Medical Policy

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Title: Surgical Treatment of Snoring and Obstructive Sleep Apnea (OSA) Syndrome

Related Policy:	▪ *Diagnosis and Medical Management of Obstructive Sleep Apnea Syndrome*

Professional / Institutional
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Populations	Interventions	Comparators	Outcomes
Individuals: • With obstructive sleep apnea.	Interventions of interest are: • Laser-assisted uvulopalatoplasty	Comparators of interest are: • Continuous positive airway pressure • Conventional surgical procedures	Relevant outcomes include: • Symptoms • Functional outcomes • Quality of life • Treatment-related morbidity
Individuals: • With obstructive sleep apnea.	Interventions of interest are: • Tongue base suspension	Comparators of interest are: • Continuous positive airway pressure	Relevant outcomes include: • Symptoms • Functional outcomes • Quality of life

Populations	Interventions	Comparators	Outcomes
		• Conventional surgical procedures	• Treatment-related morbidity
Individuals: • With obstructive sleep apnea.	Interventions of interest are: • Radiofrequency volumetric reduction of palatal tissues and base of tongue	Comparators of interest are: • Continuous positive airway pressure • Conventional surgical procedures	Relevant outcomes include: • Symptoms • Functional outcomes • Quality of life • Treatment-related morbidity
Individuals: • With obstructive sleep apnea.	Interventions of interest are: • Palatal stiffening procedures	Comparators of interest are: • Continuous positive airway pressure • Conventional surgical procedures	Relevant outcomes include: • Symptoms • Functional outcomes • Quality of life • Treatment-related morbidity
Individuals: • With obstructive sleep apnea.	Interventions of interest are: • Hypoglossal nerve stimulation	Comparators of interest are: • Conventional surgical procedures	Relevant outcomes include: • Symptoms • Functional outcomes • Quality of life • Treatment-related morbidity

DESCRIPTION

Obstructive sleep apnea (OSA) syndrome is characterized by repetitive episodes of upper airway obstruction due to the collapse of the upper airway during sleep. For individuals who have failed conservative therapy, established surgical approaches may be indicated. This evidence review addresses minimally invasive surgical procedures for the treatment of OSA. They include laser-assisted uvuloplasty, tongue base suspension, radiofrequency volumetric reduction of palatal tissues and base of tongue, palatal stiffening procedures, and hypoglossal nerve stimulation (HNS). This evidence review does not address conventional surgical procedures such as uvulopalatopharyngoplasty (UPPP), hyoid suspension, surgical modification of the tongue, maxillofacial surgery, or adenotonsillectomy.

OBJECTIVE

The objective of this evidence review is to determine whether the use of minimally invasive surgical procedures improves the net health outcome for individuals being treated for obstructive sleep apnea.

BACKGROUND

Obstructive Sleep Apnea

Obstructive sleep apnea (OSA) is characterized by repetitive episodes of upper airway obstruction due to the collapse and obstruction of the upper airway during sleep. The hallmark symptom of OSA is excessive daytime sleepiness, and the typical clinical sign of OSA is snoring, which can abruptly cease and be followed by gasping associated with a brief arousal from sleep. The snoring resumes when the patient falls back to sleep, and the cycle of snoring/apnea/arousal may be repeated as frequently as every minute throughout the night. Sleep fragmentation

associated with the repeated arousal during sleep can impair daytime activity. For example, adults with OSA-associated daytime somnolence are thought to be at higher risk for accidents involving motorized vehicles (ie, cars, trucks, heavy equipment). OSA in children may result in neurocognitive impairment and behavioral problems. In addition, OSA affects the cardiovascular and pulmonary systems. For example, apnea leads to periods of hypoxia, alveolar hypoventilation, hypercapnia, and acidosis. This, in turn, can cause systemic hypertension, cardiac arrhythmias, and cor pulmonale. Systemic hypertension is common in individuals with OSA. Severe OSA is associated with decreased survival, presumably related to severe hypoxemia, hypertension, or an increase in automobile accidents related to overwhelming sleepiness.

There are racial and ethnic health disparities seen for OSA, impacting the prevalence of disease and accessibility to treatment options, particularly affecting children. Black children are 4 to 6 times more likely to have OSA than White children.[1,] Among young adults 26 years of age or younger, African American individuals are 88% more likely to have OSA compared to White individuals. Another study found that African American individuals 65 years of age and older were 2.1 times more likely to have severe OSA than White individuals of the same age group. These health disparities may affect accessibility to treatment for OSA and impact health outcomes. One analysis of insurance claims data, including over 500,000 patients with a diagnosis of OSA, found that increased age above the 18- to 29-year range ($p<.001$) and Black race ($p=.020$) were independently associated with a decreased likelihood of receiving surgery for sleep apnea.[2,] Lee et al (2022) found that Black men had a continuous mortality increase specifically related to OSA over the study period (1999 to 2019; annual percentage change 2.7%; 95% confidence interval, 1.2 to 4.2) compared to any other racial group.[3,]

Terminology and diagnostic criteria for OSA are shown in Table 1.

Table 1. Terminology and Definitions for Obstructive Sleep Apnea

Terms	Definitions
Respiratory Event	
Apnea	The frequency of apneas and hypopneas is measured from channels assessing oxygen desaturation, respiratory airflow, and respiratory effort. In adults, apnea is defined as a drop in airflow by ≥90% of the pre-event baseline for at least 10 seconds. Due to faster respiratory rates in children, pediatric scoring criteria define apnea as ≥2 missed breaths, regardless of its duration in seconds.
Hypopnea	Hypopnea in adults is scored when the peak airflow drops by at least 30% of the pre-event baseline for at least 10 seconds in association with either at least 3% or 4% decrease in arterial oxygen desaturation (depending on the scoring criteria) or arousal. Hypopneas in children are scored by a ≥50% drop in nasal pressure and either a ≥3% decrease in oxygen saturation or associated arousal.
RERA	RERA is defined as an event lasting at least 10 seconds associated with flattening of the nasal pressure waveform and/or evidence of increased respiratory effort, terminating in arousal but not otherwise meeting criteria for apnea or hypopnea.
Respiratory event reporting	
AHI	The average number of apneas or hypopneas per hour of sleep.

Terms	Definitions
RDI	The RDI is the number of apneas, hypopneas, or respiratory event-related arousals per hour of sleep time. RDI is often used synonymously with the AHI.
REI	The respiratory event index is the number of events per hour of monitoring time. Used as an alternative to AHI or RDI in-home sleep studies when actual sleep time from EEG is not available.
Diagnosis	
OSA	Repetitive episodes of upper airway obstruction due to the collapse and obstruction of the upper airway during sleep.
Mild OSA	Adults: AHI 5 to <15; Children: AHI ≥1 to 5
Moderate OSA	Adults: AHI 15 to <30; Children: AHI >5 to 10
Severe OSA	Adults: AHI ≥30; Children: AHI >10
Treatment	
PAP	CPAP, APAP, or Bi-PAP
PAP Failure	Usually defined as an AHI greater than ≥15 to 20 events per hour while using PAP.
PAP Intolerance	PAP use for less than 4 h per night for 5 nights or more per week, or refusal to use CPAP. CPAP intolerance may be observed in patients with mild, moderate, or severe OSA

AHI: Apnea/Hypopnea Index; APAP: auto-adjusting positive airway pressure; Bi-PAP: Bi-level positive airway pressure; CPAP: continuous positive airway pressure; EEG: electroencephalogram; OSA: obstructive sleep apnea; PAP: positive airway pressure; RDI: Respiratory Disturbance Index; REI: Respiratory Event Index; RERA: respiratory event-related arousal.

REGULATORY STATUS

The regulatory status of minimally invasive surgical interventions is shown in Table 2.

Table 2. Minimally Invasive Surgical Interventions for Obstructive Sleep Apnea

Interventions	Devices (predicate or prior name)	Manufacturer (previous owner)	Indication	PMA/ 510(k)	Year	FDA Product Code
LAUP	Various					
Radiofrequency ablation	Somnoplasty®	Somnus Medical Technologies (now Olympus)	Simple snoring and for the base of the tongue for OSA	K982717	1998	GEI
Palatal Implant	Pillar® Palatal Implant	Pillar Palatal (Restore Medical/ Medtronic)	Stiffening the soft palate which may reduce the severity of snoring and incidence of airway obstructions in patients	K040417	2004	LRK

Interventions	Devices (predicate or prior name)	Manufacturer (previous owner)	Indication	PMA/ 510(k)	Year	FDA Product Code
			with mild-to-moderate OSA			
Tongue base suspension	AIRvance® (Repose)	Medtronic	OSA and/or snoring. The AIRvance TM Bone Screw System is also suitable for the performance of a hyoid suspension.	K122391	1999	LRK
Tongue base suspension	Encore™ (PRELUDE III)	Siesta Medical	Treatment of mild or moderate OSA and/or snoring	K111179	2011	ORY
Hypoglossal nerve stimulation	Inspire® Upper Airway Stimulation	Inspire Medical Systems	The original PMA (P130008) was approved on April 30, 2014 and is indicated to treat a subset of patients with moderate to severe OSA who have been confirmed to fail or cannot tolerate PAP treatment and who do not have a complete concentric collapse at the soft palate level. The original PMA was approved in adult patients 22 years of age or older. Supplements: • S039 expanded the indications for the Inspire UAS system to include adolescent patients between 18 and 21 years of age. • S089 expanded the indications to include pediatric patients with Down syndrome between 13 and 18 years of age. • S090 expanded the indications further to include OSA patients, 18 years of age or older, with AHI ≥15 and ≤100. This supplement	P130008, S039, S089, S090, S098	2014	MNQ

Interventions	Devices (predicate or prior name)	Manufacturer (previous owner)	Indication	PMA/ 510(k)	Year	FDA Product Code
			also updated the BMI warning to note that the BMI upper limit for which safety and effectiveness data is available has increased from BMI≤32 to BMI≤40. • S098 was FDA approval in Aug 2024 of the current version, Inspire V system which includes a next generation neurostimulator and associated Bluetooth patient remote and physician programmer.			
Hypoglossal nerve stimulation	aura6000™	LivaNova (ImThera Medical)		IDE	2014	
Hypoglossal nerve stimulation	Genio®	Nyxoah		European CE Mark	2019	
Hypoglossal nerve stimulation	Genio® System 2.1	Nyxoah	For use in treatment of moderate to severe OSA (AHI of ≥15 and ≤65). The device is intended for adult patients ≥22 years of age who have been confirmed to fail, cannot tolerate or are ineligible to be treated with current standard of care treatments including lifestyle modifications, PAP treatments (such as CPAP or BiPAP machines), oral appliances (such as mandibular advancement devices), and pharmacotherapy (such as tirzepatide). PAP failure is defined as an inability to eliminate OSA (residual AHI of >15	P240024	2025	MNQ

Interventions	Devices (predicate or prior name)	Manufacturer (previous owner)	Indication	PMA/ 510(k)	Year	FDA Product Code
			despite PAP usage), and PAP intolerance is defined as: • 1. Inability to use PAP (at least 5 nights per week of usage; usage defined as >4 hours of use per night), or • 2. Unwillingness to use PAP (PAP therapy initiated and subsequently discontinued by choice).			

AHI: Apnea/Hypopnea Index; BiPAP: bi-level positive airway pressure; CPAP: continuous positive airway pressure; IDE: investigational device exemption; LAUP: Laser-assisted uvulopalatoplasty; OSA: obstructive sleep apnea; PAP: positive airway pressure.

For Inspire Upper Airway Stimulation (UAS), the expanded indication for hypoglossal nerve stimulation in patients age 18 to 21 was based on patients with Down Syndrome and is contingent on a post-approval study in this age group (NCT06851338). The post-approval study will be a multicenter, single-arm, prospective registry with 60 pediatric patients age 13 to 18. Visits will be scheduled at pre-implant, post-implant, 6 months, and yearly thereafter through 5 years.

POLICY

A. Palatopharyngoplasty (e.g., uvulopalatopharyngoplasty, uvulopharyngoplasty, uvulopalatal flap, expansion sphincter pharyngoplasty, lateral pharyngoplasty, palatal advancement pharyngoplasty, relocation pharyngoplasty) may be considered **medically necessary** for the treatment of clinically significant obstructive sleep apnea syndrome (OSA) in appropriately select adults who have failed an adequate trial of continuous positive airway pressure (CPAP) (see Policy Guidelines) or failed an adequate trial of an oral appliance. Clinically significant OSA is defined as those individuals who have:

1. Apnea/Hypopnea Index (AHI) or Respiratory Disturbance Index (RDI) of 15 or more events per hour, **OR**
2. AHI or RDI of at least 5 events per hour with one or more signs or symptoms associated with OSA (e.g., excessive daytime sleepiness, hypertension, cardiovascular heart disease, or stroke).

B. Hyoid suspension, surgical modification of the tongue, and/or maxillofacial surgery, including mandibular-maxillary advancement (MMA), may be considered **medically necessary** in appropriately selected adults with clinically significant OSA and objective documentation of hypopharyngeal obstruction who have failed an adequate trial of CPAP (see Policy Guidelines) or failed an adequate trial of an oral appliance. Clinically significant OSA is defined as those individuals who have:

1. AHI or RDI of 15 or more events per hour, **OR**
2. AHI or RDI of at least 5 events per hour with one or more signs or symptoms associated with OSA (e.g., excessive daytime sleepiness, hypertension, cardiovascular heart disease, or stroke).

C. Adenotonsillectomy may be considered **medically necessary** in pediatric individuals with clinically significant OSA and hypertrophic tonsils. Clinically significant OSA is defined as those pediatric individuals who have:

1. AHI or RDI of at least 5 per hour, **OR**
2. AHI or RDI of at least 1.5 per hour in an individual with excessive daytime sleepiness, behavioral problems, or hyperactivity.

D. Hypoglossal nerve stimulation with the Inspire U.S. Food and Drug Administration (FDA) approved device may be considered **medically necessary** in adults with OSA under the following conditions:

1. Age ≥18 years; **AND**
2. AHI ≥15 and ≤100 with less than 25% central apneas; **AND**
3. CPAP failure (residual AHI ≥15 or failure to use CPAP ≥4 hours per night for ≥5 nights per week) or inability to tolerate CPAP; **AND**
4. Body mass index ≤40 kg/m^2; **AND**
5. Absence of complete concentric collapse at the soft palate level (see Policy Guidelines).

E. Hypoglossal nerve stimulation with the Inspire U.S. Food and Drug Administration (FDA) approved device may be considered **medically necessary** in adolescents or young adults with Down's syndrome and OSA under the following conditions:

1. Age 13 to 18 years; **AND**
2. AHI >10 and <50 with less than 25% central apneas after prior adenotonsillectomy; **AND**
3. Have either tracheotomy or be ineffectively treated with CPAP due to noncompliance, discomfort, undesirable side effects, persistent symptoms despite compliance use, or refusal to use the device; **AND**
4. Body mass index ≤95th percentile for age; **AND**
5. Absence of complete concentric collapse at the soft palate level (see Policy Guidelines).

F. Hypoglossal nerve stimulation with other U.S. Food and Drug Administration (FDA) approved devices (e.g., Genio) are considered **experimental / investigational** for the treatment of clinically significant OSA syndrome.

G. Surgical treatment of OSA that does not meet the criteria above would be considered **experimental / investigational**.

H. The following minimally-invasive surgical procedures are considered **experimental / investigational** for the sole or adjunctive treatment of OSA or upper airway resistance syndrome (UARS):

1. Radiofrequency volumetric tissue reduction of the tongue, with or without radiofrequency reduction of the palatal tissues
2. Laser-assisted palatoplasty (LAUP) or radiofrequency volumetric tissue reduction of the palatal tissues
3. Palatal stiffening procedures including, but not limited to, cautery-assisted palatal stiffening operation, injection of a sclerosing agent, and the implantation of palatal implants
4. Tongue base suspension
5. All other minimally-invasive surgical procedures not described above.

I. Implantable hypoglossal nerve stimulators are considered **experimental / investigational** for all indications other than listed above.

J. All interventions, including LAUP, radiofrequency volumetric tissue reduction of the palate, or palatal stiffening procedures, are considered **experimental / investigational** for the treatment of snoring in the absence of documented OSA; snoring alone is not considered a medical condition.

POLICY GUIDELINES

A. CPAP is the preferred first-line treatment for obstructive sleep apnea for most individuals. A smaller number of individuals may use oral appliances as a first line treatment.
B. The Apnea/ Hypopnea Index (AHI) is the total number of events (apnea or hypopnea) per hour of recorded sleep. The Respiratory Disturbance Index (RDI) is the total number of events (apnea or hypopnea) per hour of recording time. An obstructive apnea is defined as at least a 10-second cessation of respiration associated with ongoing ventilatory effort. Hypopnea is defined as an abnormal respiratory event lasting at least 10 seconds with at least a 30% reduction in thoracoabdominal movement or airflow compared with baseline, and with at least a 4% oxygen desaturation.
C. The hypoglossal nerve (cranial nerve XII) innervates the genioglossus muscle. Stimulation of the nerve causes anterior movement and stiffening of the tongue and dilation of the pharynx. Hypoglossal nerve stimulation reduces airway collapsibility and alleviates obstruction at both the level of the soft palate and tongue base.
D. Drug-induced sleep endoscopy (DISE) replicates sleep with an infusion of propofol. DISE will suggest either a flat, anterior-posterior collapse or complete circumferential oropharyngeal collapse. Concentric collapse decreases the success of hypoglossal nerve stimulation and is an exclusion criteria for hypoglossal nerve stimulation from the Food and Drug Administration.
E. A trial of CPAP is defined as utilization for 60 days or greater.

Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

RATIONALE

This evidence review was created using searches of the PubMed database. The most recent literature update was performed through November 17, 2025.

Evidence reviews assess the clinical evidence to determine whether the use of a technology improves the net health outcome. Broadly defined, health outcomes are the length of life, quality of life, and ability to function-including benefits and harms. Every clinical condition has specific outcomes that are important to patients and managing the course of that condition. Validated outcome measures are necessary to ascertain whether a condition improves or worsens; and whether the magnitude of that change is clinically significant. The net health outcome is a balance of benefits and harms.

To assess whether the evidence is sufficient to draw conclusions about the net health outcome of a technology, 2 domains are examined: the relevance and the quality and credibility. To be relevant, studies must represent 1 or more intended clinical use of the technology in the intended population and compare an effective and appropriate alternative at a comparable intensity. For some conditions, the alternative will be supportive care or surveillance. The quality and credibility of the evidence depend on study design and conduct, minimizing bias and confounding that can generate incorrect findings. The randomized controlled trial (RCT) is preferred to assess efficacy; however, in some circumstances, nonrandomized studies may be adequate. RCTs are rarely large enough or long enough to capture less common adverse events and long-term effects. Other

types of studies can be used for these purposes and to assess generalizability to broader clinical populations and settings of clinical practice.

Obstructive Sleep Apnea

Obstructive sleep apnea (OSA) is associated with a heterogeneous group of anatomic variants producing obstruction. The normal pharyngeal narrowing may be accentuated by anatomic factors, such as a short, fat "bull" neck, elongated palate and uvula, and large tonsillar pillars with redundant lateral pharyngeal wall mucosa. In addition, OSA is associated with obesity. OSA may also be associated with craniofacial abnormalities, including micrognathia, retrognathia, or maxillary hypoplasia. Obstruction anywhere along the upper airway can result in apnea. The severity and type of obstruction may be described with the Friedman staging system.[4,] Nonsurgical treatment for OSA or upper airway resistance syndrome includes continuous positive airway pressure (CPAP) or mandibular repositioning devices. Patients who fail conservative therapy may be evaluated for surgical treatment of OSA.

Traditional surgeries for OSA or upper airway resistance syndrome include uvulopalatopharyngoplasty (UPPP) and a variety of maxillofacial surgeries such as mandibular-maxillary advancement. UPPP involves surgical resection of the mucosa and submucosa of the soft palate, tonsillar fossa, and the lateral aspect of the uvula. The amount of tissue removed is individualized for each patient, as determined by the potential space and width of the tonsillar pillar mucosa between the 2 palatal arches. UPPP enlarges the oropharynx but cannot correct obstructions in the hypopharynx. Patients who have minimal hypoglossal obstruction have greater success with UPPP. Patients who fail UPPP may be candidates for additional procedures, depending on the site of obstruction. Additional procedures include hyoid suspensions, maxillary and mandibular osteotomies, or modification of the tongue. Drug-induced sleep endoscopy and/or cephalometric measurements have been used as methods to identify hypopharyngeal obstruction in these patients. The first-line treatment in children is usually adenotonsillectomy. Minimally invasive surgical approaches are being evaluated for OSA in adults.

Clinical Context and Therapy Purpose

The purpose of minimally invasive surgery in individuals who have OSA is to provide a treatment option that is an alternative to or an improvement on existing therapies.

The following PICO was used to select literature to inform this review.

Populations

The population of interest is individuals with OSA who have failed or are intolerant of positive airway pressure (PAP). Indications for the various procedures are described in Table 3 and in the Regulatory Status section.

Interventions

The interventions addressed in this review are laser-assisted uvulopalatoplasty (LAUP), radiofrequency (RF) volumetric reduction of palatal tissues and base of tongue, palatal stiffening procedures, tongue base suspension, and hypoglossal nerve stimulation (HNS) (see Table 3).

Table 3. Minimally Invasive Surgical Interventions for Obstructive Sleep Apnea

Interventions	Devices	Description	Key Features	Indications
LAUP	Various	Superficial palatal tissues are sequentially reshaped over 3 to 7 sessions using a carbon dioxide laser	• Part of the uvula and associated soft-palate tissues are reshaped • Does not alter tonsils or lateral pharyngeal wall tissues	Snoring with or without OSA
RF volumetric reduction of palatal tissues and base of tongue	Somnoplasty	Radiofrequency is used to produce thermal lesions within the tissues	• Similar to LAUP • Can include soft palate and base of tongue	Simple snoring and base of tongue OSA
Palatal Implant	Pillar Palatal Implant	Braided polyester filaments that are implanted submucosally in the soft palate	Up to 5 implants may be used	Snoring
Tongue base suspension	AIRvance Encore	A suture is passed through the tongue and fixated with a screw to the inner side of the mandible, below the tooth roots	The suspension aims to make it less likely for the base of the tongue to prolapse during sleep	Snoring and/or OSA
Hypoglossal nerve stimulation	Inspire II Upper Airway Stimulation	Stimulation of the hypoglossal nerve which contracts the tongue and some palatal tissue	The device includes an implanted stimulator and a sensor implanted in the ribs to detect respiration.	A subset of patients with moderate-to-severe OSA who have failed or cannot tolerate CPAP (see Regulatory Status section)

CPAP: positive airway pressure; LAUP: laser-assisted uvulopalatoplasty; OSA: obstructive sleep apnea; RF: radiofrequency.

Comparators

The following therapies and practices are currently being used to treat OSA:

For individuals with mild OSA who are intolerant of CPAP, the comparator would be oral appliances or an established upper airway surgical procedure.

For individuals with moderate-to-severe OSA who have failed CPAP or are intolerant of CPAP, the comparator would be conventional surgical procedures such as maxillofacial surgeries that may include UPPP, hyoid suspensions, maxillary and mandibular osteotomies, and modification of the tongue. UPPP may be modified or combined with a tongue base procedure such as UPPP,

depending on the location of the obstruction. It is uncertain whether UPPP variants without tongue volume reduction are the most appropriate comparator for HNS, since the procedures may address different sources of obstruction.

Outcomes

Established surgical procedures are associated with adverse events such as dysphagia. In addition, the surgical procedures are irreversible should an adverse event occur. Therefore, an improvement in effectiveness and/or a decrease in adverse events compared with standard surgical procedures would be the most important outcomes.

The outcome measures used to evaluate treatment success are a decrease in Apnea/Hypopnea Index (AHI) and Oxygen Desaturation Index on polysomnography (PSG) and improvement in a measure of sleepiness such as the Epworth Sleepiness Scale (ESS) or Functional Outcomes of Sleep Questionnaire (FOSQ) (see Table 4).

Table 4. Health Outcome Measures Relevant to Obstructive Sleep Apnea

Outcome	Measure (Units)	Description	Clinically Meaningful Difference (If Known)
Change in AHI	AHI	Mean change in AHI from baseline to post-treatment	Change from severe to moderate or mild OSA
AHI Success	Percentage of patients achieving success.	Studies may use different definitions of success; the most common definition of AHI success is the Sher criteria	Sher criteria is a decrease in AHI ≥50% and an AHI <20. Alternative measures of success may be AHI <15, <10, or <5
Oxygen Desaturation Index	Oxygen levels in the blood during sleep	The number of times per hour of sleep that the blood oxygen level drops by ≥4 percentage points	More than 5 events per hour
Snoring	10-point visual analog score	Filled out by the bed partner to assess snoring intensity or frequency	There is no standard for a good outcome. Studies have used a 50% decrease in VAS[4,] or final VAS of <5 or <3[5,]
ESS	Scale from 0 to 24	The ESS is a short self-administered questionnaire that asks patients how likely they are to fall asleep in 8 different situations such as watching television, sitting quietly in a car, or sitting and talking to someone	An ESS of ≥10 is considered excessively sleepy. The MCID has been estimated at -2 to -3.[6,]
FOSQ	30 questions	Disease-specific quality of life questionnaire that evaluates functional status related to excessive sleepiness	A score of ≥18 is the threshold for normal sleep-related functioning, and a change of ≥2 points is considered to be a clinically meaningful improvement
OSA-18	18 item survey graded from 1 to 7	Validated survey to assess the quality of life in children	Change score of 0.5 to 0.9 is a small change, 1.0 to 1.4 a moderate change, and 1.5 a large change

AHI: Apnea/Hypopnea Index; ESS: Epworth Sleepiness Score; FOSQ: Functional Outcomes of Sleep Questionnaire; MCID: minimum clinically import difference; OSA; obstructive sleep apnea; VAS: visual analog score.

The effect of surgical treatment of OSA should be observed on follow-up PSG that would be performed from weeks to months after the surgery. Longer-term follow-up over 2 years is also needed to determine whether the effects of the procedure are durable or change over time.

Study Selection Criteria
Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies.
- To assess long-term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought.
- Studies with duplicative or overlapping populations were excluded.

REVIEW OF EVIDENCE

Laser-Assisted Uvulopalatoplasty

LAUP is proposed as a treatment of snoring with or without associated OSA. LAUP cannot be considered an equivalent procedure to the standard UPPP, with the laser simply representing a surgical tool that the physician may opt to use. LAUP is considered a unique procedure, which raises its own issues of safety and, in particular, effectiveness.

Systematic Reviews
Wischhusen et al. (2019) conducted a systematic review on the complications and side effects of LAUP for the treatment of snoring and OSA.[7,] Forty-two studies (N=3,093 patients, 4 RCTs) published through September 2018, with a mean follow up of 16 months were included. The most common complications included globus sensation (8%), dryness (7%) and VP insufficiency (4%). Only globus and VP insufficiency had a significant incidence compared with either the general population or the post-oropharyngeal surgery population with relative risks of 1.48 and 2.25, respectively. Among studies reporting pain, the average duration reported by patients was 11.65 days. In general, about 26 complications were observed for every 100 patients treated with LAUP.

Camacho et al (2017) performed a meta-analysis to evaluate the use of LAUP alone as a treatment for OSA in adults.[8,] Twenty-three adult studies (N=717, 2 RCTs), published through October 2016, were selected for review. Random effects modeling for 519 patients demonstrated an AHI mean difference of -6.56 [95% CI, -10.14 to -2.97] events/hour (h). Individual patient data analyses demonstrated a 23% success rate (≥50% reduction in AHI and <20 events/h) and an 8% cure rate; 44% of patients had worsening of their AHI after LAUP. Lowest oxygen saturation improved from a mean of 80 (SD =8%) to 82 (SD=7%).

Randomized Controlled Trials
No additional RCTs have been published since the above systematic reviews.

Section Summary: Laser-Assisted Uvulopalatoplasty
A 2019 systematic review involving 3,093 patients across 42 studies (4 RCTs) to assess complications of LAUP for snoring and OSA identified the most frequent complications being globus sensation (8%), dryness (7%), and velopharyngeal (VP) insufficiency (4%), with globus

and VP insufficiency occurring significantly more than in the general or post-oropharyngeal surgery populations (relative risks: 1.48 and 2.25, respectively). On average, 26 complications were seen per 100 LAUP-treated patients, and pain lasted around 12 days. A earlier meta-analysis of 23 studies (717 adults) on LAUP for OSA, found an AHI mean decrease of 6.56 events/h, but only a 23% success rate and 8% cure rate. Notably, 44% of patients experienced worsening AHI, with minimal improvement in lowest O2 saturation.

Radiofrequency Volumetric Reduction of Palatal Tissues and Base of Tongue
RF is used to produce thermal lesions within the tissues rather than using a laser to ablate the tissue surface. In some situations, RF of the soft palate and base of tongue are performed together as a multilevel procedure.

REVIEW OF EVIDENCE

Randomized Controlled Trials

Two RCTs have been identified on RF volumetric reduction of the palate and tongue. One of the trials (Back et al 2009) gave a single RF treatment to palatal tissues and found no statistical difference in scores on the AHI, visual analog scale (VAS) for snoring, ESS, or FOSQ between RF and sham (see Tables 5 through 7).[9,] The second trial (Woodson et al 2003), provided a mean of 4.8 sessions of RF to the tongue and palate. This trial found a statistically significant improvement from baseline to post-treatment for ESS and FOSQ.[10,] However, the improvement in the FOSQ score (1.2; standard deviation [SD], 1.6) was below the threshold of 2.0 for clinical significance and the final mean score in ESS was 9.8, just below the threshold for excessive sleepiness. AHI decreased by 4.5 events per hour, which was not statistically or clinically significant. The statistical significance of between-group differences was not reported (see Tables 6 and 8).

Table 5. Summary of Key Randomized Controlled Trial Characteristics

Study	Countries	Sites	Participants	Interventions	
				Active	Comparator
Back et al (2009)[9,]	Finland	1	32 patients with symptomatic mild OSA and habitual snoring with only velopharyngeal obstruction	Single-stage RF to palatal tissues	Sham control with local anesthetic and multiple insertions of an applicator needle without the RF
Woodson et al (2003)[10,]	U.S.	2	90 patients with symptomatic mild-to-moderate OSA, randomized to RF, sham, or CPAP	30 subjects received up to 7 sessions (mean, 4.8) of RF to tongue base and palate	30 subjects received a sham procedure to the tongue for 3 sessions, including local anesthetic and multiple insertions of an applicator needle without the RF

CPAP: continuous positive airway pressure; OSA: obstructive sleep apnea; RF: radiofrequency.

Table 6. Summary of Key Randomized Controlled Trial Results

Study	AHI	Snoring	ESS	Function	Adverse Events
	Median (Range)	Snoring Median (Range)	Median (Range)	Compound End Point Score[a] Median (Range)	
Back et al (2009)[9,]					
N	32	30	32	32	32
RF	13.0 (2.0-26.0)	5.0 (2.0-8.0)	7.0 (0-20.0)	6 (3-9)	
Sham	11.0 (1.0-29.0)	6.0 (3.0-8.0)	5.0 (2.0-15.0)	7 (4-10)	
p	.628	.064	.941	.746	No significant differences after 6 d
	Change Score (SD)		Change Score (SD)	FOSQ Score (SD)	
Woodson et al (2003)[10,]					
N	52		54	54	54
RF	-4.5 (13.8)		-2.1 (3.9)[b]	1.2 (1.6)[b]	
Sham	-1.8 (11.5)		-1.0 (3.1)	0.4 (2.0)	
Effect size[c]	0.34		0.50	0.66	No significant differences after 1 wk

AHI: Apnea/Hypopnea Index; ESS: Epworth Sleepiness Scale (maximum of 24); FOSQ: Functional Outcomes of Sleep Questionnaire; MCS: Mental Component Summary score; PCS: Physical Component Summary score; RF: radiofrequency; SD: standard deviation; SF-36: 36-Item Short-Form Health Survey.
[a] The compound end point scored added points derived from AHI, ESS, SF-36 PCS, and SF-36 MCS.
[b]p=.005 for baseline to post-treatment.
[c]Effect size=post-treatment mean - baseline mean.

Tables 7 and 8 display notable limitations identified in each study.

Table 7. Study Relevance Limitations

Study	Population[a]	Intervention[b]	Comparator[c]	Outcomes[d]	Follow-Up[e]
Back et al (2009)[9,]	4. Included patients with mild OSA and snoring	4. Single treatment with RFA			
Woodson et al (2003)[10,]					

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
OSA: obstructive sleep apnea; RFA: radiofrequency ablation.
[a] Population key: 1. Intended use population unclear; 2. Clinical context is unclear; 3. Study population is unclear; 4. Study population not representative of intended use.
[b] Intervention key: 1. Not clearly defined; 2. Version used unclear; 3. Delivery not similar intensity as comparator; 4. Not the intervention of interest.

[c] Comparator key: 1. Not clearly defined; 2. Not standard or optimal; 3. Delivery not similar intensity as intervention; 4. Not delivered effectively.
[d] Outcomes key: 1. Key health outcomes not addressed; 2. Physiologic measures, not validated surrogates; 3. No CONSORT reporting of harms; 4. Not establish and validated measurements; 5. Clinical significant difference not prespecified; 6. Clinical significant difference not supported.
[e] Follow-Up key: 1. Not sufficient duration for benefit; 2. Not sufficient duration for harms.

Table 8. Study Design and Conduct Limitations

Study	Allocation[a]	Blinding[b]	Selective Reporting[c]	Data Completeness[d]	Power[e]	Statistical[f]
Back et al (2009)[9,]		2. Surgeons also performed follow-up assessments				.
Woodson et al (2003)[10,]						3. Comparative treatment effects not reported

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
[a] Allocation key: 1. Participants not randomly allocated; 2. Allocation not concealed; 3. Allocation concealment unclear; 4. Inadequate control for selection bias.
[b] Blinding key: 1. Not blinded to treatment assignment; 2. Not blinded outcome assessment; 3. Outcome assessed by treating physician.
[c] Selective Reporting key: 1. Not registered; 2. Evidence of selective reporting; 3. Evidence of selective publication.
[d] Data Completeness key: 1. High loss to follow-up or missing data; 2. Inadequate handling of missing data; 3. High number of crossovers; 4. Inadequate handling of crossovers; 5. Inappropriate exclusions; 6. Not intent to treat analysis (per protocol for noninferiority trials).
[e] Power key: 1. Power calculations not reported; 2. Power not calculated for primary outcome; 3. Power not based on clinically important difference.
[f] Statistical key: 1. Intervention is not appropriate for outcome type: (a) continuous; (b) binary; (c) time to event; 2. Intervention is not appropriate for multiple observations per patient; 3. Confidence intervals and/or p values not reported; 4.Comparative treatment effects not calculated.

Observational Studies

Herman et al (2023) published a prospective, open-label, single-arm, nonrandomized trial that investigated multilevel RFA as an alternative therapy for patients with mild-to-moderate OSA (AHI 10 to 30) with intolerance or inadequate adherence to CPAP.[11,] Patients were treated with 3 sessions of office-based RFA to the soft palate and tongue base. Of the 56 patients recruited for the study, 43 completed the protocol. Overall, 22/43 (51%) were considered complete responders with a ≥50% reduction in baseline AHI and an overall AHI <20 at study completion. A statistically significant reduction in mean and median AHI was observed at 6 months follow-up (p=.001 for both); the mean AHI decreased from 19.7 to 9.86 and the median AHI decreased from 17.8 to 7.5. Likewise, ODI scores were significantly reduced at 6 months follow-up; the mean ODI score decreased from 12.79 to 8.36 (p=.006) and the median ODI score decreased from 11.65 to 6.23 (p=.008).

Section Summary: Radiofrequency Volumetric Reduction of Palatal Tissues and Base of Tongue

The evidence on RF volume reduction includes 2 randomized trials, both sham-controlled, and a prospective, single-arm cohort study. Single-stage RF to palatal tissues did not improve outcomes compared with sham. Multiple sessions of RF to the palate and base of the tongue did not significantly (statistically or clinically) improve AHI, while the improvement in functional outcomes did not achieve a level of clinical significance. The prospective cohort study included 56 patients with mild-to-moderate OSA who received 3 sessions of office-based multilevel RFA. Results demonstrated improvement in AHI and ODI at the 6-month follow up.

Palatal Stiffening Procedures

Palatal stiffening procedures include insertion of palatal implants, injection of a sclerosing agent (snoreplasty), or a cautery-assisted palatal stiffening operation. Snoreplasty and cautery-assisted palatal stiffening operations are intended for snoring and are not discussed here. Palatal implants are cylindrically shaped devices that are implanted in the soft palate.

REVIEW OF EVIDENCE

Randomized Controlled Trials

Two double-blind, sham-controlled randomized trials with over 50 patients have evaluated the efficacy of palatal implants to improve snoring and OSA (see Table 9). AHI success by the Sher criteria ranged from 26% to 45% at 3-month follow-up. AHI success was observed in 0% to 10% of the sham control patients (see Table 10). In 1 study (Steward et al 2008), the statistical significance of AHI success was marginal, and there was no statistical difference in snoring or change in ESS between the 2 groups.[12,] In the study by Friedman et al (2008), there was greater success in AHI (45% vs 0%, p<.001), improvement in snoring (-4.7 vs -0.7 on a 10-point VAS, p<.001), and improvement in ESS (-2.4 vs -0.5, p<.001) with palatal implants compared with sham controls.[4,] Patient selection criteria were different in the 2 studies. In the trial by Friedman et al (2008), patients with a Friedman tongue position of IV and palate of 3.5 cm or longer were excluded. In the trial by Steward et al (2008), selection criteria included patients with primarily retropalatal pharyngeal obstruction.

Table 9. Summary of Key Randomized Controlled Trial Characteristics

Study	Countries	Sites	Participants	Interventions	
				Active	Comparator
Steward et al (2008)[12,]	U.S.	3	100 patients with mild-to-moderate OSA (AHI ≥5 and ≤40) and primarily retropalatal pharyngeal obstruction; BMI ≤32 kg/m^2	50 received the office-based insertion of 3 palatal implants	50 received the sham procedure
Friedman et al (2008)[4,]	U.S.	1	62 patients with mild-to-moderate OSA (AHI ≥5 and ≤40); soft palate ≥2 cm and <3.5 cm; Friedman tongue position I, II, or III; BMI ≤32 kg/m^2	31 received the office-based insertion of 3 palatal implants	31 received the sham procedure

AHI: Apnea/Hypopnea Index, BMI: body mass index; OSA: obstructive sleep apnea.

Table 10. Summary of Key Randomized Controlled Trial Results

Study	AHI Success (Sher criteria)	Snoring (10- point VAS)	Change in ESS (95% CI) or (SD)	Change in FOSQ Score (95% CI)	Foreign Body Sensation/Extrusion
Steward et al (2008)[12,]					
N	97	43	96	98	100
Palatal implants	26%	6.7	-1.8 (-0.8 to -2.9)	1.43 (0.84 to 2.03)	18%/4 extruded
Sham control	10%	7.0	-1.5 (-.04 to -2.5)	0.6 (0.01 to 1.20)	2%
p	.04	.052	*NS*	.05	
Friedman et al (2008)[4,]		Change in VAS			
N	55	62	62		
Palatal implants (SD)	44.8%	-4.7 (2.1)	-2.4 (2.2)		2 extruded
Sham control (SD)	0%	-0.7 (0.9)	-0.5 (1.5)		
MD (95% CI)		4.0 (3.2 to 4.9)	1.9 (1.0 to 2.9)		
p	<.001	<.001	<.001		
Summary: Range	26% to 44.8%				

AHI: Apnea/Hypopnea Index; CI: confidence interval; ESS: Epworth Sleepiness Score; FOSQ: Functional Outcomes of Sleep Questionnaire; MD: mean difference; *NS*: not significant; SD: standard deviation; VAS: visual analog scale.

Case Series

Uncontrolled series have provided longer follow-up data on patients treated with palatal implants. Using criteria of 50% improvement in AHI and final AHI of less than 10 events hour, Neruntarat et al (2011) reported a success rate of 52% at a minimum of 24 months (see Tables 11 and 12).[13,] Compared with nonresponders, responders had lower body mass index (BMI), lower baseline AHI, and a lower percentage of patients with a modified Mallampati classification of III or IV (obscured visualization of the soft palate by the tongue). Tables 13 and 14 summarize the limitations of the case series and the RCTs described above.

Table 11. Summary of Key Case Series Characteristics

Study	Country	Participants	Follow-Up
Neruntarat et al (2011)[13,]	Thailand	92 patients with mild-to-moderate symptomatic OSA and palate >2 cm	Minimum 24 mo

OSA: obstructive sleep apnea.

Table 12. Summary of Key Case Series Results

Study	N	AHI (SD)	Snoring (SD) (10-point VAS)	ESS (SD)	Implant Extrusion
Neruntarat et al (2011)[13,]	92				
Baseline		21.7 (6.8)	8.2 (1.2)	12.3 (2.6)	
29 months		10.8 (4.8)	3.8 (2.3)	7.9 (1.8)	7 (7.6%)
p		<.001	<.001	<.001	

AHI: Apnea/Hypopnea Index; ESS: Epworth Sleepiness Score; SD: standard deviation; VAS: visual analog scale.

Table 13. Study Relevance Limitations

Study	Population[a]	Intervention[b]	Comparator[c]	Outcomes[d]	Follow-Up[e]
Neruntarat et al (2011)[13,]			2. No comparator		
Steward et al (2008)[12,]	4. Out of 968 patients assessed for eligibility, 100 were enrolled				1,2: 3 mo
Friedman et al (2008)[4,]	4. Number screened was not reported. Soft palate was at least 2 cm but less than 3.5 cm.				1,2: 3 mo

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
[a] Population key: 1. Intended use population unclear; 2. Clinical context is unclear; 3. Study population is unclear; 4. Study population not representative of intended use.
[b] Intervention key: 1. Not clearly defined; 2. Version used unclear; 3. Delivery not similar intensity as comparator; 4. Not the intervention of interest.
[c] Comparator key: 1. Not clearly defined; 2. Not standard or optimal; 3. Delivery not similar intensity as intervention; 4. Not delivered effectively.
[d] Outcomes key: 1. Key health outcomes not addressed; 2. Physiologic measures, not validated surrogates; 3. No CONSORT reporting of harms; 4. Not established and validated measurements; 5. Clinical significant difference not prespecified; 6. Clinical significant difference not supported.
[e] Follow-Up key: 1. Not sufficient duration for benefit; 2. Not sufficient duration for harms.

Table 14. Study Design and Conduct Limitations

Study	Allocation[a]	Blinding[b]	Selective Reporting[c]	Data Completeness[d]	Power[e]	Statistical[f]
Neruntarat et al (2011)[13,]	1. Retrospective	1. None (case series)				
Steward et al (2008)[12,]						
Friedman et al (2008)[4,]						

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
[a] Allocation key: 1. Participants not randomly allocated; 2. Allocation not concealed; 3. Allocation concealment unclear; 4. Inadequate control for selection bias.
[b] Blinding key: 1. Not blinded to treatment assignment; 2. Not blinded outcome assessment; 3. Outcome assessed by treating physician.
[c] Selective Reporting key: 1. Not registered; 2. Evidence of selective reporting; 3. Evidence of selective publication.
[d] Data Completeness key: 1. High loss to follow-up or missing data; 2. Inadequate handling of missing data; 3. High number of crossovers; 4. Inadequate handling of crossovers; 5. Inappropriate exclusions; 6. Not intent to treat analysis (per protocol for noninferiority trials).
[e] Power key: 1. Power calculations not reported; 2. Power not calculated for primary outcome; 3. Power not based on clinically important difference.
[f] Statistical key: 1. Intervention is not appropriate for outcome type: (a) continuous; (b) binary; (c) time to event; 2. Intervention is not appropriate for multiple observations per patient; 3. Confidence intervals and/or p values not reported; 4.Comparative treatment effects not calculated.

Section Summary: Palatal Stiffening Procedures

Two sham-controlled trials and several case series have assessed palatal implants for the treatment of snoring and OSA. The sham-controlled studies differed in the inclusion criteria, with the study that excluded patients with Friedman tongue position of IV and palate of 3.5 cm or longer reporting greater improvement in AHI (45% success) and snoring (change of -4.7 on a 10-point VAS) than the second trial.

Tongue Base Suspension

In this procedure, the base of the tongue is suspended with a suture that is passed through the tongue and fixated with a screw to the inner side of the mandible, below the tooth roots. The suspension aims to make it less likely for the base of the tongue to prolapse during sleep.

Review of Evidence

One preliminary RCT with 17 patients was identified that compared UPPP plus tongue suspension with UPPP plus tongue advancement (see Table 15).[14,] Success rates using the Sher criteria ranged from 50% to 57% (see Table 16). Both treatments improved snoring and reduced ESS to below 10. The major limitations of the trial were the number of subjects (N=17) in this feasibility study and the lack of blinding (see Tables 17 and 18). In addition, there was no follow-up after 16 weeks.

Table 15. Summary of Key Randomized Controlled Trial Characteristics

Study	Countries	Sites	Participants	Interventions	
				Active	Comparator
Thomas et al (2003)[15,]	U.S.	1	17 patients with moderate-to-severe OSA who failed conservative treatment	• UPPP with tongue suspension • Mean AHI=46 (n=9)	• UPPP with tongue advancement • Mean AHI=37.4 (n=8)

AHI: Apnea/Hypopnea Index; OSA: obstructive sleep apnea; UPPP: uvulopalatopharyngoplasty.

Table 16. Summary of Key Randomized Controlled Trial Results

Study	AHI Success (Sher Criteria)	Snoring (SD)	ESS (SD)	Pain, Speech, Swallowing
Thomas et al (2003)[15,]				
N	11	17	17	17
UPPP plus tongue suspension	57%	3.3 (2.1)[a]	4.1 (3.4)[b]	
UPPP plus tongue advancement	50%	5.0 (0.6)[c]	5.4 (3.5)[d]	No significant differences between groups

AHI: Apnea/Hypopnea Index; ESS: Epworth Sleepiness Score; SD: standard deviation; UPPP: uvulopalatopharyngoplasty.
[a] Baseline to post-treatment p=.02. [b] Baseline to post-treatment p=.007. [c] Baseline to post-treatment p=.04. [d] Baseline to post-treatment p=.004.

Table 17. Study Relevance Limitations

Study	Population[a]	Intervention[b]	Comparator[c]	Outcomes[d]	Follow-Up[e]
Thomas et al (2003)[15,]					1, 2. Follow-up was to 16 wk

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
[a] Population key: 1. Intended use population unclear; 2. Clinical context is unclear; 3. Study population is unclear; 4. Study population not representative of intended use.
[b] Intervention key: 1. Not clearly defined; 2. Version used unclear; 3. Delivery not similar intensity as comparator; 4. Not the intervention of interest.
[c] Comparator key: 1. Not clearly defined; 2. Not standard or optimal; 3. Delivery not similar intensity as intervention; 4. Not delivered effectively.
[d] Outcomes key: 1. Key health outcomes not addressed; 2. Physiologic measures, not validated surrogates; 3. No CONSORT reporting of harms; 4. Not established and validated measurements; 5. Clinical significant difference not prespecified; 6. Clinical significant difference not supported.
[e] Follow-Up key: 1. Not sufficient duration for benefit; 2. Not sufficient duration for harms.

Table 18. Study Design and Conduct Limitations

Study	Allocation[a]	Blinding[b]	Selective Reporting[c]	Data Completeness[d]	Power[e]	Statistical[f]
Thomas et al (2003)[15,]	3. Allocation concealment unclear	1-3. Not blinded			1. Feasibility study	4. Comparative treatment effects not calculated

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
[a] Allocation key: 1. Participants not randomly allocated; 2. Allocation not concealed; 3. Allocation concealment unclear; 4. Inadequate control for selection bias.
[b] Blinding key: 1. Not blinded to treatment assignment; 2. Not blinded outcome assessment; 3. Outcome assessed by treating physician.
[c] Selective Reporting key: 1. Not registered; 2. Evidence of selective reporting; 3. Evidence of selective publication.
[d] Data Completeness key: 1. High loss to follow-up or missing data; 2. Inadequate handling of missing data; 3. High number of crossovers; 4. Inadequate handling of crossovers; 5. Inappropriate exclusions; 6. Not intent to treat analysis (per protocol for noninferiority trials).
[e] Power key: 1. Power calculations not reported; 2. Power not calculated for primary outcome; 3. Power not based on

clinically important difference.
[f] Statistical key: 1. Intervention is not appropriate for outcome type: (a) continuous; (b) binary; (c) time to event; 2. Intervention is not appropriate for multiple observations per patient; 3. Confidence intervals and/or p values not reported; 4.Comparative treatment effects not calculated.

Section Summary: Tongue Base Suspension
One feasibility study with 17 patients was identified on tongue suspension. This study compared tongue suspension plus UPPP with tongue advancement plus UPPP and reported 50% to 57% success rates for the 2 procedures. Additional RCTs with a larger number of subjects are needed to determine whether tongue suspension alone or added to UPPP improves the net health outcome.

Hypoglossal Nerve Stimulation
Stimulation of the hypoglossal nerve causes tongue protrusion and stiffening of the anterior pharyngeal wall, potentially decreasing apneic events. For individuals with moderate-to-severe sleep apnea who have failed or are intolerant of CPAP, the alternatives would be minimally invasive surgical procedures, as described below.

They are currently 2 FDA-approved HNS devices for the treatment of OSA. Both are implanted devices that stimulate a nerve to keep the airway open during sleep, though they have different technological designs.

- The Inspire Upper Airway Stimulation (UAS) system (Inspire Medical Systems) was initially approved by the FDA in April 2014, for adults aged 22 and older with moderate to severe OSA who failed or could not tolerate PAP therapy and did not have complete concentric collapse at the soft palate (PMA: P130008). Subsequent supplements broadened its indications: S039 included adolescents aged 18 to 21, S089 added pediatric patients with Down syndrome aged 13 to 18, and S090 further expanded eligibility to adults 18 and older with an AHI ≥15 and ≤100. S090 also raised the BMI upper limit for available safety and effectiveness data from BMI≤32 to BMI≤40. The latest supplement, S098, approved in August 2024, introduced the Inspire V system, featuring an advanced neurostimulator and Bluetooth-enabled patient remote and physician programmer, representing the most current generation of the device. Inspire V includes two implantable components: an implantable programmable pulse generator (IPG) placed in the chest wall and a stimulation lead in the neck. The procedure requires two incisions, pocket creation for the IPG and tunneling to connect the lead to the IPG.[16,]
- The Genio system (Nyxoah) was approved by the FDA in August 2025 and is designed for adults aged 22 and older with moderate to severe OSA (AHI of ≥15 and ≤65). It is intended for patients who have failed, cannot tolerate, or are not eligible for standard treatments such as lifestyle changes, PAP devices (including CPAP and BiPAP), oral appliances, or medications like tirzepatide. PAP failure is defined as an inability to eliminate OSA (residual AHI of >15 despite PAP usage), while PAP intolerance is defined as either being unable to use PAP consistently (at least 5 nights per week, usage defined as >4 hours of use per night) or unwillingness to use PAP. Genio consists of a single piece of implanted hardware that contains an antenna/receiver and two attached electrode paddles. The battery is external and transmits energy to the implant via Bluetooth. It is implanted under the chin through a single incision. There is no implanted battery, no pocket creation for the IPG, no tunneling, and no second incision.[17,]https://www.geniosleep.com/?page_country_id=us

The third device, the aura6000 system (LivaNova) is currently an investigational implantable HNS device undergoing clinical evaluation for the treatment of adult patients with moderate to severe OSA. The aura6000 system is a HNS device which utilizes six electrodes placed on the proximal trunk of the hypoglossal nerve, offering broad access to the muscles controlling the airway and providing customized titration. LivaNova completed its premarket approval submission to FDA for the aura6000 device based on meeting the primary safety and efficacy endpoints (AHI and ODI) following six months of treatment.[18,]This submission was based on a U.S. multi-center, open-label, prospective, RCT (NCT04950894, N=150 patients, see Table 36, Summary of Key Trials).

The review of evidence will focus on the two approved FDA devices: Inspire UAS system and Genio system.

REVIEW OF EVIDENCE

INSPIRE UPPER AIRWAY STIMULATION (UAS) SYSTEM

Systematic Reviews

A summary of systematic reviews is included in Tables 19 and 20.

Costantino et al (2020) conducted a systematic review and meta-analysis of 6- to 60-month outcomes following HNS.[19,] They identified 12 studies with a total of 350 patients (median BMI, 29.8 [IQR, 28.8 to 31.6 kg/m^2] with OSA who were treated with the Inspire, ImThera (this is now part of the aura6000 device, acquired by LivaNova), or Apnex HNS (which is no longer available) systems. The Inspire device contributed the largest number of patients to the meta-analysis. In addition to the trials described below by Steffen et al (2015, 2018)[20,21,] and Strollo et al (Stimulation Therapy for Apnea Reduction [STAR] Trial, 2014, 2018)[22,23,], several other trials with the Inspire system were included in the meta-analysis. At the 6-month follow-up, the overall change in AHI was -17.74, with an improvement in ESS of -5.36. At the 12 mo follow-up, the change in AHI was -17.50 with an improvement in ESS of -5.27. Sixty-month data were provided only by the STAR trial as reported by Woodson et al (2018) and are described below.[24,]

Kim et al (2023) compared HNS to other OSA treatments in a systematic review and meta-analysis.[25,] A total of 10 studies with 2209 patients (mean BMI ≤30 kg/m^2 in every study) who were treated with HNS or alternative interventions were included. HNS improved post-treatment AHI <10 and <15 events/h compared with other surgical options including uvulopalatopharyngoplasty, expansion sphincterpharyngoplasty, or tongue-based surgery (odds ratio [OR]; 5.33; 95% CI, 1.21 to 23.42). Other results are summarized in Table 20.

Alrubasy et al (2024) published a meta-analysis that included 30 studies (26 single-arm and 4 RCTs) assessing the efficacy and safety of HNS devices - Inspire (n=24 studies), Apnex (n=2 studies), ImThera (n=3 studies), and Genio (n=1 study)- for treating OSA in adults intolerant to CPAP therapy.[26,] The analysis showed that HNS significantly reduced AHI, ODI, and ESS scores, while improving FOSQ scores, with the Inspire device consistently demonstrating the most robust improvements across short- and long-term (ie, <1 year vs >1 year) outcomes. The results of long-term outcomes are summarized in Table 20.

Table 19. Meta-analysis Characteristics

Study	Dates	Trials	Participants	N (Range)	Design	Duration
Constantino et al (2020)[19,]	Through 2018	12	Adult patients with moderate to severe OSA	350 (8-124)	Cohort	6, 12, and 60 mo
Kim et al (2023)[25,]	Through March 2023	10	Adults with moderate to severe OSA with inadequate CPAP adherence	2209 (23-698)	RCT (n=2)/cohort (n=8)	NR
Alrubasy et al (2024)[26,]	Through March 2024	30	Adults with OSA and failed CPAP therapy	822 (8 to 126)	RCT (n=4)/cohort (n=26)	1 week to 60 months

CPAP: continuous positive airway pressure; NR: not reported; OSA: obstructive sleep apnea; RCT: randomized controlled trial.

Table 20. Meta-analysis Results

Study	AHI Change at 6 mo (95% CI)	AHI Change at 12 mo (95% CI)	ESS Change at 6 mo (95% CI)	ESS Change at 12 mo (95% CI)	AHI Success n(%) Sher Criteria[a]
Constantino et al (2020)[19,]					
Total N	210	255	210	255	
Inspire	-17.74 (-24.73 to -10.74)	-17.50 (-20.01 to -14.98)	-5.36 (-6.64 to -4.08)	-5.27 (-6.18 to -4.35)	115 (70%)
ImThera	-9.50 (-19.14 to 0.14)	-24.20 (-37.39 to -11.01)	-3.70 (-5.65 to -1.75)	-2.90 (-6.97 to 1.17)	46 (35%)
Apnex	-24.20 (-30.94 to -17.45)	-20.10 (-29.62 to -10.58)	-3.87 (-5.53 to -2.21	-4.20 (-6.30 to -2.10)	115 (59.8%)
I^2 (p)	*68%* (.004)	*0%* (.77)	*25%* (.25)	*27%* (.24)	
Range of N	8 to 56	13 to 124	21 to 56	13 to 124	
Kim et al (2023)[25,]	**AHI MD (95% CI)**	**ESS MD (95% CI)**	**ODI (95% CI)**		
HNS vs all other airway surgeries	-8.0 (95% CI, -12.0344 to -3.9656)	0.3968 (95% CI, -1.5231 to 2.3167)			
HNS vs no treatment	-12.8394 (95% CI, -16.1475 to -9.5312)	-5.3929 (95% CI, -6.6078 to -4.1781)	-11.8384 (95% CI, -17.4476 to -6.2292)		
HNS vs CPAP	1.5000 (95% CI -1.0145 to 4.0145)	-1.8236 (95% CI, -4.5634 to 0.9163)			

Study	AHI Change at 6 mo (95% CI)	AHI Change at 12 mo (95% CI)	ESS Change at 6 mo (95% CI)	ESS Change at 12 mo (95% CI)	AHI Success n(%) Sher Criteria[a]
Alrubasy et al (2024)[26,]	**AHI long term[b] MD (95% CI)**	**ODI long term[b] MD (95% CI)**	**ESS long term[b] MD (95% CI)**	**FOSQ long term[b] MD (95% CI)**	
Total N	1109	892	1109	931	
Baseline vs post-HNS	-15.60 (-21.72 to -9.48)	-12.75 (-18.91 to –-6.58)	-4.86 (-5.42 to -4.29)	3.28 (2.89 to 3.67)	

AHI: Apnea/Hypopnea Index; CI: confidence interval; CPAP: continuous positive airway pressure; ESS: Epworth Sleepiness Score; HNS: hypoglossal nerve stimulation; MD: mean difference; ODI: oxygen desaturation index.
[a]Surgical success according to Sher criteria is defined as a 50% reduction in AHI and overall AHI <20.
[b]Long-term outcomes were measured at >1 year interval.

Wollny et al (2024) published an additional meta-analysis not mentioned in the tables that focused on the safety of HNS with the Inspire device in patients with OSA.[27,] A total of 17 studies (N=1962) were included. The findings showed that HNS has a very low pooled mortality rate of 0.01%, and no deaths related to the therapy. Over an average follow-up of 17.5 months, device survival at 60 months was high (98.34%). The most common reasons for device removal were infections and patient requests. Surgical revision was rare (0.08%), and the most frequently reported treatment-related side effects were also rare, including transient stimulation discomfort (0.08%) and tongue abrasions (0.07%).

Randomized Controlled Trials

Several RCTs have been identified on the effect of HNS in patients with OSA. Study characteristics and a summary of results are described in Tables 21 and 22, respectively.

Heiser et al (2021) conducted The Effect of Upper Airway Stimulation in Patients With Obstructive Sleep Apnea (EFFECT) trial, a multicenter, randomized, double-blind, crossover design study in adult patients with moderate-to-severe OSA (defined as AHI >15) who were intolerant to CPAP.[28,] All individuals included in the study were White. All patients received implantation of the Inspire device at least 6 months prior to enrollment. Baseline AHI before implantation was 32.2 events/h; after implantation, baseline AHI was approximately 8.3 events/h. All participants received therapeutic stimulation during the baseline visit. Patients were then randomized to 1 of 2 treatment groups: HNS-Sham (n=45) or Sham-HNS (n=44). After randomization, the HNS-Sham group received therapeutic stimulation and the Sham-HNS received sham stimulation for 1 week. During the second week, the HNS-Sham group received sham stimulation while the Sham-HNS group received therapeutic stimulation. Changes in AHI over time showed a statistically significant decrease in AHI with stimulation compared to sham stimulation during the baseline, week 1, and week 2 visits. This meant that during week 1 when the HNS-Sham group received stimulation, they had significantly lower AHI; during week 2, when the Sham-HNS group received stimulation, they had significantly lower AHI. Similarly, participants reported a lower ESS with stimulation compared to sham stimulation during all visits. The change of AHI and ESS from baseline to the 1-week and 2-week visits was analyzed between the groups and investigators found no evidence of a carryover effect for AHI or ESS.

Dedhia et al (2024) conducted a double-blind, randomized, crossover study comparing cardiovascular outcomes in patients (N=60) with severe OSA who had an Inspire device implanted.[29,] Patients were randomized to a 4-week period of active HNS and a 4-week period of sham HNS. The primary endpoint was mean 24-hour systolic blood pressure. In patients with a BMI of 30 kg/2 or more, the decrease in SBP (+0.5 mmHg vs. -0.64 mmHg) and DBP (-0.17 mmHg vs. -0.25 mmHg) measurements were numerically smaller than those who had a lower BMI; however, the clinical importance of this is unclear).

Table 21. Summary of Key RCT Characteristics

Study; Trial	Countries	Sites	Dates	Participants	Interventions	
					Active	Comparator
Heiser et al (2021);[28,] EFFECT	Germany	3	2018-2019	Adults with moderate-to-severe OSA (AHI >15), intolerant to CPAP; 100% of participants were White; mean BMI, 29.2 kg/m^2 (SD, 4.4)	HNS (Inspire device) for week 1 followed by crossover to sham in week 2 (n=45)	Sham stimulation for week 1 followed by crossover to HNS (Inspire device) in week 2 (n=44)
Dedhia et al (2024);[29,] CARDIOSA-12	US	3	2018-2022	Adults with severe OSA who had an HNS device; mean BMI, 28.7 kg/m^2(SD, 4.6)	HNS (Inspire device) for 4 weeks before crossover (n=29 received active treatment first)	Sham for 4 weeks (n=31 received sham first)

AHI: Apnea/Hypopnea Index; CPAP: continuous positive airway pressure; HNS: hypoglossal nerve stimulation; OSA: obstructive sleep apnea; RCT: randomized controlled trial; SD, standard deviation.

Table 22. Summary of Key RCT Results

Study			
	AHI response at month 4 (≥50% reduction to 20 or fewer events/hr)	**ODI response at month 4 (≥25% reduction)**	
Heiser et al (2021);[28,] EFFECT	N=89	N=89	N=86
HNS	73.3%	0.4 + 2.3	0.2 (-0.5 to 0.9)
Sham	29.5%	5.0 + 4.6	-1.9 (-2.6 to -1.2)
Difference (95% CI)	43.8% (25.1 to 62.5)	4.6 (3.1 to 6.1)	2.1 (1.4 to 2.8)
p-value	<.001	.001	<.001
	AHI events per hour (SD)	**24 hour SBP, mean (SD)**	**24 hour DBP, mean (SD)**
Dedhia et al (2024);[29,] CARDIOSA-12			
HNS	18.1 (14.8)	122.8 mmHg (11.8)	71.9 mmHg (7.8)

Study			
Sham	23.0 (15.6)	123.0 mmHg (10.8)	72.1 mmHg (7.0)
Difference (95% CI)	-4.9 (-8.8 to -1.0)	-0.18 (-2.21 to 1.84)	−0.22 (−1.27 to 0.83)
p-value	NR	NR	NR

AHI: Apnea/Hypopnea Index; CI: confidence interval; ESS: Epworth Sleepiness Scale; FOSQ: Functional Outcomes of Sleep Questionnaire; HNS: hypoglossal nerve stimulation; HR: hazard ratio; NNT: number needed to treat; NR: not reported; ODI: oxygen desaturation index; OR: odds ratio; RCT: randomized controlled trial; RR: relative risk.

Notable study limitations are described in Tables 23 and 24.

Table 23. Study Relevance Limitations

Study	Population[a]	Intervention[b]	Comparator[c]	Outcomes[d]	Duration of Follow-up[e]
Heiser et al (2021);[28,] EFFECT	4. Study population was predominantly male and exclusively White				1, 2. Limited follow-up period precluded long-term evaluation of safety and efficacy
Dedhia et al (2024);[29,] CARDIOSA-12	4. Study population was predominantly male and White			1. Primary outcomes were cardiovascular focused	1. Total duration of 10 weeks

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
[a] Population key: 1. Intended use population unclear; 2. Study population is unclear; 3. Study population not representative of intended use; 4, Enrolled populations do not reflect relevant diversity; 5. Other.
[b] Intervention key: 1. Not clearly defined; 2. Version used unclear; 3. Delivery not similar intensity as comparator; 4. Not the intervention of interest (e.g., proposed as an adjunct but not tested as such); 5: Other.
[c] Comparator key: 1. Not clearly defined; 2. Not standard or optimal; 3. Delivery not similar intensity as intervention; 4. Not delivered effectively; 5. Other.
[d] Outcomes key: 1. Key health outcomes not addressed; 2. Physiologic measures, not validated surrogates; 3. Incomplete reporting of harms; 4. Not establish and validated measurements; 5. Clinically significant difference not prespecified; 6. Clinically significant difference not supported; 7. Other.
[e] Follow-Up key: 1. Not sufficient duration for benefit; 2. Not sufficient duration for harms; 3. Other.

Table 24. Study Design and Conduct Limitations

Study	Allocation[a]	Blinding[b]	Selective Reporting[c]	Data Completeness[d]	Power[e]	Statistical[f]
Heiser et al (2021);[28,] EFFECT		4. Most participants randomized to sham stimulation became aware of the group allocation, possibly				

Study	Allocation[a]	Blinding[b]	Selective Reporting[c]	Data Completeness[d]	Power[e]	Statistical[f]
		impacting subjective outcomes				
Dedhia et al (2024);[29,] CARDIOSA-12						

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
[a] Allocation key: 1. Participants not randomly allocated; 2. Allocation not concealed; 3. Allocation concealment unclear; 4. Inadequate control for selection bias; 5. Other.
[b] Blinding key: 1. Participants or study staff not blinded; 2. Outcome assessors not blinded; 3. Outcome assessed by treating physician; 4. Other.
[c] Selective Reporting key: 1. Not registered; 2. Evidence of selective reporting; 3. Evidence of selective publication; 4. Other.
[d] Data Completeness key: 1. High loss to follow-up or missing data; 2. Inadequate handling of missing data; 3. High number of crossovers; 4. Inadequate handling of crossovers; 5. Inappropriate exclusions; 6. Not intent to treat analysis (per protocol for noninferiority trials); 7. Other.
[e] Power key: 1. Power calculations not reported; 2. Power not calculated for primary outcome; 3. Power not based on clinically important difference; 4. Other.
[f] Statistical key: 1. Analysis is not appropriate for outcome type: (a) continuous; (b) binary; (c) time to event; 2. Analysis is not appropriate for multiple observations per patient; 3. Confidence intervals and/or p values not reported; 4. Comparative treatment effects not calculated; 5. Other.

Comparative Studies

Study characteristics and results are described in Tables 25 and 26. Limitations in relevance and design and conduct, including comparative studies and 2 single-arm studies, are described in Tables 27 and 28.

Besides the RCT described above, comparative evidence consists of 3 studies that compared HNS (using the Inspire device) with historical controls treated with UPPP or a variant of UPPP (expansion sphincter pharyngoplasty) and a study that compared HNS with transoral robotic surgery. AHI success by the Sher criteria ranged from 87% to 100% in the HNS groups compared with 40% to 64% in the UPPP groups. Post-treatment ESS was below 10 in both groups. It is not clear from some studies whether the patients in the historical control group were similar to the subset of patients in the HNS group, particularly in regards to the pattern of palatal collapse and from patients who did not return for postoperative PSG.

Several comparative studies have addressed these concerns by only including patients who meet the criteria for HNS in the control group. Yu et al (2019) compared outcomes for patients who met the criteria for both HNS (non-concentric collapse on drug-induced sleep endoscopy) and transoral robotic surgery (retroglossal obstruction).[30,] When patients with similar anatomic criteria were compared, HNS led to significantly better improvements in AHI, cure rate (defined as AHI <5), and the percentage of time that oxygen saturation fell below 90%. Huntley et al (2021) selected patients in the control group who met the criteria for HNS (non-concentric collapse on drug-induced sleep endoscopy and BMI criteria) but had been treated at their institutions by single or multi-level palatal and lingual surgery.[31,] There was no explanation of why the different treatments were given during the overlap period of 2010 to 2019, but the HNS patients were older and heavier. HNS resulted in a modestly greater decrease in AHI (HNS: -21.4 vs -15.9.

p<.001), but not in ESS (HNS: -4.7 vs -5.8, p=.06). More patients in the HNS group achieved success by the Sher criteria (70% vs 48 to 49%) suggesting that there might be a clinical benefit for some patients.

Another report from Adherence and Outcome of Upper Airway Stimulation for OSA International Registry (ADHERE) registry investigators (Mehra et al 2020) compared outcomes from HNS patients with patients who met the criteria but had been denied insurance coverage.[32,] In a post-hoc multivariate analysis, previous use of PAP and prior surgical procedures were predictors of insurance approval. In the group of patients who received HNS, the average use downloaded from the device was 5.6 h/night and 92% of patients had usage greater than 20 h/week. A majority of the comparator group (86%) were not using any therapy at follow-up. The remaining 14% were using PAP, an oral appliance, or underwent OSA surgery. The AHI decreased to 15 events/h (moderate OSA) on the night of the sleep test in patients with HNS, with only a modest improvement in patients who did not receive HNS. The hours of use on the night of the post-operative sleep study were not reported, and the HNS patients may have been more likely to use their device on the test night. In addition, the use of a home sleep test for follow-up may underestimate the AHI. The ESS improved in the HNS group but worsened in the controls. This suggests the possibility of bias in this subjective measure in patients who were denied coverage.

Additional non-comparative reports from the ADHERE registry are described below.

Table 25. Summary of Observational Comparative Study Characteristics

Study	Study Type	Country	Dates	Participants	HNS	Traditional Surgery	Follow-Up
Shah et al (2018)[33,]	Retrospective series with historical controls	US	• HNS 2015-2016 • UPPP 2003-2012	40 OSA patients with AHI >20 and <65, BMI ≤32 kg mg/m^2, failed CPAP, favorable pattern of palatal collapse[a]	35% had previously had surgery for OSA	UPPP 50% of patients had additional surgical procedures	2-13 mo
Huntley et al (2018)[34,]	Retrospective series with historical controls	US	• HNS 2014-2016 • Modified UPPP 2011-2016	Retrospective review included treated patients who had a postoperative PSG	75 patients age 61.67 y with a favorable pattern of palatal collapse	33 patients age 43.48 y treated by ESP	To post-operative PSG
Yu et al (2019)[30,]	Retrospective series with historical controls	US	• HNS 2014-2016 • TORS 2011-NR	OSA patients with AHI >20 and <65, BMI ≤32 kg mg/m^2, failed CPAP, favorable pattern of palatal collapse[a]	27 patients age 62 with retroglossal collapse amenable to TORS	20 patients age 53 y who would have qualified for HNS and were treated by TORS	NR

Study	Study Type	Country	Dates	Participants	HNS	Traditional Surgery	Follow-Up
Huntley et al (2020)[31,]	ADHERE registry compared to retrospective controls	US, EU	• HNS 2010-2019 • Modified UPPP 2003-2019	OSA patients who were intolerant to CPAP and met HNS criteria of AHI 15 to 65, BMI <35, and favorable pattern of palatal collapse[a]	465 registry patients treated with HNS who had 12 mo follow-up	233 patients who would have qualified for HNS and were treated by single level (68%) or multilevel (31%) surgery	173 days after surgery 383 days after HNS
Mehra et al (2020)[32,]	ADHERE registry	US, EU	2017-2019	OSA patients who were intolerant to CPAP and met HNS criteria of AHI 15 to 65, BMI <35, and favorable pattern of palatal collapse[a]	250 registry patients treated with HNS	100 patients who qualified for HNS but were denied insurance coverage	6 to 24 months

AHI: Apnea/Hypopnea Index; BMI: body mass index; CPAP: continuous positive airway pressure; ESP: expansion sphincter pharyngoplasty; HNS: hypoglossal nerve stimulation; NR: not reported; OSA: obstructive sleep apnea; PSG: polysomnography; TORS: transoral robotic surgery; UPPP: uvulopalatopharyngoplasty.
[a] A favorable pattern of palatal collapse is not concentric retropalatal obstruction on drug-induced sleep endoscopy.

Table 26. Summary of Key Observational Comparative Study Results

Study	Baseline AHI (SD)	Post-treatment AHI (SD)	AHI Success n(%) Sher Criteria	Baseline ESS (SD)	Post-treatment ESS (SD)
Shah et al (2018)[33,]					
HNS	38.9 (12.5)	4.5 (4.8)[b]	20 (100%)	13 (4.7)	8 (5.0)[b]
UPPP	40.3 (12.4)	28.8 (25.4)[a]	8 (40%)	11 (4.9)	7 (3.4)[b]
Huntley et al (2018)[34,]					
HNS	36.8 (20.7)	7.3 (11.2)	86.7	11.2 (4.2)	5.4 (3.4)
ESP	26.7 (20.3)	13.5 (19.0)	63.6	10.7 (4.5)	7.0 (6.0)
p-value	.003	.003	.008	.565	*NS*
Yu et al (2018) [30,]		Average AHI Reduction	% Cure Rate	Change in SaO_2 <90%	
HNS		33.3	70.4%	14.1	

Study	Baseline AHI (SD)	Post-treatment AHI (SD)	AHI Success n(%) Sher Criteria	Baseline ESS (SD)	Post-treatment ESS (SD)
TORS		12.7	10.0%	1.3	
p-value		.002	<.001	.02	
Huntley et al (2020)[31,]					
HNS	35.5 (15.0)	14.1 (14.4)	70	11.9 (5.5)	7.3 (4.7)
Single or multi-level UPPP	35.0 (13.1)	19.3 (16.3)	48 to 49	11.3 (5.1)	5.9 (4.0)
p-value	.88	<.001	<.001	.22	.06
Mehra et al (2020)[32,]					
HNS	33.7 (13.4)	14.7 (13.8)		12.3 (5.5)	7.2 (4.8)
No HNS	34.9 (16.4)	26.8 (17.6)		10.9 (5.4)	12.8 (5.2)
p-value	.95	<.001		.06	<.001

AHI: Apnea/Hypopnea Index; ESP: expansion sphincter pharyngoplasty; ESS: Epworth Sleepiness Score; HNS: hypoglossal nerve stimulation; *NS*: not significant; Sher criteria: 50% decrease in AHI and final AHI <20; SD; standard deviation; SaO_2: oxygen saturation; TORS: transoral robotic surgery; UPPP: uvulopalatopharyngoplasty.
[a] Baseline vs post-treatment p<.05.
[b] Baseline vs post-treatment p<.001.

Table 27. Study Relevance Limitations

Study	Population[a]	Intervention[b]	Comparator[c]	Outcomes[d]	Follow-Up[e]
Shah et al (2018)[33,]			2. UPPP may not be the preferred treatment for patients with primarily lingual obstruction		
Huntley et al (2018)[34,]	4. Study populations not comparable		1. Not clearly defined, few ESP patients had follow-up PSG		
Yu et al (2018) [30,]					1, 2. Duration of follow-up unclear
Huntley et al (2020)[31,]	4. Study populations				1. The timing of follow-up was different (173

Study	Population[a]	Intervention[b]	Comparator[c]	Outcomes[d]	Follow-Up[e]
	not comparable				days after surgery and 383 days after HNS)
Mehra et al (2020)[32,]	4. Study populations not comparable		3. Hours of use on the test night was not reported. This may not represent the normal use of the device.		1. The timing of follow-up was different
Steffen et al (2018)[20,]			2. No comparator		
STAR trial[22,23,35,36,37,38,]			2. No comparator		

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
ESP: expansion sphincter pharyngoplasty; HNS: hypoglossal nerve stimulation; PSG: polysomnography; STAR: Stimulation Therapy for Apnea Reduction; UPPP: uvulopalatopharyngoplasty.
[a] Population key: 1. Intended use population unclear; 2. Clinical context is unclear; 3. Study population is unclear; 4. Study population not representative of intended use.
[b] Intervention key: 1. Not clearly defined; 2. Version used unclear; 3. Delivery not similar intensity as comparator; 4. Not the intervention of interest.
[c] Comparator key: 1. Not clearly defined; 2. Not standard or optimal; 3. Delivery not similar intensity as intervention; 4. Not delivered effectively.
[d] Outcomes key: 1. Key health outcomes not addressed; 2. Physiologic measures, not validated surrogates; 3. No CONSORT reporting of harms; 4. Not established and validated measurements; 5. Clinical significant difference not prespecified; 6. Clinical significant difference not supported.
[e] Follow-Up key: 1. Not sufficient duration for benefit; 2. Not sufficient duration for harms.

Table 28. Study Design and Conduct Limitations

Study	Allocation[a]	Blinding[b]	Selective Reporting[c]	Data Completeness[d]	Power[e]	Statistical[f]
Shah et al (2018)[33,]	1. Not randomized (retrospective) 4. Inadequate control for selection bias	1-3. No blinding				4. Comparative treatment effects not calculated
Huntley et al (2018)[34,]	1. Not randomized (retrospective)	1-3. No blinding				
Yu et al (2018) [30,]	1. Not randomized (retrospective)					

Study	Allocation[a]	Blinding[b]	Selective Reporting[c]	Data Completeness[d]	Power[e]	Statistical[f]
Huntley et al (2020)[31,]	1. Not randomized (retrospective)	1-3. No blinding				
Mehra et al (2020)[32,]	1. Not randomized	1-3. No blinding			1. Power calculations not reported	
Steffen et al (2018)[20,]	1. Not randomized	1-3. No blinding				
STAR trial[22,23,35,36,37,38,]	1. Not randomized	1-3. No blinding				

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
STAR: Stimulation Therapy for Apnea Reduction.
[a] Allocation key: 1. Participants not randomly allocated; 2. Allocation not concealed; 3. Allocation concealment unclear; 4. Inadequate control for selection bias.
[b] Blinding key: 1. Not blinded to treatment assignment; 2. Not blinded outcome assessment; 3. Outcome assessed by treating physician.
[c] Selective Reporting key: 1. Not registered; 2. Evidence of selective reporting; 3. Evidence of selective publication.
[d] Follow-Up key: 1. High loss to follow-up or missing data; 2. Inadequate handling of missing data; 3. High number of crossovers; 4. Inadequate handling of crossovers; 5. Inappropriate exclusions; 6. Not intent to treat analysis (per protocol for noninferiority trials).
[e] Power key: 1. Power calculations not reported; 2. Power not calculated for primary outcome; 3. Power not based on clinically important difference.
[f] Statistical key: 1. Intervention is not appropriate for outcome type: (a) continuous; (b) binary; (c) time to event; 2. Intervention is not appropriate for multiple observations per patient; 3. Confidence intervals and/or p values not reported; 4.Comparative treatment effects not calculated.

Single-Arm Studies

Characteristics and results of single-arm studies are described in Tables 29 to 31. Limitations are mentioned in Tables 27 and 28, above.

Results of prospective single-arm studies show AHI success rates in 66% to 68% of patients who had moderate-to-severe sleep apnea and a favorable pattern of palatal collapse. Mean AHI was 31 to 32 at baseline, decreasing to 14 to 15 at 12 months. ESS scores decreased from 6.5 to 7.0. All improvements were maintained through 5 years of follow-up. Discomfort due to the electrical stimulation and tongue abrasion were initially common but were decreased when stimulation levels were reduced (see Table 30). In the post-market study, a normal ESS score (<10) was obtained in 73% of patients. A FOSQ score of at least 19 was observed in 59% of patients compared to 13% at baseline. At the 12-month follow-up, 8% of bed partners regularly left the room due to snoring, compared to 75% of bed partners at baseline. The average use was 5.6 + 2.1 hours per night. Use was correlated with the subjective outcomes but not with AHI response. Two- and 3-year follow-ups of this study were reported by Steffen et al (2020)[21,], but the percentage of patients at follow-up was only 68% at 2 years and 63% at 3 years, limiting conclusions about the longer-term efficacy of the procedure. A comparison of the populations who had 12-month versus 2- or 3-year results showed several differences between the patients

who followed up and those who dropped out, including higher baseline AHI, higher baseline Oxygen Desaturation Index (ODI), and trends towards lower usage per night and a lower responder rate at 12 months.

Table 29. Summary of Prospective Single-Arm Study Characteristics

Study	Country	Participants	Treatment Delivery	Follow-Up
STAR trial[22,23,35,36,39,24,]	EU, U.S.	126 patients with AHI >20 and <50, BMI ≤32 kg/m^2, failed CPAP, favorable pattern of palatal collapse[a]	Stimulation parameters titrated with full PSG	5 y
Postmarket studies: Heiser et al (2017);[40,] Steffen et al (2018);[20,] Hasselbacher et al (2018);[41,] Steffen et al (2020)[21,]	3 sites in Germany	60 patients with AHI ≥15 and ≤65 on home sleep study, BMI ≤35 kg/m^2, failed CPAP; favorable pattern of palatal collapse[a]		12 mo, 2 yr, and 3 yr

AHI: apnea/hypopnea index; BMI: body mass index; CPAP: continuous positive airway pressure; PSG: polysomnography; STAR: Stimulation Therapy for Apnea Reduction.
[a] A favorable pattern of palatal collapse is non-concentric retropalatal obstruction on drug-induced sleep endoscopy.

Table 30. Summary of Prospective Single-Arm Study Results

Study	N	Percent of Patients With AHI Success (Sher criteria)	Mean AHI Score (SD)	Mean ODI Score (SD)	FOSQ Score (SD)	ESS Score (SD)
STAR trial[22,23,35,36,39,24,]						
Baseline	126		32.0 (11.8)	28.9 (12.0)	14.3 (3.2)	11.6 (5.0)
12 months	124	66%	15.3 (16.1)[d]	13.9 (15.7)[d]	17.3 (2.9)[d]	7.0 (4.2)[d]
3 years	116[a]	65%	14.2 (15.9)	9.1 (11.7)	17.4 (3.5)[b]	7.0 (5.0)[b]
5 years	97[c]	63%	12.4 (16.3)	9.9 (14.5)	18.0 (2.2)	6.9 (4.7)
Postmarket studies: Heiser et al (2017);[40,] Steffen et al (2018)[20,] Hasselbacher et al (2018);[41,] Steffen et al (2020)[21,]						
Baseline	60		31.2 (13.2)	27.6 (16.4)	13.7 (3.6)	12.8 (5.3)
6 months					17.5 (2.8)[d]	7.0 (4.5)[d]
12 months	56[f]	68%	13.8 (14.8)[e]	13.7 (14.9)[e]	17.5 (3)[e]	6.5 (4.5)[e]
Normalized at 12 months					59%	73%

AHI: Apnea/Hypopnea Index; ESS: Epworth Sleepiness Scale; FOSQ: Functional Outcomes of Sleep Questionnaire; ODI: Oxygen Desaturation Index; PSG: polysomnography; SD: standard deviation; STAR: Stimulation Therapy for Apnea Reduction.

[a] Ninety-eight participants agreed to undergo PSG at 36 months, of the 17 participants who did not undergo PSG at 36 months, 54% were non-responders and their PSG results at 12 or 18 months were carried forward.
[b] The change from baseline was significant at p<.001.
[c] Seventy-one participants agreed to a PSG.
[d] p<.001.
[e] p<.05.
[f] Four patients lost to follow-up were analyzed as treatment failures.

Table 31. Device-Related Adverse Events From Prospective Single-Arm Studies

Study	N	Discomfort due to Electrical Stimulation[a]	Tongue Abrasion	Dry Mouth	Mechanical Pain From Device	Internal Device Usability	External Device Usability
STAR trial[24,]							
0 to 12 months	126	81	28	10	7	12	11
12 to 24 months	124	23	12	5	2	8	11
24 to 36 months	116	26	4	2	3	1	8
36 to 48 months	97	7	3	0	1	3	9
>48 months		5	3	3	1	1	6
Participants with an event, n of 126 (%)		76 (60.3)	34 (27.0)	19 (15.1)	14 (11.1)	21 (16.7)	33 (26.2)

STAR: Stimulation Therapy for Apnea Reduction.
[a] Stimulation levels were adjusted to reduce discomfort.

Down Syndrome

Liu et al (2022) published a systematic review investigating HNS in adolescents with Down Syndrome and OSA.[42,] A total of 9 studies were included with a follow up period ranging from 2 to 58 months; 6 studies had sample sizes of fewer than 10 patients. The largest of the included studies was a prospective cohort study published by Yu et al (2022), which is summarized below. In an analysis that included 104 patients, AHI scores were significantly reduced in patients after HNS (mean AHI reduction, 17.43 events/h; 95% CI, 13.98 to 20.88 events/h; p<.001). Similarly, in an analysis that included 88 patients, OSA-18 survey scores were significantly reduced after HNS (mean OSA-18 reduction, 1.67; 95% CI, 1.27 to 2.08; p<.001).

Yu et al (2022) reported on the safety and effectiveness of HNS in 42 adolescents with Down Syndrome and severe OSA (AHI of 10 events/h or greater).[43,] This was a single-group, multicenter, cohort study with a 1-year follow-up that included non-obese (BMI <95%) children and adolescents aged 10 to 21 years who were refractory to adenotonsillectomy and unable to tolerate CPAP. Patients who were included had an AHI between 10 and 50 on baseline PSG; the mean baseline AHI was 23.5 (SD, 9.7). All patients included tolerated HNS without any intraoperative complications. The most common complication was tongue or oral discomfort or pain, which occurred in 5 (11.9%) patients and was temporary, lasting weeks or, rarely, months. Four patients (9.5%) had device extrusion, resulting in readmissions to replace the extruded device. At 12 months, there was a mean decrease in AHI of 12.9 (SD, 13.2) events per hour (95% CI, -17.0 to -8.7 events/h). At the 12-month PSG, 30 of 41 patients (73.2%) had an AHI of less than 10 events/h, 14/41 patients (34.1%) had an AHI of less than 5 events/h, and 3/41

patients (7.3%) had an AHI of less than 2 events/h. There was also a significant improvement in quality of life outcomes. The mean improvement in the OSA-18 total score was 34.8 (SD, 20.3; 95% CI, -42.1 to -27.5), and the ESS improved by 5.1 (SD, 6.9; 95% CI, -7.4 to -2.8).

Registry

Boon et al (2018) reported results from 301 patients in the multicenter Adherence and Outcome of Upper Airway Stimulation for OSA International Registry (ADHERE).[44,] The ADHERE registry included both retrospective and prospectively collected data from the U.S. and Germany between October 2016 and September 2017. Data were collected from PSG prior to implantation and between 2 and 6 months after implantation or from home sleep tests, which were often performed at 6 and 12 months after implantation as part of routine care. Mean AHI decreased from 35.6 (SD, 15.3) to 10.2 (SD, 12.9) post-titration with 48% of patients achieving an AHI of 5 or less. ESS decreased from 11.9 (5.5) to 7.5 (4.7) ($p<.001$).

Kent et al (2019) pooled data from the ADHERE registry plus data from 3 other studies to evaluate factors predicting success.[45,] Over 80% of the 584 patients were men, and most were overweight. Seventy-seven percent of patients achieved treatment success, defined as a decrease in AHI by at least 50% and below 20 events/per hour. AHI decreased to below 5 in 41.8% of patients. Greater efficacy was observed in patients with a higher preoperative AHI, older patient age, and lower BMI. A report of data from the ADHERE registry by Thaler et al (2020) included 640 patients with a 6-month follow-up and 382 with a 12-month follow-up.[46,] AHI was reduced from 35.8 at baseline to 14.2 at 12 months ($p<.001$), although the number of hours of use during the sleep test was not reported, and home sleep studies may underestimate AHI. ESS was reduced from 11.4 at baseline to 7.2 at 12 months ($p<.001$), and patient satisfaction was high. In a multivariate model, only female sex (OR, 3.634; $p=.004$) and lower BMI (OR, 0.913; $p=.011$) were significant predictors of response according to the Sher criteria. In sensitivity analysis, higher baseline AHI was also found to be a negative predictor of success.

Suurna et al (2021) evaluated the impact of BMI on HNS using the ADHERE registry (N=1849).[47,] The mean BMI of all patients in the registry was 29.3 kg/m^2. All patients had a BMI of 35 kg/m^2 or lower and were categorized as those with BMI of 32 kg/m^2 or less and those with a BMI greater than 32kg/m^2 and less than or equal to 35 kg/m^2. At 12 months, both groups had reduced AHI events/h compared with baseline, although the mean change was greater in the lower BMI group (-21.4) compared with the higher BMI group (-20.3; mean difference 1.05 with the upper 97.5% CI at 4.5 which fell within the noninferiority margin). The difference in ESS scores between groups was also noninferior.

In a retrospective analysis by Huntley et al (2018) of procedures at 2 academic institutions, patients with a BMI of greater than 32 did not have lower success rates than patients with a BMI less than 32.[48,] However, only patients who had palpable cervical landmarks and carried most of their weight in the waist and hips were offered HNS. Therefore, findings from this study are limited to this select group of patients with BMI greater than 32.

Patel et al (2024) conducted a retrospective cohort study at a single academic institution evaluating the effects of BMI on response to HNS.[49,] A total of 76 patients with an average age of 61 years and a median BMI of 28.9 kg/m^2 were identified. Patients with a BMI of 32 to 35 kg/m^2 had 75% lower odds of a response to HNS (OR, 0.25; 95% CI, 0.07 to 0.90). Further

analysis revealed an approximate 17% decrease in odds of being a responder for each 1 unit BMI increase.

Genio System

No systematic reviews or RCTs have been published on the Genio system. The FDA approval was based on results of a nonrandomized clinical trial (DREAM: Dual-sided Hypoglossal neRvE stimulAtion for the treatMent of Obstructive Sleep Apnea). Woodson et al (2025) conducted this trial in adult patients with moderate-to-severe OSA who refused, failed, or did not tolerate PAP therapy underwent implantation and nightly use of the Genio device.[50,] The coprimary endpoints at 12 months were (1) a minimum of 50% reduction in the 4% AHI from baseline with a final AHI of <20 events/h, and (2) a minimum of 25% reduction in the 4% ODI. Objective secondary endpoints included changes in mean AHI, ODI, and sleep time with blood oxygen saturation <90%. Self-reported secondary endpoints included changes in ESS, the short FOSQ, the Symptoms of Nocturnal Obstruction and Related Events score, and bedpartner assessment of snoring. The Genio device was implanted in 113 patients. Eleven serious adverse events occurred in 10 (9%) patients of which 3 (3%) were device-related, 5 (4%) were procedure-related, and 3 (3%) were unrelated to the device or the procedure. The coprimary endpoints were completed by 89 (77%) patients. AHI and ODI responses were achieved in 63.5% (73/115, p =.002) and 71.3% of patients (82/115, p <.001), respectively. Secondary endpoint analysis revealed significant changes in mean AHI (-18.3 ± 11.8 events/h, p <.001), ODI (-17.7 ± 14.6 events/h, p <.001), and sleep time with blood oxygen saturation less than 90% (6.9 ± 10.7%, p <.001). Significant changes were observed in all secondary endpoints (p <.001). Study Limitations are described in Tables 32 and 33.

Table 32. Study Relevance Limitations

Study	Population[a]	Intervention[b]	Comparator[c]	Outcomes[d]	Duration of Follow-up[e]
Woodson et al (2025)[50,]	4. Study population was predominantly male (70%) and exclusively White (94%)				1, 2. Limited follow-up period precluded long-term evaluation of safety and efficacy

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.

[a] Population key: 1. Intended use population unclear; 2. Study population is unclear; 3. Study population not representative of intended use; 4, Enrolled populations do not reflect relevant diversity; 5. Other.

[b] Intervention key: 1. Not clearly defined; 2. Version used unclear; 3. Delivery not similar intensity as comparator; 4. Not the intervention of interest (e.g., proposed as an adjunct but not tested as such); 5: Other.

[c] Comparator key: 1. Not clearly defined; 2. Not standard or optimal; 3. Delivery not similar intensity as intervention; 4. Not delivered effectively; 5. Other.

[d] Outcomes key: 1. Key health outcomes not addressed; 2. Physiologic measures, not validated surrogates; 3. Incomplete reporting of harms; 4. Not establish and validated measurements; 5. Clinically significant difference not prespecified; 6. Clinically significant difference not supported; 7. Other.

[e] Follow-Up key: 1. Not sufficient duration for benefit; 2. Not sufficient duration for harms; 3. Other.

Table 33. Study Design and Conduct Limitations

Study	Allocation[a]	Blinding[b]	Selective Reporting[c]	Data Completeness[d]	Power[e]	Statistical[f]
Woodson et al (2025)[50,]	1. Single-arm, open-label design	1. Single-arm, open-label design	4. Treatment adherence assessed by patient self-reporting	1. 24% of patients did not complete the trial per protocol		

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
[a] Allocation key: 1. Participants not randomly allocated; 2. Allocation not concealed; 3. Allocation concealment unclear; 4. Inadequate control for selection bias; 5. Other.
[b] Blinding key: 1. Participants or study staff not blinded; 2. Outcome assessors not blinded; 3. Outcome assessed by treating physician; 4. Other.
[c] Selective Reporting key: 1. Not registered; 2. Evidence of selective reporting; 3. Evidence of selective publication; 4. Other.
[d] Data Completeness key: 1. High loss to follow-up or missing data; 2. Inadequate handling of missing data; 3. High number of crossovers; 4. Inadequate handling of crossovers; 5. Inappropriate exclusions; 6. Not intent to treat analysis (per protocol for noninferiority trials); 7. Other.
[e] Power key: 1. Power calculations not reported; 2. Power not calculated for primary outcome; 3. Power not based on clinically important difference; 4. Other.
[f] Statistical key: 1. Analysis is not appropriate for outcome type: (a) continuous; (b) binary; (c) time to event; 2. Analysis is not appropriate for multiple observations per patient; 3. Confidence intervals and/or p values not reported; 4. Comparative treatment effects not calculated; 5. Other.

Section Summary: Hypoglossal Nerve Stimulation

They are currently 2 FDA-approved HNS devices for the treatment of OSA: the Inspire Upper Airway Stimulation (UAS) system and the Genio system. The evidence on the Inspire device for the treatment of OSA includes systematic reviews, 2 RCTs, nonrandomized prospective studies, nonrandomized studies with historical controls, and prospective single-arm studies. Three meta-analyses have assessed the efficacy of HNS for OSA. A 2020 meta-analysis showed notable decreases in both the AHI and the Epworth Sleepiness Scale (ESS) between 6 and 12 months after treatment, with the Inspire device accounting for the majority of individuals. Another review of 10 studies involving 2,209 patients found that HNS led to lower post-treatment AHI scores compared to other surgical options for OSA (odds ratio 5.33; 95% Confidence Interval, 1.21 to 23.42). A meta-analysis of 30 studies (80% of studies on the Inspire device), demonstrated improved health outcomes in adults who could not tolerate CPAP therapy, with benefits lasting up to five years following HNS. An RCT of 89 adults with moderate-to-severe OSA who did not tolerate CPAP found significant short-term improvement in AHI, ESS, and quality of life measures with HNS compared to sham stimulation. The study was limited by a short duration of follow-up and the lack of diverse individuals included in the trial. HNS has shown success rates for about two-thirds of a subset of patients who met selection criteria that included AHI, BMI (≤32 or ≤35 kg/m^2), and favorable pattern of palatal collapse across nonrandomized studies. These results were maintained out to 5 years in the pivotal single-arm study. The single prospective comparative study of patients who received HNS versus patients who were denied insurance coverage for the procedure has a high potential for performance bias.

For children and adolescents with OSA and Down Syndrome who are unable to tolerate CPAP, the evidence includes a systematic review and a prospective study of 42 individuals. The systematic

review investigated HNS in adolescents with Down Syndrome and OSA, and demonstrated significant improvement in AHI and OSA-18 survey scores after HNS. A study of 42 individuals with Down Syndrome and OSA found a success rate of 73.2% with 4 device extrusions corrected with replacement surgery. The evidence on the Genio device is limited to results of a nonrandomized clinical trial. This study enrolled 113 patients across 21 centers (including 16 U.S. locations), with coprimary endpoints focused on reducing the AHI and ODI at 12 months. Serious adverse events occurred in 9% of patients, with only a small proportion attributed directly to the device or procedure. Of the patients who completed the study, 63% met the AHI reduction endpoint and 71% achieved the ODI reduction. Secondary outcomes showed significant improvements in mean AHI, ODI, nocturnal oxygen saturation, and patient-reported sleep quality measures. Limitations of the current evidence-base preclude determination of who is most likely to benefit from these minimally invasive procedures.

SUPPLEMENTAL INFORMATION

The purpose of the following information is to provide reference material. Inclusion does not imply endorsement or alignment with the evidence review conclusions.

Clinical Input From Physician Specialty Societies and Academic Medical Centers

While the various physician specialty societies and academic medical centers may collaborate with and make recommendations during this process, through the provision of appropriate reviewers, input received does not represent an endorsement or position statement by the physician specialty societies or academic medical centers, unless otherwise noted.

2018 Input

Clinical input was sought to help determine whether the use of hypoglossal nerve stimulation (HNS) for individuals with obstructive sleep apnea (OSA) would provide a clinically meaningful improvement in net health outcome and whether the use is consistent with generally accepted medical practice. In response to requests, clinical input was received from 2 respondents, including 1 specialty society-level response and physicians with academic medical center affiliation. At the time of the clinical input, the Inspire UAS system was the only HNS device that had received FDA approval.

For individuals who have OSA who receive HNS, clinical input supports that this use provides a clinically meaningful improvement in net health outcome and indicates this use is consistent with generally accepted medical practice in subgroups of appropriately selected patients. One subgroup includes adult patients with a favorable pattern of non-concentric palatal collapse. The alternative treatment for this anatomical endotype is maxillo-mandibular advancement (MMA), which is associated with greater morbidity and lower patient acceptance than HNS. The improvement in Apnea/Hypopnea Index (AHI) with HNS, as shown in the STAR trial, is similar to the improvement in AHI following MMA. Another subgroup includes appropriately selected adolescents with OSA and Down's syndrome who have difficulty in using continuous positive airway pressure (CPAP). The following patient selection criteria are based on information from clinical study populations and clinical expert opinion.

- Age ≥22 years in adults or adolescents with Down's syndrome age 10 to 21; AND
- Diagnosed moderate to severe OSA (with less than 25% central apneas); AND
- CPAP failure or inability to tolerate CPAP; AND
- Body mass index ≤32 kg/m^2 in adults; AND
- Favorable pattern of palatal collapse

Further details from clinical input are included in the Appendix.

Practice Guidelines and Position Statements
Guidelines or position statements will be considered for inclusion in 'Supplemental Information' if they were issued by, or jointly by, a US professional society, an international society with US representation, or National Institute for Health and Care Excellence (NICE). Priority will be given to guidelines that are informed by a systematic review, include strength of evidence ratings, and include a description of management of conflict of interest.

American Academy of Sleep Medicine
The American Academy of Sleep Medicine (AASM, 2021) published practice guidelines on when to refer patients for surgical modifications of the upper airway for OSA.[51,] These guidelines replaced the 2010 practice parameters for surgical modifications.[52,] The AASM guidelines note that PAP is the most efficacious treatment for OSA, but effectiveness can be compromised when patients are unable to adhere to therapy or obtain an adequate benefit, which is when surgical management may be indicated. The AASM guideline recommendations are based on a systematic review and meta-analysis of 274 studies of surgical interventions, including procedures such as uvulopalatopharyngoplasty (UPPP), modified UPPP, MMA, tongue base suspension, and HNS.[53,] The systematic review deemed most included data of low quality, consisting of mostly observational data. The AASM strongly recommends that clinicians discuss referral to a sleep surgeon with adults with OSA and body mass index (BMI) <40 kg/m2 who are intolerant or unaccepting of PAP. Clinically meaningful and beneficial differences in nearly all critical outcomes, including a decrease in excessive sleepiness, improved quality of life (QOL), improved AHI or respiratory disturbance index (RDI), and sleep quality, were demonstrated with surgical management in patients who are intolerant or unaccepting of PAP. The AASM makes a conditional recommendation that clinicians discuss referral to a sleep surgeon with adults with OSA, BMI <40 kg/m2, and persistent inadequate PAP adherence due to pressure-related side effects, as available data (very low-quality), suggests that upper airway surgery has a moderate effect in reducing minimum therapeutic PAP level and increasing PAP adherence. In adults with OSA and obesity (class II/III, BMI >35) who are intolerant or unaccepting of PAP, the AASM strongly recommends discussion of referral to a bariatric surgeon, along with other weight-loss strategies.

The AASM (2025) guidelines on the evaluation and management of OSA in adults hospitalized for medical care recommend that treatment of sleep-disordered breathing should be continued regardless of modality (e.g., PAP, HNS therapy, oral appliance therapy, pharmacotherapies) if feasible given the clinical setting.[54,]Recommendations to continue therapy apply not only to PAP therapy, but also to alternative non-PAP modalities including oral appliances and HNS.

American Academy of Pediatrics
The American Academy of Pediatrics (2012) published a clinical practice guideline on the diagnosis and management of childhood OSA.[55,] The Academy indicated that if a child has OSA, a clinical examination consistent with adenotonsillar hypertrophy, and does not have a contraindication to surgery, the clinician should recommend adenotonsillectomy as first-line treatment. The Academy recommended that patients should be referred for CPAP management if symptoms/signs or objective evidence of OSA persist after adenotonsillectomy or if

adenotonsillectomy is not performed. Weight loss was recommended in addition to other therapy if a child or adolescent with OSA is overweight or obese (defined as BMI >95th percentile).

American Academy of Otolaryngology - Head and Neck Surgery
The American Academy of Otolaryngology - Head and Neck Surgery (AAO-HNS; 2021) has a position statement on surgical management of OSA.[56,] Procedures AAO-HNS supported as effective and not considered investigational when part of a comprehensive approach in the medical and surgical management of adults with OSA include:

- tracheostomy,
- nasal and pharyngeal airway surgery,
- tonsillectomy and adenoidectomy,
- palatal advancement,
- UPPP,
- genioglossal advancement,
- hyoid myotomy,
- midline glossectomy,
- tongue suspension,
- maxillary and mandibular advancement.

In a 2021 position statement, AAO-HNS supported HNS as an effective second-line treatment of moderate-to-severe OSA.[57,]

American Society for Metabolic and Bariatric Surgery
The American Society for Metabolic and Bariatric Surgery (2012) published guidelines on the perioperative management of OSA.[58,] The guideline indicated that OSA is strongly associated with obesity, with the incidence of OSA in the morbidly obese population reported as between 38% and 88%. The Society recommended bariatric surgery as the initial treatment of choice for OSA in this population, besides CPAP, as opposed to surgical procedures directed at the mandible or tissues of the palate. The updated 2017 guidelines reaffirmed these recommendations.[59,]

National Institute for Health and Care Excellence
The National Institute for Health and Care Excellence (NICE) 2017 guidance concluded that evidence on the safety and efficacy of HNS is limited in quantity and quality, and the procedure should only be used in the context of a clinical trial.[60,]

U.S. Preventive Services Task Force Recommendations
Not applicable.

Ongoing and Unpublished Clinical Trials
Some currently unpublished trials that might influence this review are listed in Table 34.

Table 34. Summary of Key Trials

NCT No.	Trial Name	Planned Enrollment	Completion Date
Ongoing			
NCT06851338[a]	Pediatric Down Syndrome Post-Approval Study	60	May 2030
NCT05592002[a]	A Multicenter Study to Assess the Safety and Effectiveness of the Genio® Dual-sided Hypoglossal Nerve Stimulation System for the Treatment of Obstructive Sleep Apnea in Subjects With Complete Concentric Collapse of the Soft Palate	124	Sep 2028
NCT02413970[a]	Inspire® Upper Airway Stimulation System (UAS): Post-Approval Study Protocol Number 2014-001	127	Jun 2025
NCT04801771[a]	Effects of Hypoglossal Nerve Stimulation on Cognition and Language in Down Syndrome and Obstructive Sleep Apnea	57	Sept 202 7
NCT02907398[a]	Adherence and Outcome of Upper Airway Stimulation (UAS) for OSA International Registry	5000	Dec 2025
NCT04950894[a]	Treating Obstructive Sleep Apnea Using Targeted Hypoglossal Neurostimulation	150	Oct 2025

NCT: national clinical trial.
[a] Denotes industry-sponsored or cosponsored trial.

CODING

The following codes for treatment and procedures applicable to this policy are included below for informational purposes. This may not be a comprehensive list of procedure codes applicable to this policy.

Inclusion or exclusion of a procedure, diagnosis or device code(s) does not constitute or imply member coverage or provider reimbursement. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

The code(s) listed below are medically necessary ONLY if the procedure is performed according to the "Policy" section of this document.

CPT/HCPCS	
21199	Osteotomy, mandible, segmental; with genioglossus advancement
21685	Hyoid myotomy and suspension
41512	Tongue base suspension, permanent suture technique
41530	Submucosal ablation of the tongue base, radiofrequency, 1 or more sites, per session
42145	Palatopharyngoplasty (e.g., uvulopalatopharyngoplasty, uvulopharynogoplasty)
42299	Unlisted procedure, palate, uvula
42820	Tonsillectomy and adenoidectomy; younger than 12
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
42830	Adenoidectomy, primary; younger than age 12
42831	Adenoidectomy, primary; age 12 or over
42835	Adenoidectomy, secondary; younger than age 12
42836	Adenoidectomy, secondary; age 12 or over
42950	Pharyngoplasty (plastic or reconstructive operation on pharynx)
64568	Open implantation of cranial nerve (eg, vagus nerve) neurostimulator electrode array and pulse generator
64582	Open implantation of hypoglossal nerve neurostimulator array, pulse generator, and distal respiratory sensor electrode or electrode array
64583	Revision or replacement of hypoglossal nerve neurostimulator array and distal respiratory sensor electrode or electrode array, including connection to existing pulse generator
64584	Removal of hypoglossal nerve neurostimulator array, pulse generator, and distal respiratory sensor electrode or electrode array
C1767	Generator, neurostimulator (implantable), non-rechargeable
C1778	Lead, neurostimulator (implantable)
C9727	Insertion of implants into the soft palate; minimum of three implants
S2080	Laser-assisted uvulopalatoplasty (LAUP)

REVISIONS	
10-01-2015	Policy added to the bcbsks.com web site on 09-01-2015 and effective 10-01-2015.
	The new policy replaced two policies titled: "Laser Assisted Uvulopalatopharyngoplasty (LAUP)" and "Uvulopalatopharyngoplasty (UPPP) and Tongue Base Reduction Surgery"
05-13-2016	In Policy section: ▪ In Item A, added "(see Policy Guidelines)" to read "Uvulopalatopharyngoplasty (UPPP) may be considered medically necessary for the treatment of clinically significant obstructive sleep apnea syndrome (OSA) in appropriately selected adult patients who have failed an adequate trial of continuous positive airway pressure (CPAP) (see Policy Guidelines) or failed an adequate trial of an oral appliance. Clinically significant OSA is defined as those patients who have:" ▪ In Item B, added "(see Policy Guidelines)" to read "Hyoid suspension, surgical modification of the tongue, and/or maxillofacial surgery, including mandibular-maxillary advancement (MMA), may be considered medically necessary in appropriately selected adult patients with clinically significant OSA and objective documentation of hypopharyngeal obstruction who have failed an adequate trial of CPAP (see Policy Guidelines) or failed an adequate trial of an oral appliance. Clinically significant OSA is defined as those patients who have:" ▪ In Policy Guidelines, added "3. A trial of CPAP is defined as utilization for 60 days or greater."
	Updated References section.
01-18-2017	Updated Description section.
	In Policy section: ▪ In Item A, added "Palatopharyngoplasty (e.g." and "uvulopharyngoplasty, uvulopalatal flap, expansion sphincter pharyngoplasty, lateral pharyngoplasty, palatal advancement pharyngoplasty, relocation pharygoplasty)" and removed "(UPPP)" to read, "Palatopharyngoplasty (e.g., uvulopalatopharyngoplasty, uvulopharyngoplasty, uvulopalatal flap, expansion sphincter pharyngoplasty, lateral pharyngoplasty, palatal advancement pharyngoplasty, relocation pharyngoplasty) may be considered medically necessary for the treatment of clinically significant obstructive sleep apnea syndrome (OSA) in appropriately selected adult patients who have failed an adequate trial of continuous positive airway pressure (CPAP) (see Policy Guidelines) or failed an adequate trial of an oral appliance. Clinically significant OSA is defined as those patients who have:" ▪ In Item B, added an "s" and removed "patients" to read, "Hyoid suspension, surgical modification of the tongue, and/or maxillofacial surgery, including mandibular-maxillary advancement (MMA), may be considered medically necessary in appropriately selected adults with clinically significant OSA and objective documentation of hypopharyngeal obstruction who have failed an adequate trial of CPAP (see Policy Guidelines) or failed an adequate trial of an oral appliance. Clinically significant OSA is defined as those patients who have:" ▪ In Item B 1, added "of" to read, "AHI or RDI of 15 or more events per hour," ▪ In Item B 2, added "of" to read, "AHI or RDI of 5 or more events and 14 or less events per hour with documented symptoms of excessive daytime sleepiness, impaired cognition, mood disorders or insomnia, or documented hypertension, ischemic heart disease, or history of stroke."
	Updated Rationale section.
	In Coding section: ▪ Added CPT code: 64568. ▪ Added CPT codes: 0466T, 0467T, 0468T *(new codes, effective January 1, 2017)*.
10-25-2017	Updated Description section.

REVISIONS	
	Updated Rationale section.
	Updated References section.
02-01-2019	Updated Description section.
	In Policy section: ▪ In Item A, removed "patients" to read, "Palatopharyngoplasty (e.g., uvulopalatopharyngoplasty, uvulopharyngoplasty, uvulopalatal flap, expansion sphincter pharyngoplasty, lateral pharyngoplasty, palatal advancement pharyngoplasty, relocation pharyngoplasty) may be considered medically necessary for the treatment of clinically significant obstructive sleep apnea syndrome (OSA) in appropriately select adults who have failed an adequate trial of continuous positive airway pressure (CPAP) (see Policy Guidelines) or failed an adequate trial of an oral appliance. Clinically significant OSA is defined as those patients who have:" ▪ Added new Item D, "Hypoglossal nerve stimulation may be considered medically necessary in adults with OSA under the following conditions: 1. Age ≥22 years; AND 2. AHI ≥20 with less than 25% central apneas; AND 3. CPAP failure (residual AHI ≥20 or failure to use CPAP ≥4 hours per night for ≥5 nights per week) or inability to tolerate CPAP; AND 4. Body mass index ≤32 kg/m^2; AND 5. Non-concentric retropalatal obstruction on drug-induced sleep endoscopy (see Policy Guidelines)." ▪ Added new Item E, "Hypoglossal nerve stimulation may be considered medically necessary in adolescents or young adults with Down's syndrome and OSA under the following conditions: 1. Age 10 to 21 years; AND 2. AHI >10 and <50 with less than 25% central apneas after prior adenotonsillectomy; AND 3. Have either tracheotomy or be ineffectively treated with CPAP due to noncompliance, discomfort, undesirable side effects, persistent symptoms despite compliance use, or refusal to use the device; AND 4. Body mass index ≤95th percentile for age; AND 5. Non-concentric retropalatal obstruction on drug-induced sleep endoscopy (see Policy Guidelines). ▪ In Item H (previously Item F), removed "including, but not limited to, the treatment of OSA" and added "other than listed above" to read, "Implantable hypoglossal nerve stimulators are considered experimental / investigational for all indications other than listed above." ▪ Updated Policy Guidelines.
	Updated Rationale section.
	In Coding section: ▪ Removed CPT code: 41599. ▪ Removed ICD-9 codes.
	Updated References section.
09-13-2019	The policy published to the bcbsks.com website on August 14, 2019 with an effective date of September 13, 2019.
	Updated Description section.
	In Policy section: ▪ In Item A 1, removed "An" to read, "Apnea/Hypopnea Index (AHI) or Respiratory Disturbance Index (RDI) of 15 or more events per hour, OR" ▪ In Item A 2, removed "An", "or more", "and 14 or less events", "documented", "impaired cognition, mood disorders or insomnia, or documented", "ischemic", and "history of" and added "at least", "one or more signs or", "associated with OSA (e.g.", and "cardiovascular" to read, "AHI or RDI of at least 5 events per hour with one or more signs or symptoms associated with OSA (e.g., excessive daytime sleepiness, hypertension, heart disease, or stroke)." ▪ In Item B 1, removed "An" to read, "AHI or RDI of at least 5 per hour, OR" ▪ In Item B 2, removed "An", "or more", "and 14 or less events per hour with documented", "impaired cognition, mood disorders or insomnia, or documented",

REVISIONS	
	"ischemic", and "history of" and added "at least", "per hour with one or more signs or", "associated with OSA (e.g.", and "cardiovascular" to read, "AHI or RDI of at least 5 events per hour with one or more signs or symptoms associated with OSA (e.g., excessive daytime sleepiness, hypertension, cardiovascular heart disease, or stroke)." ▪ In Item C 1, removed "An" to read, "AHI or RDI of at least 5 per hour, OR" ▪ In Item C 2, removed "An" to read, "AHI or RDI of at least 1.5 per hour in a patient with excessive daytime sleepiness, behavioral problems, or hyperactivity." ▪ In Item D 2, removed "20" and added "15" to read, "AHI ≥15 with less than 25% central apneas; AND" ▪ In Item D 3, removed "20" and added "15" to read, "CPAP failure (residual AHI ≥15 or failure to use CPAP ≥4 hours per night for ≥5 nights per week) or inability to tolerate CPAP; AND" ▪ In Item H, added "other than listed above" to read, "Implantable hypoglossal nerve stimulators are considered experimental / investigational for all indications other than listed above." ▪ Updated Policy Guidelines.
	Updated Rationale section.
	In Coding section: ▪ Added CPT code: 21685. ▪ Added HCPCS code: C9727.
	Updated References section.
04-19-2021	Updated Description section.
	Updated Rationale section.
	Updated References section.
08-19-2021	Updated Description section.
	Updated Rationale section.
	Updated References section.
01-01-2022	In Codding Section • Added: CPT 42975
04-01-2022	In Coding Section • Deleted 0468T
04-25-2022	Updated Coding Section ▪ Removed: 0466T and 0467T ▪ Added: 64582, 64583, 64584 ▪ Updated nomenclature for 64568
08-25-2022	Updated Description Section
	Updated Policy Guideline Section ▪ Section A Added: "for obstructive sleep apnea" to statement "CPAP is the preferred first-line treatment for obstructive sleep apnea for most individuals. A smaller number of individuals may use oral appliances as a first line treatment."
	Updated Rationale Section
	Updated Coding Section ▪ Added CPT code 42950 ▪ Removed CPT code 42975 and 64568
	Updated References Section
07-25-2023	Updated Description Section.
	Updated Rationale Section
	Updated Coding Section ▪ Added C1767 and C1778 ▪ Removed ICD-10 Codes
	Updated References Section

REVISIONS	
Posted 08-27-2024 Effective 09-26-2024	Updated Description Section
	Updated Policy Section Hypoglossal nerve stimulation adults: ▪ Section D1: Age changed from 22 to 18 ▪ Section D2: Added and ≤100 ▪ Section D4: Changed BMI from ≤32 kg/m2 to ≤ 40 kg/m2 ▪ Section D5: Changed "Non-concentric retropalatal obstruction on drug-induced sleep endoscopy" to read "Absence of complete concentric collapse at the soft palate level" ▪ Hypoglossal nerve stimulation Down's syndrome: ▪ Section E1: Changed age from 10 to 21 to 13 to 18 ▪ Section E5: Changed "Non-concentric retropalatal obstruction on drug-induced sleep endoscopy" to read "Absence of complete concentric collapse at the soft palate level"
	Updated Rationale Section
	Updated References Section
08-12-2025	Updated Description Section
	Updated Rationale Section
	Updated Reference Section
Posting 01-27-2026 Effective 02-26-2026	Updated Description Section
	Updated Policy Section
	Updated Rationale Section
	Updated Policy Statement ▪ Added D, E: with the Inspire U.S. Food and Drug Administration (FDA) approved device ▪ Added F: Hypoglossal nerve stimulation with other U.S. Food and Drug Administration (FDA) approved devices (e.g., Genio) are considered experimental / investigational for the treatment of clinically significant OSA syndrome. ▪ Changed statement: "Surgical treatment of OSA that does not meet the criteria above would be considered not medically necessary" to experimental / investigational ▪ Changed statement: "All interventions, including LAUP, radiofrequency volumetric tissue reduction of the palate, or palatal stiffening procedures, are considered not medically necessary for the treatment of snoring in the absence of documented OSA; snoring alone is not considered a medical condition;" to experimental / investigational.
	Updated Coding Section ▪ Added code 64568
	Updated Reference Section

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