in time points for assessment (range is 6 months to 4 years) 			

PROCEDURE-RELATED SAE						
12 studies (5 RCTs, 1 comparative cohort, 2 registry studies, and 4 SRs) N = 15,503	Not serious <ul style="list-style-type: none"> ■ 6 studies rated as moderate RoB, 6 studies rated as high RoB ■ Some author COI concerns and limited funding information 	Not serious <ul style="list-style-type: none"> ■ Generally consistent findings in terms of reported SAEs ■ Generally low rates of SAEs ■ Inconsistencies can be explained by the nature of the surgery 	Serious Downgraded 1 level <ul style="list-style-type: none"> ■ Differences in classification of SAEs and inability to differentiate seriousness of adverse events ■ Inability to precisely determine population with moderate to severe OSA in some studies ■ Surgical techniques have evolved over time and studied procedures, especially in 	Not serious <ul style="list-style-type: none"> ■ Few events are reported; studies have generally large sample sizes 	<ul style="list-style-type: none"> ■ None 	Moderate 

**NO. OF STUDIES
SAMPLE SIZE**

RISK OF BIAS

INCONSISTENCY

INDIRECTNESS

IMPRECISION

OTHER FACTORS

**LEVEL OF
CONFIDENCE**

older studies,
may not reflect
contemporary
practice

OSA SEVERITY (POLYSOMNOGRAPHY INDICES)

5 studies
(5 RCTs)
N = 315

Serious

Downgraded 1 level

- 2 studies rated as moderate RoB, 3 studies rated as high RoB
- Lack of funding information
- Some concerns with author COI
- Lack of ability to blind
- Issues with adequacy of allocation concealment
- Lack of information on randomization or issues with rigor of randomization methods

Not serious

- Generally consistent direction and magnitude of effect
- Inconsistencies can be explained by the nature of the comparison group or differences in the polysomnography measure used (AHI3, AHI4, ODI3, OD4, RDI)

Serious

Downgraded 1 level

- Mismatch in definition of AHI may overestimate change in AHI (downgraded 1 level)
- 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

Not serious

- Although population sample sizes are small, studies were generally powered to detect changes in OSA severity by AHI
- 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



**NO. OF STUDIES
SAMPLE SIZE**

RISK OF BIAS

INCONSISTENCY

INDIRECTNESS

IMPRECISION

OTHER FACTORS

**LEVEL OF
CONFIDENCE**

population with OSA

- Surgical techniques have evolved over time and studied procedures, especially in older studies, may not reflect contemporary practice

DAYTIME SLEEPINESS

6 studies
(5 RCTs and 1 comparative cohort study)
N = 481

Serious

Downgraded 2 levels

- 2 RCTs rated as moderate RoB, 4 studies (3 RCTs and 1 comparative cohort study) rated as high RoB
- Unblinded studies are a major concern when outcome measures are patient-reported (downgraded 1 level)
- Downgraded 1 level for:

Not serious

- Generally consistent direction and magnitude of effect
- 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

- 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

Not serious

- Although population sample sizes are generally small, the studies are generally well powered to assess ESS (the measure of daytime sleepiness evaluated)
- 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



NO. OF STUDIES SAMPLE SIZE	RISK OF BIAS	INCONSISTENCY	INDIRECTNESS	IMPRECISION	OTHER FACTORS	LEVEL OF CONFIDENCE
	<ul style="list-style-type: none"> ■ Issues with adequacy of allocation concealment for RCTs ■ Lack of funding information ■ Some concerns with author COI for RCTs ■ Details on confounding variables in the cohort study were lacking 		<p>population with OSA</p> <ul style="list-style-type: none"> ■ Surgical techniques have evolved over time and studied procedures, especially in older studies, may not reflect contemporary practice ■ 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 \geq 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, tonsillectomy, 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

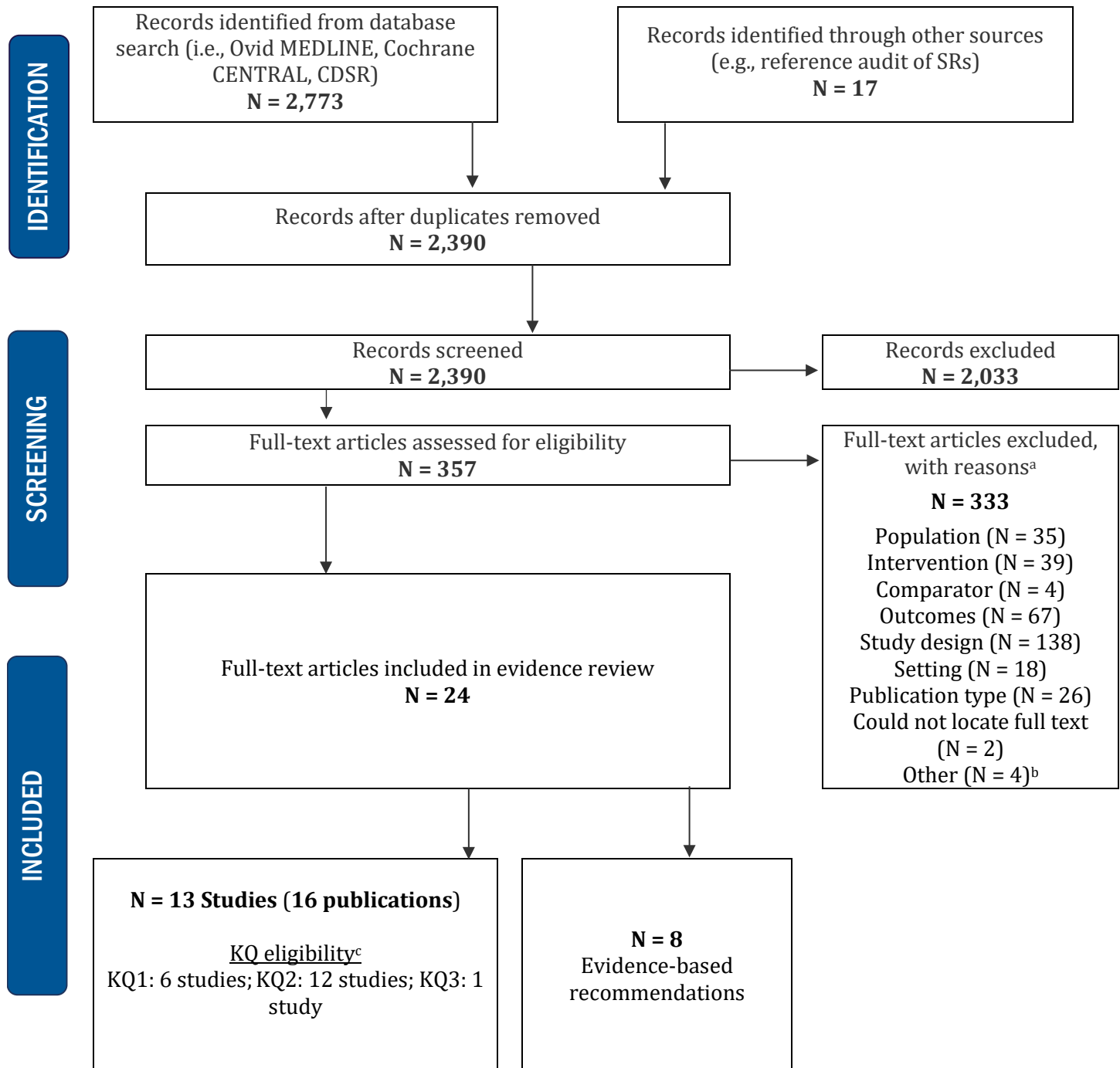
Low risk of bias cohort studies include a sample that is representative of the source population, have low loss to follow-up, and measure and consider relevant confounding factors. Low risk of bias cohort studies also list their funding source(s) and have a low potential of bias from conflicts of interest. 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	STUDY GROUPS	MEAN AGE	MEAN BMI	BASELINE CHARACTERISTICS				
						CPAP TRIAL REQUIRED BEFORE STUDY	MEAN AHI	MEAN ESS	% FEMALE	% RACE/ ETHNICITY ^a
RCTs										
Browaldh, 2013 ^{43,55} SKUP3 Trial Moderate	N = 71 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 SAMS Trial Moderate	N = 102 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% 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% Other: 9.8%
Sommer, 2016 ⁴⁸ High	N = 42 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 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	BASELINE CHARACTERISTICS									
	STUDY OR REGISTRY NAME	POPULATION DESCRIPTION	STUDY SETTING	STUDY GROUPS	MEAN AGE	MEAN BMI	CPAP TRIAL REQUIRED BEFORE STUDY	MEAN AHI	MEAN ESS	% FEMALE
Vicini, 2020 ⁵²	N = 50	1 hospital in Italy	Barbed repositioning pharyngoplasty with tonsillectomy	44.6 yrs	26.5 kg/m ²	Yes	25.6 events/hr	9.3	12%	NR
High	Adults with moderate to severe OSA		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	N = 166	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
High	Adults with moderate to severe OSA		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	N= 1,692 (UPPP alone: 1,079)	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%
Moderate	Adults with sleep apnea who									Black or African

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

Notes. ^aTerminology used is directly from study publications. ^bNo other treatment for OSA permitted. ^cNot required if Friedman stage 1 and BMI < 30 kg/m². ^d(e.g., CPAP, MAD, behavioral interventions), low uptake of MAD or CPAP. ^eNot specified by the study authors if other treatment for OSA was permitted. ^fUPPP with or without tonsillectomy (100%), genioglossus 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%). ^gWith 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	REVIEW OBJECTIVE	PUBLICATION DATE RANGE	STUDY INCLUSION CRITERIA	STUDY EXCLUSION CRITERIA	TOTAL INCLUDED STUDIES	TOTAL PARTICIPANTS
Iannella, 2022 ⁴⁴ Barbed repositioning pharyngoplasty with tonsillectomy High	To present the state of the art and evolution on barbed repositioning pharyngoplasty in velopharyngeal surgery.	2015 to 2021	<ul style="list-style-type: none"> ■ Prospective and retrospective studies on barbed repositioning pharyngoplasty ■ Snorers and OSA patients ■ Single level procedure and/or as a part of multilevel surgery ■ Studies comparing barbed repositioning pharyngoplasty with other similar velopharyngeal surgical techniques 	<ul style="list-style-type: none"> ■ Studies not in English ■ Case reports, reviews, meta-analysis, conference abstracts, and letters to the editor ■ Studies with unclear and/or incomplete data ■ 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 <ul style="list-style-type: none"> ■ Prospective cohort studies ■ Retrospective cohort studies ■ RCTs 	1,531 participants

AUTHOR, YEAR	SURGERY RISK OF BIAS	REVIEW OBJECTIVE	PUBLICATION DATE RANGE	STUDY INCLUSION CRITERIA	STUDY EXCLUSION CRITERIA	TOTAL INCLUDED STUDIES	TOTAL PARTICIPANTS
Stuck, 2018 UPPP ^{49,a} 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	<ul style="list-style-type: none"> Adult patients with OSA diagnosed by PSG or comparative objective measures Studies in English, French, German, or Dutch RCTs, nonrandomized controlled trials, prospective cohort studies Effectiveness data Retrospective studies, case series, and reports that otherwise met inclusion criteria Adverse events, Studies evaluating survival/mortality 	<ul style="list-style-type: none"> Experimental/trial studies or not clinical studies E.g., reviews, guidelines, study protocols, conference proceedings, comments, posters or a letter to the editor Studies evaluating significant surgical variations of UPPP Studies that included patients undergoing concomitant surgery 	N = 48 studies <ul style="list-style-type: none"> Prospective cohort studies RCTs Controlled clinical trials 	1,919 participants	
Tang, 2017 ⁵⁰ UPPP and mUPPP High	To assess the incidence of long-term VPI and to determine other sequelae following classic and modified	1984 to 2013	<ul style="list-style-type: none"> Studies in English Discussed the complications of UPPP, specifically reporting the incidence of VPI or another variation of 	<ul style="list-style-type: none"> Studies not in English Did not mention VPI or any other descriptive form of VPI as a 	N = 24 studies <ul style="list-style-type: none"> NR 	2,353 participants	

AUTHOR, YEAR					TOTAL INCLUDED	
SURGERY	REVIEW	PUBLICATION	STUDY INCLUSION	STUDY EXCLUSION	STUDIES	TOTAL
RISK OF BIAS	OBJECTIVE	DATE RANGE	CRITERIA	CRITERIA	STUDY DESIGNS	PARTICIPANTS
	UPPP for the treatment of OSA.		<p>VPI such as nasal regurgitation, nasopharyngeal reflux, swallowing reflux, pharyngonasal reflux, palatopharyngeal incompetency, or nasopharyngeal unclosure</p> <ul style="list-style-type: none"> ■ Included only classic or modified UPPP procedures 	<p>complication of UPPP</p> <ul style="list-style-type: none"> ■ Other methods of UPPP outside of the classic or modified approach such as laser-assisted or radiofrequency-assisted ■ Reported the incidences of VPI in combination with other sequelae such as difficulty swallowing. 		
Zhou, 2022 ⁵³ MMA 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)	<ul style="list-style-type: none"> ■ Adult patients (> 18 years old) ■ Moderate-to-severe OSA (PSG; AHI ≥ 15 events/h) ■ Patients underwent MMA or UAS for OSA ■ Studies that reported pre- and postoperative PSG data ■ Follow-up ≥ 6 months 	<ul style="list-style-type: none"> ■ Sample size < 10 patients ■ Patients who underwent other adjunctive surgical at the time of MMA or UAS ■ Preliminary studies in which the findings were nested in other studies with larger sample size 	N = 30 studies (21 studies on MMA) <ul style="list-style-type: none"> ■ Prospective cohort studies ■ Retrospective cohort studies ■ RCTs 	1,610 participants (581 participants with MMA)

AUTHOR, YEAR	REVIEW OBJECTIVE	PUBLICATION DATE RANGE	STUDY INCLUSION CRITERIA	STUDY EXCLUSION CRITERIA	TOTAL INCLUDED STUDIES	TOTAL PARTICIPANTS
	were also investigated.		<ul style="list-style-type: none"> Randomized controlled trials (RCTs), quasi-experimental studies, and cohort studies 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		NO SURGERY		BETWEEN-GROUP ESTIMATE	P VALUE
				N	MEAN (SD)	N	MEAN (SD)		
FUNCTIONAL OUTCOMES OF SLEEP QUESTIONNAIRE (SCORE RANGE, 5–20 POINTS; HIGHER SCORES ARE BETTER; MCID ≥ 1 POINT)²¹									
Browaldh, 2013 ^{43,56} SKUP3 Trial N = 71 Moderate RoB	RCT ■ UPPP and tonsillectomy ■ Waitlist ^a	6 mos	Change from baseline	32	+1.5 (2.6)	33	-0.2 (1.2)	NR	<i>P</i> <.001 ^b
MacKay, 2020 ⁴⁶ SAMS Trial N = 102 Moderate RoB	RCT ■ mUPPP and minimally invasive tongue volume reduction ■ 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)	<i>P</i> <.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		NO SURGERY		BETWEEN-GROUP ESTIMATE	P VALUE
				N	MEAN (SD)	N	MEAN (SD)		
SAMS Trial N = 102 Moderate RoB	<ul style="list-style-type: none"> mUPPP and minimally invasive tongue volume reduction 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 INDICATE A BETTER HEALTH-RELATED QUALITY OF LIFE; MCID ≥ 3 POINTS)^{54, 59}

Browaldh, 2013 ^{43,54} SKUP3 Trial N = 71 Moderate RoB	<ul style="list-style-type: none"> UPPP and tonsillectomy Waitlist^a 	6 mos	Mean	31	51.2 (8.8)	31	48.3 (9.1)	NR	P = .007 ^b
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SHORT FORM-36 QUESTIONNAIRE: MENTAL HEALTH COMPONENT (SCORE RANGE 0 TO 100; HIGHER SCORES INDICATE A BETTER HEALTH-RELATED QUALITY OF LIFE; MCID ≥ 3 POINTS)^{54,59}

Browaldh, 2013 ⁵⁴ SKUP3 Trial N = 71 Moderate RoB	<ul style="list-style-type: none"> UPPP and tonsillectomy Waitlist^a 	6 mos	Mean	31	48.1 (9.7)	31	42.7 (11.5)	NR	P = .03 ^b
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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 N = 166 High RoB	<ul style="list-style-type: none"> Multilevel multistage surgery^d CPAP 	~4 yrs	Median	77	19.4 (IQR, 25)	89	16.7 (IQR, 22.2)	NR	P = .79
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Notes ^aNo treatment at all. ^bITT analysis did not change the results of this per protocol analysis. ^cThis 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 pts in total) as well as minimal weight loss in either study group or change in health behaviors. ^dUPPP 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 EVENTS
RCTs					
Browaldh, 2013 ⁴³ SKUP3 Trial N = 71 Moderate RoB	■ UPPP with tonsillectomy	6 mos	n (%)	Total SAE	32 0 (0) ^a
MacKay, 2020 ⁴⁶ SAMS Trial N = 102 Moderate RoB	■ mUPPP and minimally invasive tongue volume reduction	6 mos	n (%)	Total SAE	50 2 (4)
Sommer, 2016 ⁴⁸ N = 42 High RoB	■ UPPP with tonsillectomy	3 mos	n (%)	Postoperative hemorrhages ^{b, c}	39 2 (5.1)
			n (%)	Repeat surgery ^c	39 1 (2.6)
Vicini, 2010 ⁵¹ N = 50 High RoB	■ MMA	12 mos	n (%)	Total SAE	25 0 (0)
Vicini, 2020 ⁵²	■ Barbed repositioning	6 mos	n (%)	Total SAE	25 0 (0)

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

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

STUDY INFO	SURGERY	TIME POINT	MEASURE	OUTCOME	TOTAL N EVENTS
		15–60 days post-op	n (%)	Dysphagia ^b	7,559 128 (1.7)
		61–183 days post-op	n (%)	Dysphagia ^b	7,559 187 (2.5)
		15–60 days post-op	n (%)	Velopharyngeal insufficiency ^b	7,559 21 (0.3)
		61–183 days post-op	n (%)	Velopharyngeal insufficiency ^b	7,559 20 (0.3)

SYSTEMATIC REVIEWS

Iannella, 2022 ⁴⁴ 15 studies/n = 1,531 High RoB	■ Barbed repositioning pharyngoplasty with tonsillectomy	NA	Events	Significant intra-operative or post-operative complications	15 studies 0
Stuck, 2018 ⁴⁹ 48 studies/n = 1,919 Moderate RoB	■ UPPP ^k	NA	No. studies	Major complication ^l	48 studies 8 studies ^l
			Rate	Complication Rate "airway"	Out of 8 studies ^m 0% to 13.3%
			Rate	Complication Rate "bleeding" ⁿ	Out of 8 studies ^m 0% to 7.8%

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

Notes. ^aThe 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%), geniogloss 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 pts 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		NO SURGERY		BETWEEN-GROUP ESTIMATE	P VALUE
				N	MEAN (SD)	N	MEAN (SD)		
APNEA-HYPOPNEA INDEX (EVENTS PER HOUR; LOWER SCORES ARE BETTER; MCID ≥ 5 EVENTS PER HOUR)⁵⁹									
AHI3									
Browaldh, 2013 ⁴³ SKUP3 Trial N = 71 Moderate RoB	RCT ■ UPPP with tonsillectomy ■ 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 SAMS Trial N = 102 Moderate RoB	RCT ■ mUPPP and minimally invasive tongue volume reduction ■ 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 N = 50 High RoB	RCT ■ Barbed repositioning pharyngoplasty with tonsillectomy ■ 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		NO SURGERY		BETWEEN-GROUP ESTIMATE	P VALUE
				N	MEAN (SD)	N	MEAN (SD)		
Sommer, 2016 ⁴⁸ N = 42 High RoB	<ul style="list-style-type: none"> ■ UPPP with tonsillectomy ■ 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 N = 50 High RoB	RCT <ul style="list-style-type: none"> ■ MMA ■ 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 SKUP3 Trial N = 71 Moderate RoB	RCT <ul style="list-style-type: none"> ■ UPPP with tonsillectomy ■ 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 SAMS Trial N = 102 Moderate RoB	RCT <ul style="list-style-type: none"> ■ mUPPP and minimally invasive tongue volume reduction ■ 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		NO SURGERY		BETWEEN-GROUP ESTIMATE	P VALUE
				N	MEAN (SD)	N	MEAN (SD)		
Vicini, 2020 ⁵² N = 50 High RoB	<ul style="list-style-type: none"> Barbed repositioning pharyngoplasty with tonsillectomy 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 SAMS Trial N = 102 Moderate RoB	<ul style="list-style-type: none"> mUPPP and minimally invasive tongue volume reduction 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 SKUP3 Trial N = 71 Moderate RoB	<ul style="list-style-type: none"> UPPP with tonsillectomy 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
			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
Sommer, 2016 ⁴⁸ N = 42 High RoB	<ul style="list-style-type: none"> UPPP with tonsillectomy 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. ^aNo treatment at all. ^bITT analysis did not change the results of this per protocol analysis. ^cThis 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 retriial 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. ^dNot 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		NO SURGERY		BETWEEN-GROUP ESTIMATE	P VALUE
				N	MEAN (SD)	N	MEAN (SD)		
EPWORTH SLEEPINESS SCALE (SCORE RANGE, 0–24 POINTS; LOWER SCORES ARE BETTER; MCID ≥ 2 POINTS)^{59,63}									
Browaldh, 2013 ^{43,54} SKUP3 Trial N = 71	RCT ■ UPPP with tonsillectomy ■ 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	<i>P</i> < .001 ^b
			Median	32	6 (range: 2 to 16)	33	12 (range: 5 to 21)	NR	NR
MacKay, 2020 ⁴⁶ SAMS Trial N = 102	RCT ■ mUPPP and minimally invasive tongue volume reduction ■ 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)	<i>P</i> < .001
Robinson, 2009 ⁴⁷ N = 166	Comparative cohort ■ Multilevel multistage surgery ^d ■ CPAP	~4 yrs	Median	77	4.0 (IQR, 4.0)	89	4.0 (IQR, 6.0)	NR	<i>P</i> = .78
Sommer, 2016 ⁴⁸ N = 42	RCT ■ UPPP with tonsillectomy ■ 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)	<i>P</i> = .01

Vicini, 2010 ⁵¹ N = 50	RCT ■ MMA ■ APAP	12 mos	Mean	25	7.7 (1.3)	25	5.9 (1.6)	NR	NR
			Change from baseline	25	NR	25	NR	NR	<i>P</i> = .20
Vicini, 2020 ⁵² N = 50	RCT ■ Barbed repositioning pharyngoplasty with tonsillectomy ■ 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	<i>P</i> = .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 retrieval of CPAP or mandibular advancement device therapies if participants were willing. However, there was low uptake of MAD or CPAP (only n = 8 pts 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 (4.1%) 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.