

DOI:10.58240/1829006X-2026.22.3-163



## REVIEW ARTICLE

**PREVENTION STRATEGIES AND TREATMENT OF OBSTRUCTIVE SLEEP APNEA SYNDROME: A NARRATIVE REVIEW**Bedros Yavru-Sakuk<sup>1</sup><sup>1</sup>Professor, DDS, CHDF, MAGD, FWSO: Vice-President of the World Stomatological Organization. Executive Director of the Commonwealth of CIS Countries Association, USA**Corresponding Author:** Bedros Yavru-Sakuk Professor, DDS, CHDF, MAGD, FWSO: Vice-President of the World Stomatological Organization. Executive Director of the Commonwealth of CIS Countries Association, USA

E-mail: byavrusakuk@yahoo.com

**Received:** Mar 6. 2026; **Accepted:** Apr 28. 2026; **Published:** May 9. 2026**Abstract**

Obstructive sleep apnea (OSA) is a prevalent sleep-related breathing disorder characterized by recurrent episodes of upper airway collapse during sleep, resulting in intermittent hypoxia and sleep fragmentation. Oral and maxillofacial surgeons play a pivotal role in both the prevention and management of OSA through surgical and non-surgical interventions that target craniofacial anatomy. This narrative review critically summarizes current evidence regarding the etiology, diagnostic approaches, preventive strategies, and treatment modalities of OSA within the scope of oral and maxillofacial surgery. Particular emphasis is placed on mandibular advancement devices, orthognathic surgical procedures, and multidisciplinary treatment strategies. Contemporary evidence indicates that maxillomandibular advancement (MMA) is among the most effective surgical interventions, achieving significant reductions in the apnea–hypopnea index (AHI) and substantial improvement in clinical outcomes. Preventive approaches, including early identification of craniofacial risk factors and timely orthodontic intervention, are also addressed. This review underscores the importance of individualized treatment planning and close interdisciplinary collaboration in optimizing patient outcomes. OSA is a multifactorial condition that requires personalized management strategies. Oral and maxillofacial surgery occupies a central position in both preventive and therapeutic pathways, with MMA remaining the gold standard surgical option, while early diagnosis and multidisciplinary care are essential for long-term success.

**Keywords:** Obstructive sleep apnea, maxillofacial surgery, mandibular advancement, orthognathic surgery, airway management**1. INTRODUCTION**

Obstructive sleep apnea (OSA) is a chronic disorder characterized by recurrent episodes of upper airway obstruction during sleep, leading to intermittent hypoxia, sleep fragmentation, and sympathetic activation<sup>1,2</sup>. It is increasingly recognized as a major global health problem due to its association with cardiovascular diseases, metabolic syndrome, and neurocognitive impairment<sup>2,3</sup>.

The prevalence of OSA has risen significantly, affecting approximately 10–17% of adult males and 3–9% of females<sup>3</sup>. Despite its high prevalence, a substantial proportion of cases remain undiagnosed, particularly in developing healthcare systems. The

burden of untreated OSA includes increased risks of hypertension, stroke, myocardial infarction, and reduced quality of life<sup>2,4</sup>.

The pathophysiology of OSA is multifactorial, involving anatomical and neuromuscular components<sup>4</sup>. Anatomical factors include craniofacial abnormalities such as mandibular retrognathia,

maxillary constriction, increased lower facial height, and reduced posterior airway space<sup>5</sup>. These features contribute to airway narrowing and increased collapsibility during sleep. Functional factors include reduced neuromuscular tone of the pharyngeal dilator muscles, particularly during rapid eye movement sleep<sup>4</sup>.

Obesity is a major risk factor, contributing to fat deposition around the upper airway and increasing its collapsibility<sup>3,38</sup>. However, craniofacial morphology plays a particularly important role in non-obese patients, emphasizing the relevance of oral and maxillofacial surgery (OMFS) in diagnosis and management<sup>5,6</sup>.

OMFS provides unique therapeutic options that directly address the anatomical causes of airway obstruction<sup>6,12</sup>. These include both preventive interventions-such as orthodontic growth modification-and definitive surgical treatments like maxillomandibular advancement (MMA)<sup>13,18</sup>. Preventive strategies have gained increasing attention, particularly in pediatric populations. Early identification of craniofacial abnormalities allows timely intervention using rapid maxillary expansion or functional appliances, which can improve airway dimensions and reduce the risk of developing OSA later in life<sup>18-20</sup>.

Treatment of OSA includes both non-surgical and surgical modalities<sup>21</sup>. Continuous positive airway pressure (CPAP) therapy remains the gold standard for moderate-to-severe OSA; however, compliance is often poor<sup>22,31</sup>. Oral appliances, particularly mandibular advancement devices (MADs), are effective alternatives for mild-to-moderate cases<sup>7-10</sup>.

Surgical treatment is indicated in patients with anatomical abnormalities or CPAP intolerance<sup>24</sup>. Among surgical options, MMA is considered the most effective, as it enlarges the entire upper airway and provides long-term stability<sup>13,16,42</sup>. Other procedures, such as genioglossus advancement and surgically assisted rapid maxillary expansion (SARME), are used in selected cases<sup>11,17</sup>.

Given the complexity of OSA, a multidisciplinary approach involving oral surgeons, orthodontists, sleep specialists, and otolaryngologists is essential for optimal patient outcomes<sup>23</sup>.

## 2. MATERIALS AND METHODS

### Study Design

This structured narrative review was conducted to evaluate contemporary prevention strategies and treatment modalities for obstructive sleep apnea (OSA) within the field of oral and maxillofacial surgery (OMFS). The review followed a PRISMA-informed search strategy to enhance transparency, reproducibility, and methodological rigor; however, it was not registered as a systematic review protocol and does not include meta-analysis.

### Literature Search Strategy

A comprehensive electronic literature search was performed in the following databases: PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar.

Google Scholar was used as a supplementary source for citation tracking and identification of additional relevant studies not indexed in primary databases.

The search strategy combined Medical Subject Headings (MeSH) and free-text terms related to obstructive sleep apnea and oral and maxillofacial surgical management. The principal search terms included: “obstructive sleep apnea,” “sleep-disordered breathing,” “oral and maxillofacial surgery,” “maxillomandibular advancement,” “mandibular advancement device,” “orthognathic surgery,” “rapid maxillary expansion,” “drug-induced sleep endoscopy,” “hypoglossal nerve stimulation,” and “airway management.”

Boolean operators (AND/OR) were used to refine and optimize search sensitivity and specificity.

### Eligibility Criteria

#### Inclusion Criteria

Studies were included if they met the following criteria:

- Published in English
- Randomized controlled trials, prospective or retrospective clinical studies, systematic reviews, meta-analyses, or evidence-based clinical guidelines
- Focused on diagnosis, prevention, or management of OSA
- Included adult and/or pediatric populations
- Reported objective sleep-related outcome measures (e.g., apnea-hypopnea index, oxygen saturation, or validated sleep parameters)
- Addressed OMFS-related interventions, including surgical, orthodontic, or airway-focused treatments

#### Exclusion Criteria

The following were excluded:

- Non-English publications
- Animal or in vitro experimental studies
- Isolated case reports or small case series with limited generalizability
- Studies without objective sleep outcome measures

- Duplicate datasets (most complete or recent version retained)
- Articles not directly relevant to OMFS-based management of OSA

## Study Selection Process

All records identified through database searching were imported into a reference management system, and duplicate records were removed prior to screening.

Study selection was performed in two stages:

1. Title and abstract screening
2. Full-text eligibility assessment

Screening was conducted by the author, with repeated verification of eligibility criteria to minimize selection bias and ensure consistency in study inclusion.

Any uncertainties regarding study eligibility were resolved through full-text re-evaluation against predefined criteria.

## PRISMA-Informed Flow of Studies

The initial search identified 86 records across all databases:

- PubMed/MEDLINE: n = 41
- Scopus: n = 23
- Web of Science: n = 15
- Google Scholar and manual search: n = 7

After removal of 14 duplicate records, 72 studies were screened based on titles and abstracts. Nineteen studies were excluded due to irrelevance to the review topic.

Fifty-three full-text articles were assessed for eligibility. Of these, 11 studies were excluded due to insufficient clinical outcome data, absence of objective sleep parameters, duplicate patient cohorts, or lack of relevance to OMFS-based interventions. Ultimately, 42 studies were included in the qualitative synthesis.

## Data Categorization and Synthesis

Included studies were categorized into the following thematic domains:

- Pathophysiology and risk factors of OSA
- Preventive strategies
- Non-surgical treatment modalities (e.g., CPAP, oral appliances)

- Surgical interventions (e.g., maxillomandibular advancement, orthognathic surgery)
- Emerging technologies and personalized treatment approaches
- Pediatric obstructive sleep apnea management

## Data Synthesis

A qualitative narrative synthesis was performed due to heterogeneity in study designs, patient populations, intervention types, and outcome measures. Therefore, meta-analysis was not feasible.

Findings were synthesized descriptively, with emphasis on clinical relevance to oral and maxillofacial surgical practice.

## Risk of Bias Assessment

A formal risk-of-bias assessment was not performed due to the narrative nature of the review and the inclusion of heterogeneous study designs (randomized trials, observational studies, and systematic reviews). However, study quality was considered during interpretation, with preference given to higher-level evidence where available.

## Ethical Considerations

Ethical approval was not required for this study, as it was based exclusively on previously published literature and did not involve human or animal subjects.

## 3. RESULTS

### 3.1 Study Selection and Characteristics

A total of 86 studies were initially identified. After screening and eligibility assessment, 42 high-quality studies were included in the final synthesis.

### 3.2 Pathophysiology of Obstructive Sleep Apnea

OSA results from a combination of anatomical narrowing and reduced neuromuscular tone of the upper airway during sleep.

#### Key mechanisms include:

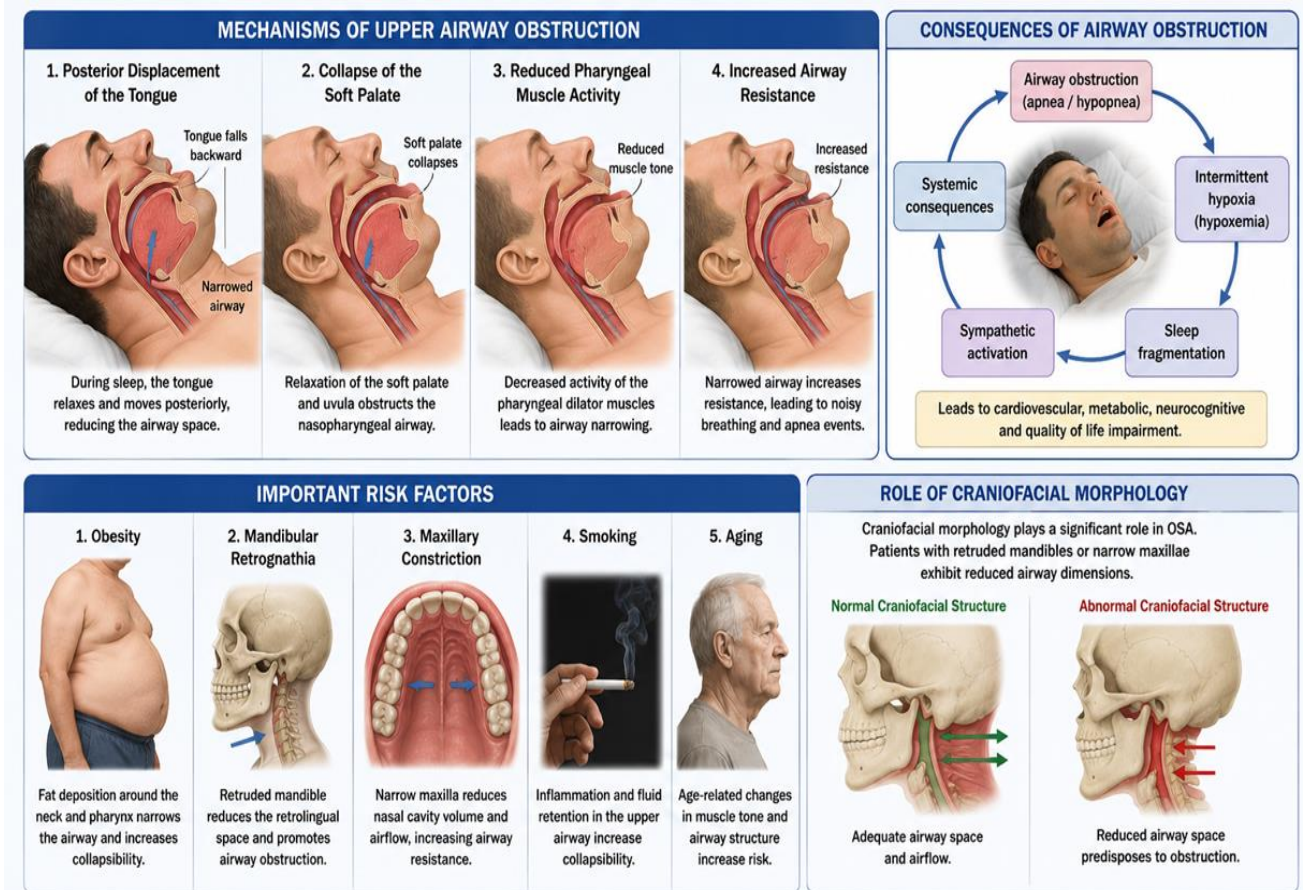
- Posterior displacement of the tongue
- Collapse of the soft palate
- Reduced pharyngeal muscle activity
- Increased airway resistance

**Important risk factors include:**

- Obesity
- Mandibular retrognathia
- Maxillary constriction
- Smoking and aging

Craniofacial morphology plays a significant role; patients with retruded mandibles or narrow maxillae exhibit reduced airway dimensions, predisposing them to obstruction.

During sleep, reduced neuromuscular tone of the upper airway leads to posterior displacement of the tongue, collapse of the soft palate, and decreased activity of pharyngeal dilator muscles. These changes result in airway narrowing and increased airway resistance, causing recurrent episodes of apnea and hypopnea. The figure 1 highlights major risk factors, including obesity, mandibular retrognathia, maxillary constriction, smoking, and aging, as well as the role of craniofacial morphology in airway obstruction.



**Figure 1.** Schematic Illustration of Pathophysiology of Obstructive Sleep Apnea (OSA)

**3.3 Drug-Induced Sleep Endoscopy (DISE)**

Drug-induced sleep endoscopy (DISE) has emerged as an important diagnostic modality in the evaluation of patients with obstructive sleep apnea. It enables direct, dynamic visualization of upper airway collapse under pharmacologically induced sleep conditions, allowing identification of the specific anatomical sites of obstruction.

In contrast to awake airway examination, DISE provides a more physiologically relevant assessment of upper airway behavior during sleep, which improves diagnostic accuracy and supports individualized surgical planning. The most commonly observed sites of obstruction include the velum (soft palate), oropharyngeal lateral walls, tongue base, and epiglottis. To standardize findings, the VOTE classification (Velum, Oropharynx, Tongue base, Epiglottis) is widely used in clinical practice. Evidence suggests that DISE-guided treatment planning may improve surgical outcomes by enabling more precise patient selection and reducing unnecessary interventions. It is particularly useful in determining candidacy for maxillomandibular advancement, tongue-base procedures, hypoglossal nerve stimulation, and multilevel airway surgery. Overall, DISE has become an important adjunct in OMFS practice, contributing to a more personalized and functionally guided approach to OSA management.

## 3.4 Role of Oral and Maxillofacial Surgery in OSA

Oral and maxillofacial surgeons play a central role in the multidisciplinary management of obstructive sleep apnea. Their contribution includes airway evaluation and diagnostic assessment<sup>5,26</sup>, fabrication and management of oral appliances<sup>6-10</sup>, surgical correction of craniofacial deformities<sup>12-14</sup>, and participation in multidisciplinary treatment planning<sup>23</sup>. Surgical intervention is particularly indicated in patients who are unable to tolerate continuous positive airway pressure therapy<sup>22,31</sup>, present with craniofacial abnormalities contributing to airway obstruction<sup>5,12</sup>, or require definitive anatomical correction through skeletal advancement procedures<sup>13,24</sup>.

## 3.5 Prevention Strategies

### Weight Management

Maintenance of healthy body weight is a key preventive strategy, as obesity is one of the most significant risk factors for obstructive sleep apnea. Weight reduction has been shown to improve upper airway patency and reduce the severity of respiratory events during sleep.

### Lifestyle Modifications

Avoidance of alcohol, sedatives, and smoking is recommended, as these factors contribute to decreased upper airway muscle tone and worsening of airway collapse during sleep. Regular physical activity may further improve respiratory efficiency and sleep quality.

### Sleep Hygiene

Maintaining a consistent sleep schedule and avoiding supine sleeping position are important behavioral strategies. Side-sleeping has been associated with reduced airway collapse in susceptible individuals.

### Management of Comorbidities

Effective control of nasal obstruction, allergic conditions, and chronic respiratory diseases may reduce upper airway resistance. Additionally, management of systemic conditions such as diabetes, hypertension, and cardiovascular disease is essential in comprehensive risk reduction.

### Oral Appliances in Early or Mild Cases

In selected patients with mild disease or anatomical predisposition, oral appliances may serve a preventive or early-intervention role by maintaining airway patency during sleep<sup>6-10</sup>.

### Regular Screening

Early identification of high-risk individuals, including obese patients, older adults, males, and those with a positive family history, allows timely intervention and risk reduction strategies<sup>2,3</sup>. Although primarily non-surgical, these preventive measures complement OMFS-based management approaches<sup>18-20</sup>.

Overview of preventive strategies for obstructive sleep apnea within oral and maxillofacial practice emphasizes early identification of craniofacial risk factors to enable timely intervention, particularly in pediatric populations. Orthodontic and growth modification approaches, including rapid maxillary expansion (RME) and functional appliances, may improve airway dimensions and support mandibular advancement.

In addition, lifestyle modifications such as weight management, smoking cessation, and sleep position therapy contribute to reducing both the risk and severity of OSA.

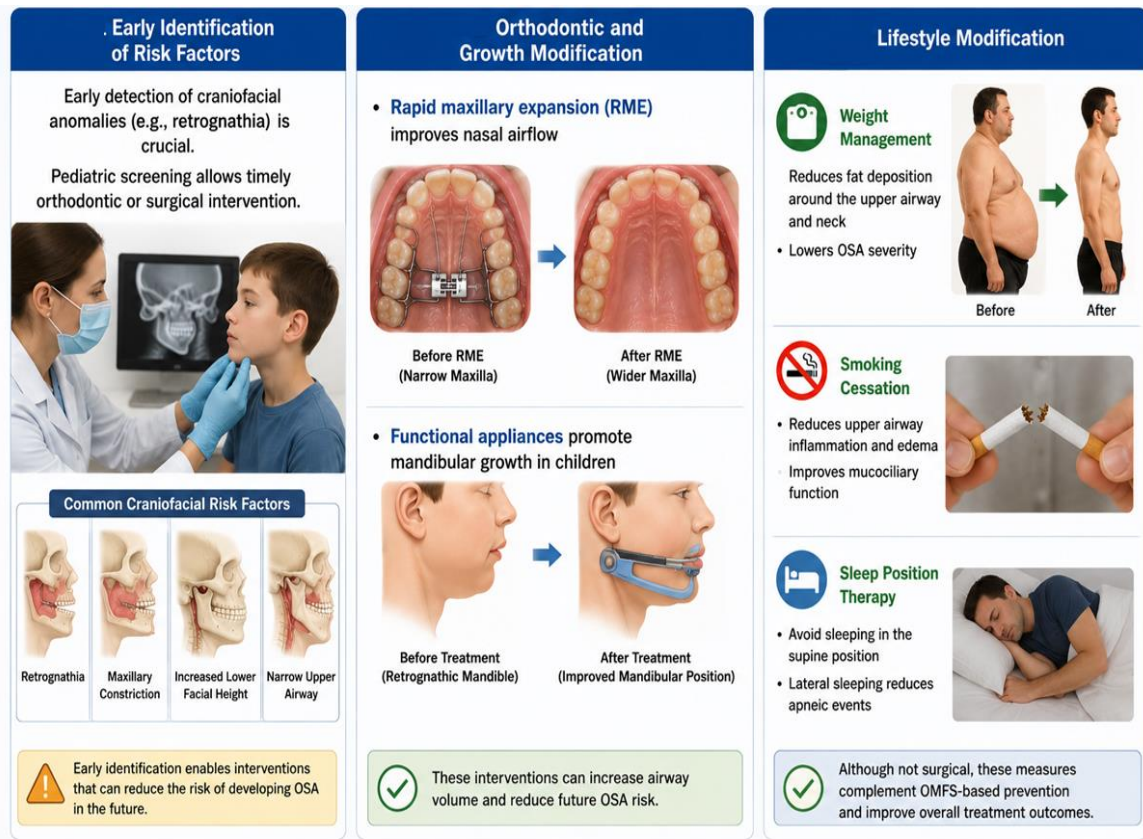


Figure 2. Prevention Strategies for Obstructive Sleep Apnea

### 3.6 Non-Surgical Treatment Modalities

#### 3.6.1 Continuous Positive Airway Pressure (CPAP)

Continuous positive airway pressure (CPAP) remains the gold standard treatment for moderate-to-severe obstructive sleep apnea; however, long-term adherence is limited in a substantial proportion of patients <sup>22</sup>.

#### 3.6.2 Oral Appliance Therapy

Mandibular advancement devices (MADs) are widely used in the management of mild-to-moderate obstructive sleep apnea <sup>7-10</sup>. These devices function by anteriorly repositioning the mandible, thereby increasing upper airway space and reducing the likelihood of tongue collapse during sleep.

Clinical evidence demonstrates that oral appliances significantly reduce the apnea-hypopnea index (AHI) compared with placebo interventions <sup>7,8</sup>.

#### Indications include:

- Mild-to-moderate OSA
- Intolerance to CPAP therapy

#### Limitations include:

- Temporomandibular joint discomfort
- Dental and occlusal changes
- Variable treatment efficacy across patient populations

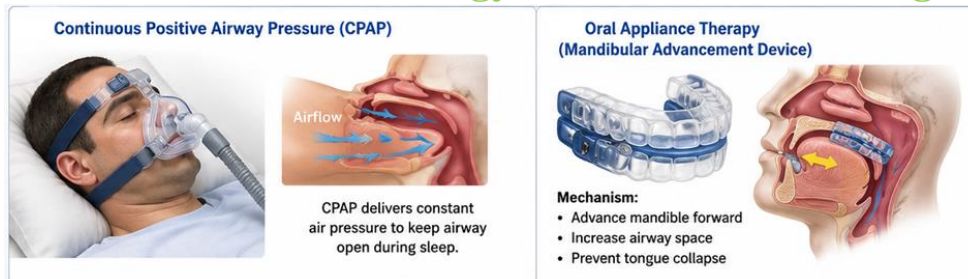


Figure 3. Non-Surgical Treatment Modalities

### 3.6.3 Hypoglossal Nerve Stimulation (HGNS)

Hypoglossal nerve stimulation (HGNS) is a minimally invasive therapeutic option for selected patients with moderate-to-severe obstructive sleep apnea who are intolerant to continuous positive airway pressure (CPAP) therapy<sup>39,40</sup>.

The technique involves implantation of a neurostimulation device that activates the hypoglossal nerve during inspiration, resulting in anterior displacement and stabilization of the tongue, thereby preventing upper airway collapse<sup>41</sup>.

#### Typical selection criteria include:

- Moderate-to-severe OSA
- CPAP intolerance
- Body mass index within recommended limits
- Absence of complete concentric palatal collapse on drug-induced sleep endoscopy (DISE)

Clinical studies have demonstrated significant improvements in apnea–hypopnea index (AHI), oxygen saturation, daytime sleepiness, and overall quality of life following HGNS therapy.

Although HGNS does not replace skeletal advancement surgery in patients with significant craniofacial abnormalities, it represents an important adjunct in multidisciplinary OSA management. Long-term outcome data suggest sustained efficacy and safety, supporting its increasing role in contemporary treatment algorithms for obstructive sleep apnea.

### 3.7 Surgical Treatment Modalities in Oral and Maxillofacial Surgery (OMFS)

Surgical management of obstructive sleep apnea represents an essential component of oral and maxillofacial practice, particularly in patients with craniofacial skeletal abnormalities or those who fail to respond to non-surgical therapies.

#### 3.7.1 Maxillomandibular Advancement (MMA)

Maxillomandibular advancement (MMA) is widely regarded as the most effective surgical treatment for obstructive sleep apnea<sup>13,16,42</sup>. The procedure involves simultaneous advancement of the maxilla and mandible, resulting in an increase in posterior airway space and reduction of upper airway collapsibility.

Clinical studies have demonstrated significant reductions in the apnea–hypopnea index (AHI), with high surgical success and cure rates reported in selected patient populations<sup>13,42</sup>. Reported success rates in the literature vary but may reach approximately 80–90% in appropriately selected cases<sup>13,19</sup>. Recent meta-analyses further confirm the long-term effectiveness and safety profile of MMA<sup>42</sup>.

#### 3.7.2 Mandibular Advancement Surgery

Mandibular advancement procedures are primarily indicated in patients with mandibular retrognathia and skeletal deficiency. These procedures improve upper airway patency by repositioning the mandible anteriorly, resulting in substantial reductions in AHI, with some studies reporting reductions of up to approximately 80% or more in selected cohorts<sup>19</sup>. Improvements in airway stability and respiratory parameters have also been documented<sup>17</sup>.

3.7.3 Genioglossus Advancement

Genioglossus advancement targets the anterior repositioning of the tongue muscle attachment, thereby reducing posterior tongue displacement during sleep. This procedure enhances airway stability and is frequently performed in combination with other surgical interventions in multilevel airway management strategies <sup>36</sup>.

3.7.4 Surgically Assisted Rapid Maxillary Expansion (SARME)

Surgically assisted rapid maxillary expansion (SARME) is indicated in adult patients with transverse maxillary deficiency <sup>20</sup>. By increasing maxillary width, SARME improves nasal airflow and contributes to enlargement of the upper airway, thereby reducing airway resistance.

3.7.5 Other Surgical Procedures

Additional surgical options include uvulopalatopharyngoplasty (UPPP) <sup>27,37</sup>, hyoid suspension <sup>36</sup>, and tongue base reduction procedures <sup>36</sup>. These interventions are generally considered less predictable in terms of long-term outcomes when compared with maxillomandibular advancement <sup>14,37</sup>, and are often reserved for selected cases or multilevel surgical approaches.

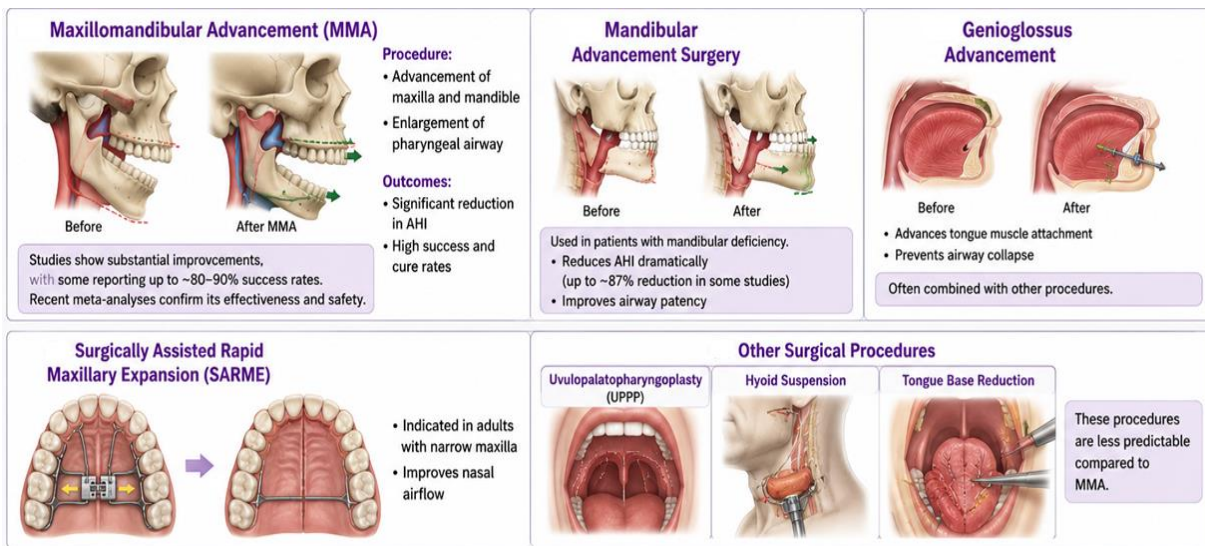


Figure 4 Surgical Treatment Modalities

Table 1 summarizes the main treatment modalities for obstructive sleep apnea, including their mechanisms of action, clinical indications, and relative effectiveness. Continuous positive airway pressure (CPAP) remains the gold standard treatment for moderate-to-severe OSA due to its ability to prevent upper airway collapse through pneumatic splinting. However, its long-term effectiveness is strongly dependent on patient adherence, which is often limited by discomfort and intolerance <sup>22,31</sup>.

Mandibular advancement devices (MADs) are primarily indicated for patients with mild-to-moderate OSA or those intolerant to CPAP therapy. These devices function by anteriorly repositioning the mandible, thereby increasing upper airway volume and reducing collapsibility during sleep. Clinical studies have demonstrated moderate but clinically significant improvements in apnea-hypopnea index (AHI) and sleep quality <sup>7,8</sup>.

Maxillomandibular advancement (MMA) is considered the most effective surgical treatment for OSA. By advancing both the maxilla and mandible, MMA produces a three-dimensional enlargement of the upper airway and directly addresses underlying skeletal deficiencies. It is mainly indicated in severe OSA and patients with craniofacial abnormalities <sup>13,16</sup>.

Surgically assisted rapid maxillary expansion (SARME) is indicated in patients with transverse maxillary deficiency. It improves nasal airflow and increases upper airway volume through skeletal widening of the maxilla, with moderate effectiveness in appropriately selected cases <sup>20</sup>.

**Table 1. Summary of Treatment Modalities for Obstructive Sleep Apnea**

<b>Treatment Type</b>	<b>Mechanism</b>	<b>Indication</b>	<b>Effectiveness</b>
CPAP	Pneumatic upper airway splinting	Moderate–severe OSA	High (adherence-dependent)
MAD	Mandibular advancement	Mild–moderate OSA	Moderate
MMA	Maxillomandibular skeletal advancement	Severe OSA	Very high
SARME	Transverse maxillary expansion	Maxillary constriction	Moderate

Table 2 summarizes outcomes and complication profiles of major surgical procedures for OSA. Maxillomandibular advancement (MMA) demonstrates the greatest reduction in apnea–hypopnea index (AHI), with reported reductions ranging from 60% to 90% and success rates approaching 85% in selected patient populations <sup>13,16</sup>. Despite its high efficacy, MMA is associated with moderate postoperative morbidity due to the complexity of skeletal surgery. Genioglossus advancement shows moderate effectiveness, with reported AHI reductions of approximately 40–60% and success rates around 60% <sup>11</sup>. The procedure primarily targets tongue-base obstruction and is associated with low complication rates, making it suitable as an adjunctive intervention. Uvulopalatopharyngoplasty (UPPP) demonstrates more variable outcomes, with AHI reductions ranging from 30% to 50% <sup>14,27</sup>. Its effectiveness is limited by its inability to address skeletal airway deficiencies, resulting in variable long-term success.

Overall, skeletal procedures-particularly MMA-provide superior and more predictable outcomes compared with isolated soft tissue surgeries.

**Table 2. Surgical Outcomes in Obstructive Sleep Apnea**

<b>Procedure</b>	<b>AHI Reduction</b>	<b>Success Rate</b>	<b>Complications</b>
MMA	60–90%	~85%	Moderate
Genioglossus advancement	40–60%	~60%	Low
UPPP	30–50%	Variable	Moderate

Table 3 categorizes the major risk factors for obstructive sleep apnea into anatomical, lifestyle-related, and physiological domains. Anatomical factors such as mandibular retrognathia and maxillary constriction contribute significantly to upper airway narrowing and increased collapsibility during sleep <sup>5</sup>. These craniofacial characteristics are particularly relevant in non-obese patients and highlight the importance of oral and maxillofacial surgical evaluation.

Lifestyle-related factors, including obesity and smoking, are strongly associated with both the development and progression of OSA <sup>3</sup>. Obesity promotes fat deposition around the upper airway, increasing airway resistance, while smoking contributes to chronic inflammation and mucosal edema, further exacerbating airway obstruction.

Physiological factors such as aging and reduced upper airway muscle tone also play a critical role in OSA pathophysiology <sup>4</sup>. Age-related neuromuscular decline increases airway collapsibility during sleep.

Together, these factors underscore the multifactorial nature of OSA and support the need for individualized, multidisciplinary management strategies.

**Table 3. Risk Factors for Obstructive Sleep Apnea**

<b>Category</b>	<b>Risk Factors</b>	<b>Mechanism</b>
Anatomical	Retrognathia, maxillary constriction	Reduced airway space
Lifestyle	Obesity, smoking	Fat deposition, inflammation
Physiological	Aging, reduced muscle tone	Increased airway collapsibility

**3.8 Evidence Level of OSA Treatment Modalities**

Table 4 summarizes the level of evidence, clinical outcomes, advantages, and limitations of major obstructive sleep apnea (OSA) treatment modalities. Continuous positive airway pressure (CPAP) remains the gold standard therapy, supported by a high level of evidence demonstrating significant reductions in apnea–hypopnea index (AHI); however, its long-term effectiveness is limited by poor patient adherence. Mandibular advancement devices (MADs) are supported by moderate-to-high levels of evidence and provide clinically relevant improvements in airway patency, although their use may be associated with dental side effects. Maxillomandibular advancement (MMA) demonstrates a high level of evidence and remains the most effective surgical option, offering long-term airway enlargement and the highest surgical success rates, despite associated surgical morbidity.

Uvulopalatopharyngoplasty (UPPP) and surgically assisted rapid maxillary expansion (SARME) demonstrate moderate evidence levels, with variable clinical outcomes and more limited indications. Hypoglossal nerve stimulation (HGNS) is supported by moderate-to-high evidence, offering effective tongue stabilization with the advantage of being minimally invasive, although cost remains a limiting factor.

**Table 4. Evidence Level of Major Obstructive Sleep Apnea Treatment Modalities**

<b>Treatment Modality</b>	<b>Level of Evidence</b>	<b>Main Clinical Outcome</b>	<b>Advantages</b>	<b>Limitations</b>
CPAP	High	Significant AHI reduction	Gold standard therapy	Poor long-term compliance
MAD	Moderate–High	Improved airway patency	Non-invasive	Dental side effects
MMA	High	Long-term airway enlargement	Highest surgical success	Surgical morbidity
UPPP	Moderate	Soft palate airway enlargement	Useful in selected cases	Variable success
HGNS	Moderate–High	Tongue stabilization	Minimally invasive	High cost
SARME	Moderate	Improved nasal airflow	Useful in transverse deficiency	Limited indications

**3.9 Comparison of Non-Surgical and Surgical Treatment Modalities**

Table 5 presents a comparative overview of non-surgical and surgical treatment approaches for OSA. Non-surgical therapies, including CPAP and oral appliance therapy, are generally less invasive and associated with variable long-term compliance. In contrast, surgical interventions such as MMA, UPPP, HGNS, and SARME provide more definitive anatomical correction, particularly in patients with craniofacial abnormalities or CPAP intolerance. While CPAP demonstrates high immediate effectiveness, surgical approaches—especially MMA—offer superior long-term anatomical and functional outcomes. However, surgical treatments are associated with higher procedural complexity and risk of complications compared to non-invasive modalities.

**Table 5. Comparison Between Non-Surgical and Surgical OSA Treatments**

<b>Parameter</b>	<b>Non-Surgical Therapy</b>	<b>Surgical Therapy</b>
Main modalities	CPAP, MAD	MMA, UPPP, HGNS, SARME
Invasiveness	Low	Moderate–High
Long-term compliance	Variable	Generally stable
Effect on anatomy	Minimal	Significant
Indications	Mild–moderate OSA	Severe OSA or CPAP intolerance
Immediate effectiveness	High with CPAP	High with MMA
Complications	Minor discomfort	Surgical risks
Long-term cure potential	Limited	Higher in selected patients

**3.10 Emerging Technologies in OSA Management**

Table 6 highlights emerging technologies that are increasingly integrated into the diagnosis and management of OSA. Cone-beam computed tomography (CBCT) enables precise airway volume assessment, while drug-induced sleep endoscopy (DISE) provides dynamic visualization of airway collapse, improving surgical planning accuracy.

Computational fluid dynamics and artificial intelligence applications are emerging tools that enhance predictive modeling and support personalized treatment strategies. Additionally, virtual surgical planning improves the precision of orthognathic procedures. Wearable sleep monitoring devices facilitate long-term follow-up and remote assessment of treatment outcomes. Collectively, these technologies contribute to a shift toward precision-based and data-driven management of OSA.

**Table 6. Emerging Technologies in OSA Management**

Technology	Clinical Application	Potential Benefit
CBCT airway analysis	Airway volume assessment	Precise anatomical diagnosis
DISE	Dynamic airway visualization	Improved surgical planning
Computational fluid dynamics	Airflow simulation	Prediction of surgical outcomes
Artificial intelligence	Automated diagnosis	Personalized treatment planning
Virtual surgical planning	Orthognathic simulation	Increased surgical precision
Wearable sleep devices	Remote monitoring	Improved follow-up

**3.11 Comparative Clinical Indications of CPAP, MAD, and MMA**

Table 7 summarizes the comparative indications for CPAP, mandibular advancement devices (MAD), and maxillomandibular advancement (MMA). CPAP remains the first-line therapy for moderate-to-severe OSA across all patient populations; however, adherence limitations are common in clinical practice.

MAD is primarily indicated for patients with mild-to-moderate OSA, particularly those who are non-obese, present with positional OSA, or are intolerant to CPAP therapy. Maxillomandibular advancement is considered the definitive treatment option for severe OSA, especially in patients with craniofacial skeletal deficiencies or mandibular retrusion.

Overall, treatment selection should be individualized based on disease severity, anatomical characteristics, and patient tolerance.

**Table 7. Comparative Indications for OSA Treatment Modalities**

Treatment	Primary Indications	Ideal Patient Profile	Limitations
CPAP	Moderate–severe OSA	All severities (first-line therapy)	Poor compliance, discomfort
MAD	Mild–moderate OSA	Non-obese, positional OSA, CPAP-intolerant	Dental changes, TMJ discomfort
MMA	Severe OSA	Craniofacial deficiency, skeletal retrusion	Surgical morbidity

**Clinical Summary**

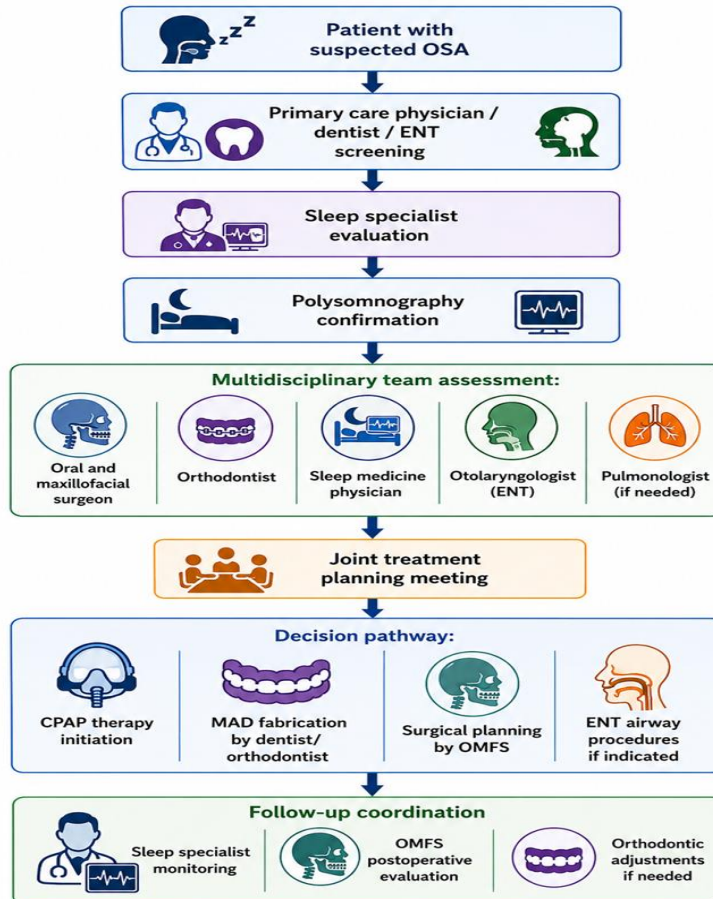
- CPAP → first-line for all moderate–severe cases
- MAD → alternative for mild–moderate or CPAP-intolerant patients
- MMA → definitive treatment for severe craniofacial OSA

**3.12 Multidisciplinary Referral Pathway in Obstructive Sleep Apnea Management**

**Clinical Importance of a Multidisciplinary Approach**

-

The management of obstructive sleep apnea (OSA) requires a multidisciplinary approach due to its complex and multifactorial pathophysiology, which involves anatomical, functional, and behavioral components. Effective diagnosis and treatment depend on close collaboration between oral and maxillofacial surgery (OMFS), sleep medicine, otolaryngology (ENT), and orthodontics. Such interdisciplinary coordination improves diagnostic accuracy, facilitates appropriate treatment selection, enhances surgical planning, and contributes to improved long-term treatment stability. In particular, integration of craniofacial assessment with sleep-related functional evaluation allows for a more precise identification of patients who may benefit from non-surgical versus surgical interventions. The implementation of a structured referral pathway also plays a critical role in reducing diagnostic delay, preventing disease progression, and improving overall patient prognosis. This coordinated model supports a more efficient and evidence-based management strategy for patients with OSA.



**Figure 5.** Multidisciplinary Care Model for OSA

**3.13 Pediatric Obstructive Sleep Apnea and Early Prevention**

Pediatric obstructive sleep apnea differs significantly from adult OSA in both pathophysiology and clinical management. In children, adenotonsillar hypertrophy is the most common etiological factor; however, craniofacial morphology also plays a significant role in airway development and obstruction<sup>23</sup>.

Children with:

- maxillary constriction,
- mandibular retrognathia,
- increased lower facial height,
- high-arched palate,
- and mouth-breathing patterns

may demonstrate increased airway resistance and impaired craniofacial growth<sup>5,20</sup>.

Early orthodontic intervention represents an important preventive strategy in growing patients. Rapid maxillary expansion (RME) has been shown to improve nasal airflow and increase transverse airway dimensions, while functional orthopedic appliances may promote mandibular advancement and optimize airway development during growth<sup>20</sup>.

Longitudinal evidence suggests that early correction of craniofacial abnormalities may reduce the risk of persistent obstructive sleep apnea into adulthood, particularly in patients with underlying skeletal discrepancies<sup>12,13</sup>.

Pediatric screening protocols should therefore include sleep-related questionnaires, craniofacial assessment, upper airway evaluation, and referral for polysomnography when clinically indicated<sup>23</sup>.

These findings highlight the essential role of oral and maxillofacial surgeons and orthodontists in early airway-focused craniofacial diagnosis and preventive management<sup>5,20</sup>.

### 3.14 Artificial Intelligence and Digital Airway Analysis

Recent advances in artificial intelligence (AI) and digital imaging technologies are progressively transforming the diagnostic and treatment planning processes in obstructive sleep apnea. Although still in an emerging stage of clinical integration, these technologies are increasingly being explored in airway assessment and surgical planning.

Machine learning-based approaches have been proposed for automated airway segmentation, cephalometric analysis, prediction of surgical outcomes, and individualized treatment planning. These developments aim to improve diagnostic efficiency and reduce inter-observer variability in craniofacial assessment<sup>5,26</sup>.

Three-dimensional cone-beam computed tomography (CBCT) provides high-resolution volumetric evaluation of upper airway anatomy and surrounding craniofacial structures. When combined with computational approaches, such as computational fluid dynamics, it allows simulation of airflow dynamics and estimation of postoperative airway changes, thereby supporting more accurate surgical planning<sup>26,17</sup>.

In addition, digital technologies may facilitate automated screening, risk stratification, interpretation of sleep studies, and computer-assisted surgical planning<sup>20,41</sup>. These applications have the potential to enhance diagnostic precision and support personalized treatment strategies in obstructive sleep apnea management.

Future integration of AI-assisted systems into oral and maxillofacial surgery workflows may contribute to improved clinical decision-making, reduced treatment variability, and more predictable long-term outcomes<sup>42</sup>.

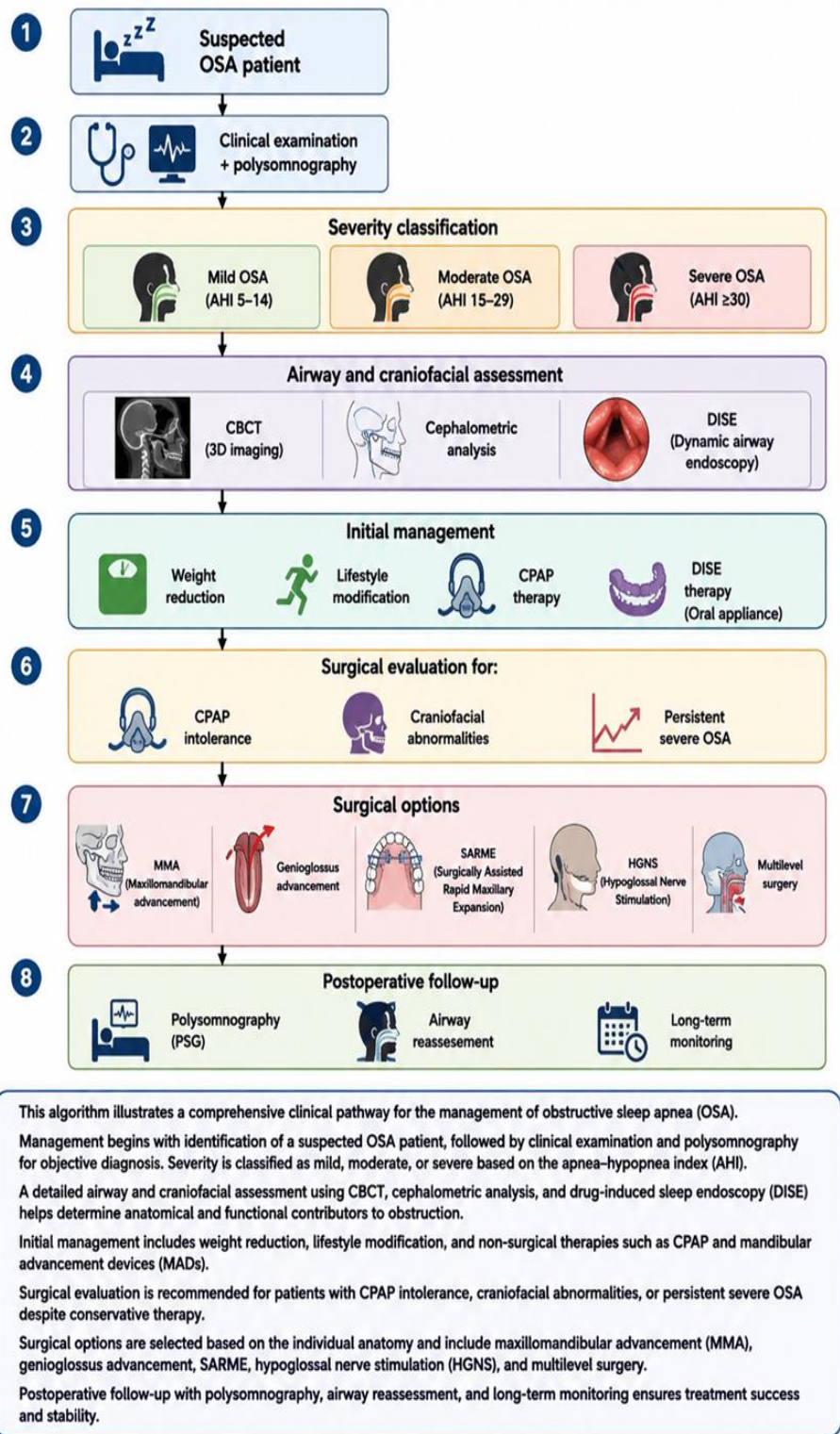
### 3.15 Clinical Decision-Making Algorithm in Obstructive Sleep Apnea Management

The clinical decision-making process in obstructive sleep apnea (OSA) management follows a structured, stepwise algorithm integrating clinical assessment, objective sleep study findings, and detailed airway evaluation. Initial identification of suspected OSA is based on clinical symptoms, which is subsequently confirmed using polysomnography as the diagnostic gold standard. Following diagnosis, patients are stratified according to disease severity into mild, moderate, and severe OSA categories. This classification is essential for guiding subsequent therapeutic decisions and selecting appropriate management pathways.

Comprehensive airway and craniofacial assessment plays a central role in treatment planning. Three-dimensional imaging using cone-beam computed tomography (CBCT), cephalometric analysis, and drug-induced sleep endoscopy (DISE) provide critical anatomical and functional information regarding upper airway obstruction patterns. Initial management typically includes conservative and non-invasive strategies such as weight reduction, lifestyle modification, continuous positive airway pressure (CPAP), and mandibular advancement device (MAD) therapy. These interventions represent first-line approaches, particularly in mild-to-moderate disease. Surgical evaluation is indicated in patients with CPAP intolerance, persistent moderate-to-severe OSA, or significant craniofacial abnormalities contributing to airway obstruction. In such cases, treatment is escalated to surgical interventions based on individualized anatomical and functional findings. Surgical options include maxillomandibular advancement (MMA), genioglossus advancement, surgically assisted rapid maxillary expansion (SARME), hypoglossal nerve stimulation (HGNS), and multilevel airway surgery. The selection of procedure is guided by the level of airway collapse, craniofacial morphology, and overall

disease severity. Postoperative management includes objective reassessment using polysomnography, evaluation of airway changes, and long-term follow-up to monitor stability of treatment outcomes and detect possible recurrence.

Overall, this algorithm emphasizes a personalized, multidisciplinary, and stepwise approach to OSA management, integrating clinical, radiological, and surgical decision-making to optimize long-term patient outcomes.



**Figure 6.** Clinical Decision-Making Algorithm for OSA Management

## 4. DISCUSSION

The present narrative review underscores the critical role of oral and maxillofacial surgery (OMFS) in the prevention and treatment of obstructive sleep apnea (OSA) <sup>6,12,13</sup>. The findings highlight that effective management requires an integrated understanding of upper airway anatomy, pathophysiology, and patient-specific craniofacial and functional characteristics <sup>4,5</sup>.

Non-surgical therapies remain the first-line approach in the management of OSA. Continuous positive airway pressure (CPAP) therapy is widely regarded as the gold standard due to its high efficacy in reducing apnea-hypopnea index (AHI) and improving oxygenation parameters <sup>22,28</sup>. However, long-term adherence remains a significant limitation, with reported compliance rates often below 50% <sup>22,31</sup>. This limitation has contributed to increasing clinical interest in alternative treatment modalities, particularly oral appliance therapy <sup>7-10</sup>.

Mandibular advancement devices (MADs) have demonstrated moderate-to-high effectiveness in patients with mild-to-moderate OSA, with reported reductions in AHI ranging from approximately 30% to 60% <sup>7,8</sup>. Evidence suggests improvements in daytime sleepiness and quality of life; however, their efficacy remains inferior to CPAP in severe cases <sup>8,9</sup>. Long-term use may be associated with dental occlusal changes and temporomandibular joint discomfort, requiring regular monitoring <sup>8,33</sup>.

Surgical intervention is indicated in patients with craniofacial abnormalities or CPAP intolerance <sup>12,24</sup>. Among surgical modalities, maxillomandibular advancement (MMA) demonstrates the highest and most predictable effectiveness. By advancing both jaws, MMA significantly enlarges the upper airway and reduces collapsibility across multiple anatomical levels <sup>13,16,17</sup>. Meta-analyses report success rates of approximately 80–85%, with sustained long-term outcomes <sup>13,42</sup>.

Adjunctive procedures, including genioglossus advancement, hyoid suspension, and tongue base reduction, may be used as isolated or multilevel approaches in selected patients; however, their outcomes are generally more variable compared with skeletal surgery <sup>11,36,37</sup>. Soft tissue procedures such as uvulopalatopharyngoplasty (UPPP) demonstrate inconsistent effectiveness, largely due to their limited impact on underlying skeletal airway constraints <sup>27,37</sup>.

Preventive strategies are particularly relevant in pediatric populations, where early identification of craniofacial abnormalities allows for timely

intervention <sup>18-20</sup>. Rapid maxillary expansion (RME) has been shown to improve nasal airflow and airway dimensions, while functional orthopedic appliances may promote favorable craniofacial growth and airway development <sup>19,20</sup>. These findings emphasize the importance of early screening and interceptive orthodontic treatment in reducing long-term OSA risk <sup>18</sup>.

Obesity remains a major modifiable risk factor for OSA. Weight reduction has been associated with improvement in disease severity and may enhance treatment response across both surgical and non-surgical modalities <sup>3,38</sup>. However, in patients with significant craniofacial skeletal abnormalities, weight loss alone is often insufficient, highlighting the need for structural interventions <sup>5,12</sup>.

Technological advancements are increasingly shaping OMFS-based OSA management. Three-dimensional imaging techniques and virtual surgical planning improve anatomical assessment and enable patient-specific surgical strategies <sup>26</sup>. Additionally, computational fluid dynamics offers potential for simulating airflow changes and predicting postoperative outcomes.

Emerging concepts in personalized medicine and OSA phenotyping are gaining importance <sup>4,35</sup>. Treatment stratification based on anatomical versus non-anatomical phenotypes may improve therapeutic outcomes and optimize patient selection for interventions such as MMA or oral appliance therapy <sup>35</sup>.

Despite these advances, several challenges remain. Surgical interventions carry potential risks, including neurosensory disturbances, infection, relapse, and postoperative discomfort <sup>24,26,42</sup>. Therefore, careful patient selection and multidisciplinary collaboration are essential to optimize outcomes and minimize complications <sup>23,24</sup>.

### Limitations

This narrative review has inherent limitations. As a non-systematic review, there is a potential risk of selection bias despite the use of a structured search strategy <sup>13,42</sup>. The absence of formal risk-of-bias assessment limits critical appraisal of study quality.

Considerable heterogeneity exists among included studies regarding design, patient populations, diagnostic criteria, and outcome definitions, particularly AHI thresholds and surgical success criteria <sup>13,14,25</sup>. This heterogeneity precluded quantitative synthesis.

Most included studies were retrospective or observational in nature, limiting the strength of evidence and introducing potential confounding factors <sup>14,18,19</sup>. Randomized controlled trials in surgical OSA

management remain limited due to ethical and methodological constraints<sup>24</sup>.

Long-term outcome data are not uniformly available across all treatment modalities. While MMA demonstrates relatively stable long-term results<sup>13,16,35</sup>, soft tissue procedures lack consistent long-term follow-up data<sup>27,37</sup>.

Publication bias may also influence the reported effectiveness of interventions, as positive outcomes are more likely to be published than negative results<sup>13,42</sup>.

Finally, this review primarily emphasizes anatomical and surgical aspects of OSA, while non-anatomical pathophysiological factors such as loop gain and arousal threshold were not extensively explored<sup>4,35</sup>.

## Future Directions

Future research should focus on high-quality randomized controlled trials comparing surgical and non-surgical treatment modalities across well-defined phenotypic subgroups<sup>13,22,42</sup>. Standardization of outcome measures, including AHI reduction and patient-reported quality-of-life indices, is essential for improving comparability<sup>25</sup>.

Advances in imaging, including CBCT and MRI, combined with virtual surgical planning, are expected to further refine diagnostic and therapeutic precision<sup>5,26</sup>. Computational fluid dynamics may enhance predictive modeling of airway behavior and surgical outcomes.

Personalized medicine approaches and OSA phenotyping represent a promising direction for optimizing treatment selection and improving clinical outcomes<sup>4,35</sup>.

Preventive strategies in pediatric populations require further longitudinal evaluation to determine the long-term impact of orthodontic interventions on airway development<sup>18-20</sup>.

Minimally invasive surgical techniques and technological innovations, including robotic and laser-assisted procedures, may further reduce morbidity and improve recovery<sup>15,24</sup>.

Finally, strengthened interdisciplinary collaboration and integration of digital health tools, including telemedicine and wearable sleep monitoring, will be essential for improving long-term disease management<sup>21,23</sup>.

## CONCLUSION

The management of OSA requires a comprehensive, individualized, and multidisciplinary approach<sup>21,23</sup>. OMFS plays a central role not only in surgical treatment but also in early prevention and craniofacial risk assessment<sup>5,18</sup>. While non-surgical therapies remain foundational, surgical interventions-particularly maxillomandibular advancement-provide the most predictable long-term outcomes in appropriately selected patients<sup>13,16,42</sup>. Future integration of digital technologies and personalized treatment strategies is expected to further enhance clinical effectiveness and patient-centered care.

## DECLARATIONS

### Conflict of Interest

The author declare no conflict of interest.

### Funding

No external funding was received for this study.

### Ethical Approval

Ethical approval was not required as this is a narrative review of published literature.

## REFERENCES

1. Young T, Peppard PE, Gottlieb DJ. Obstructive sleep apnea: epidemiology, pathogenesis, and treatment options. *N Engl J Med.* 2002;346(16):123-131. doi:10.1056/NEJMra012997.
2. Punjabi NM. The epidemiology of adult obstructive sleep apnea. *Am J Respir Crit Care Med.* 2008;177(12):1363-1372. doi:10.1164/rccm.200709-1410PP.
3. Peppard PE, Young T, Barnet JH, Palta M, Hagen EW, Hla KM. Increased prevalence of sleep-disordered breathing in adults. *Am J Epidemiol.* 2013;177(9):1006-1014. doi:10.1093/aje/kws342.
4. Eckert DJ. Phenotypic approaches to obstructive sleep apnea. *J Appl Physiol.* 2011;110(6):188-195. doi:10.1152/jappphysiol.00956.2010.
5. Ahmed MM, Schwab RJ. Upper airway imaging in obstructive sleep apnea. *Curr Opin Pulm Med.* 2006;12(6):397-401. doi:10.1097/01.mcp.0000245706.77064.51.
6. Clark GT, Nakano M. Dental appliances for the treatment of obstructive sleep apnea. *J Am Dent Assoc.* 1989;118(5):611-619. doi:10.14219/jada.archive.1989.0086.
7. Ferguson KA, Cartwright R, Rogers R, Schmidt-Nowara W. Oral appliances for sleep-disordered breathing. *Sleep.* 2006;29(2):244-262. doi:10.1093/sleep/29.2.244.
8. Sutherland K, Vanderveken OM, Tsuda H, Marklund M, Gagnadoux F, Kushida CA, et al. Oral appliance treatment for obstructive sleep apnea: an update. *J Clin*

- Sleep Med. 2014;10(2):215-227. doi:10.5664/jcsm.3460.
9. Ramar K, Dort LC, Katz SG, Lettieri CJ, Harrod CG, Thomas SM, et al. Clinical practice guideline for oral appliance therapy. *J Clin Sleep Med.* 2015;11(7):773-827. doi:10.5664/jcsm.4858.
  10. Kushida CA, Morgenthaler TI, Littner MR, Alessi CA, Bailey D, Coleman J Jr, et al. Practice parameters for oral appliances. *Sleep.* 2006;29(2):240-243. doi:10.1093/sleep/29.2.240.
  11. Goode RL. Success and failure in treatment of sleep apnea patients. *Otolaryngol Clin North Am.* 2007;40(4):891-901. doi:10.1016/j.otc.2007.04.006.
  12. Riley RW, Powell NB. Maxillofacial surgery and obstructive sleep apnea syndrome. *Otolaryngol Clin North Am.* 1990;23(4):809-826.
  13. Holty JE, Guilleminault C. Maxillomandibular advancement for the treatment of obstructive sleep apnea: a systematic review and meta-analysis. *Sleep Med Rev.* 2010;14(5):287-297. doi:10.1016/j.smrv.2009.11.003.
  14. Zhou N, Ho JPTF, Visscher WP, et al. Maxillomandibular advancement for obstructive sleep apnea: a retrospective prognostic factor study for surgical response. *Sleep Breath.* 2023;27:1567-1576. doi:10.1007/s11325-022-02731-x.
  15. Mahmoud AF, Thaler ER. Upper airway stimulation therapy and prior airway surgery for obstructive sleep apnea. *Laryngoscope.* 2018;128(6):1486-1489. doi:10.1002/lary.26956.
  16. Heidsieck DS, de Ruiter MH, de Lange J. Management of obstructive sleep apnea in edentulous patients: an overview of the literature. *Sleep Breath.* 2016;20(2):395-404. doi:10.1007/s11325-015-1285-9.
  17. Niskanen I, Kurimo J, Järnstedt J, Himanen SL, Helminen M, Peltomäki T. Effect of maxillomandibular advancement surgery on pharyngeal airway volume and polysomnography data in obstructive sleep apnea patients. *J Oral Maxillofac Surg.* 2019;77(8):1695-1702. doi:10.1016/j.joms.2019.04.001.
  18. Smatt Y, Ferri J. Retrospective study of 18 patients treated by maxillomandibular advancement with adjunctive procedures for obstructive sleep apnea syndrome. *J Craniofac Surg.* 2005;16(5):770-777. doi:10.1097/01.scs.0000179746.98789.0f.
  19. Goodday RH, Bourque SE, Edwards PB. Objective and subjective outcomes following maxillomandibular advancement surgery for treatment of patients with extremely severe obstructive sleep apnea (Apnea-Hypopnea Index >100). *J Oral Maxillofac Surg.* 2016;74(3):583-589. doi:10.1016/j.joms.2015.07.016.
  20. Camacho M, Jacobson R, Schendel S. Surgical treatment of obstructive sleep apnea. *Sleep Med Clin.* 2013;8(4):485-498. doi:10.1016/j.jsmc.2013.07.012.
  21. Arshad M, Ghadimi N, Heidari R, Heidarkhan Tehrani S. Non-surgical treatments for patients with obstructive sleep apnea. In: Keyhan SO, Bohluli B, Fallahi HR, Khojasteh A, Fattahi T, editors. *Handbook of Oral and Maxillofacial Surgery and Implantology.* Cham: Springer; 2025. doi:10.1007/978-3-031-36962-9\_244-1.
  22. Epstein LJ, Kristo D, Strollo PJ Jr, Friedman N, Malhotra A, Patil SP, et al. Clinical guideline for CPAP treatment. *J Clin Sleep Med.* 2009;5(3):263-276. doi:10.5664/jcsm.27497.
  23. Veasey SC, Rosen IM. Obstructive sleep apnea in adults. *N Engl J Med.* 2019;380(15):1442-1449. doi:10.1056/NEJMcp181615.
  24. Tanna N, Smith B, Zapanta P, Karanetz I, Andrews B, Urata M, et al. Surgical management of obstructive sleep apnea. *Plast Reconstr Surg.* 2016;137(4):1263-1272. doi:10.1097/PRS.0000000000002017.
  25. Ravesloot MJ, de Vries N. Reliable calculation of the efficacy of non-surgical and surgical treatment of obstructive sleep apnea revisited. *Sleep.* 2011;34(1):105-110. doi:10.1093/sleep/34.1.105.
  26. Barrera JE, Holbrook AB, Santos J, Popelka GR. Sleep MRI: novel technique to identify airway obstruction in obstructive sleep apnea. *Otolaryngol Head Neck Surg.* 2009;140(3):423-425. doi:10.1016/j.otohns.2008.11.037.
  27. Aurora RN, Casey KR, Kristo D, et al. Practice parameters for the surgical modifications of the upper airway for obstructive sleep apnea in adults. *Sleep.* 2010;33(10):1408-1413.
  28. Adesanya AO, Lee W, Greulich NB, Joshi GP. Perioperative management of obstructive sleep apnea. *Chest.* 2010;138(6):1489-1498. doi:10.1378/chest.10-1108.
  29. Lyons PG, Mokhlesi B. Diagnosis and management of obstructive sleep apnea in the perioperative setting. *Semin Respir Crit Care Med.* 2014;35(5):571-581. doi:10.1055/s-0034-1390079.
  30. Shafazand S. Perioperative management of obstructive sleep apnea: ready for prime time? *Cleve Clin J Med.* 2009;76 Suppl 4:S98-S103. doi:10.3949/ccjm.76.s4.16.
  31. Seet E, Chung F. Management of sleep apnea in adults-functional algorithms for the perioperative period. *Can J Anaesth.* 2010;57(9):849-864. doi:10.1007/s12630-010-9344-y.
  32. Bériault M. Airway management in obstructive sleep apnea: local solutions. *Can J Anaesth.* 2011; 58(2):228-229. doi:10.1007/s12630-010-9427-9.
  33. Sato Y, Ikeda A, Ishikawa T, Isono S. How can we improve mask ventilation in patients with obstructive sleep apnea during anesthesia induction? *J Anesth.*



10.3389/fdmed.2022.1010916 Copyright © 2026 by author(s) and "ASTRA SCIENCE" L L C This work is licensed under the Creative Commons Attribution International License (CC BY 4.0). <https://creativecommons.org/licenses/by-nc/4.0/>

34. Shah RM, Sethi JM, Wolf L, LaCavera M, Koo P. Obstructive sleep apnea: strategies for screening, management, and overcoming treatment challenges in the outpatient setting. *Am J Lifestyle Med.* 2025;19(5):664-675.mdoi:10.1177/15598276231217949.
35. Shin W, Jen R, Li Y, Malhotra A. Tailored treatment strategies for obstructive sleep apnea. *RespirInvestig.* 2016;54(1):2-7. doi:10.1016/j.resinv.2015.09.007.
36. Kezirian EJ, Goldberg AN. Hypopharyngeal surgery in obstructive sleep apnea: an evidence-based medicine review. *Arch Otolaryngol Head Neck Surg.* 2006;132(2):206-213. doi:10.1001/archotol.132.2.206.
37. Sher AE, Schechtman KB, Piccirillo JF. The efficacy of surgical modifications of the upper airway in adults with obstructive sleep apnea syndrome. *Sleep.* 1996;19(2):156-177. doi:10.1093/sleep/19.2.156.
38. Tuomilehto HP, Seppä JM, Partinen MM, Peltonen M, Gylling H, Tuomilehto JO, et al. Lifestyle intervention with weight reduction: first-line treatment in mild obstructive sleep apnea. *Am J Respir Crit Care Med.* 2009;179(4):320-327. doi:10.1164/rccm.200805-669OC.
39. Steffen A, Sommer JU, Hofauer B, Maurer JT, Hasselbacher K, Heiser C. Outcome after one year of upper airway stimulation for obstructive sleep apnea in a multicenter German post-market study. *Laryngoscope.* 2018;128(2):509-515. doi: 10.1002/lary.26688
40. Chao TN, Thaler ER. Predictors of success in hypoglossal nerve stimulator implantation for obstructive sleep apnea. *World J Otorhinolaryngol Head Neck Surg.* 2020 Jun 30;7(1):40-44. doi: 10.1016/j.wjorl.2020.02.007.
41. Malhotra A. Hypoglossal-nerve stimulation for obstructive sleep apnea. *N Engl J Med.* 2014 Jan 9;370(2):170-1. doi: 10.1056/NEJMe1314084.
42. Walker A, Kassir MF, Sama V, Nguyen SA, Abdelwahab M. Maxillomandibular advancement safety and effectiveness in obstructive sleep apnea: systematic review and meta-analysis. *Otolaryngol Head Neck Surg.* 2025;172(4):1142-1154. doi:10.1002/ohn.1114.