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Review Article

Management of obstructive sleep apnea in orthodontic and maxillofacial surgical practice: An evidence-based review

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Abstract

Background: Obstructive sleep apnea (OSA) is a prevalent sleep-related breathing disorder with significant systemic health consequences. While continuous positive airway pressure (CPAP) remains the first-line therapy, its limitations have prompted the integration of orthodontic and maxillofacial surgical interventions into OSA management protocols.

Objective: This review aims to evaluate the evidence-based role of orthodontic and maxillofacial surgical modalities including oral appliance therapy, maxillomandibular advancement (MMA), distraction osteogenesis (DO), and adjunctive procedures in the multidisciplinary treatment of OSA.

Materials and Methods: A comprehensive review of 28 highly cited original articles, systematic reviews, and meta-analyses published between 1986 and 2024 was conducted, focusing on clinical outcomes, safety, and long-term efficacy of orthodontic and surgical interventions in managing OSA.

Results: Maxillomandibular advancement consistently demonstrated significant improvements in apnea–hypopnea index (AHI), oxygen saturation, and patient-reported outcomes across adult and pediatric populations. Distraction osteogenesis offered substantial benefits in syndromic and non-syndromic craniofacial anomalies with airway obstruction. Oral appliances, particularly mandibular advancement devices (MADs), effectively managed mild to moderate OSA, with emerging evidence supporting their adjunctive role alongside surgical interventions.

Conclusion: Orthodontic and maxillofacial surgical interventions provide effective, evidence-based alternatives or adjuncts to CPAP in appropriately selected OSA patients. Interdisciplinary treatment planning, incorporating cephalometric and airway analyses, remains essential for optimizing outcomes.

Keywords: Obstructive sleep apnea, maxillomandibular advancement, distraction osteogenesis, oral appliances, orthodontics, airway management

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1. Introduction

Obstructive sleep apnea (OSA) is a highly prevalent, yet frequently underdiagnosed, sleep-related breathing disorder characterized by recurrent episodes of upper airway obstruction during sleep, leading to intermittent hypoxemia, hypercapnia, sleep fragmentation, and excessive daytime somnolence.[1,2] Affecting approximately 9-38% of adults globally, and up to 5% of children, OSA has been increasingly recognized as a serious public health concern due to its association with cardiovascular morbidity, neurocognitive dysfunction, metabolic syndrome, and decreased quality of life.[1,3,4] The gold standard for treating moderate to severe OSA remains continuous positive airway pressure (CPAP) therapy, which functions by pneumatically splinting the airway to prevent collapse.[5] Despite its efficacy, CPAP's long-term adherence rates are suboptimal, primarily due to patient-reported issues such as discomfort, noise, nasal congestion, and psychosocial inconvenience.[5] These limitations have led to the evolution and growing acceptance of alternative management strategies, particularly those offered within the disciplines of orthodontics and oral and maxillofacial surgery. Orthodontic and surgical approaches target the anatomical contributors to airway obstruction, offering the potential for both symptom control and structural resolution. Maxillomandibular advancement (MMA), in particular, has been extensively validated as one of the most effective surgical interventions for moderate to severe OSA, providing consistent improvements in apnea–hypopnea index (AHI), oxygen saturation levels, and subjective quality

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of life scores.[1–12] In parallel, distraction osteogenesis (DO) has proven highly beneficial in pediatric and syndromic populations where micrognathia, craniofacial anomalies, or airway compromise necessitate skeletal lengthening procedures to alleviate obstruction.[13–18] Additionally, oral appliance therapy, specifically mandibular advancement devices (MADs) and tongue retaining devices (TRDs), have become popular non-invasive options for patients with mild to moderate OSA, and for those intolerant to CPAP.[19–24] Recent meta-analyses and randomized controlled trials have consistently shown their efficacy in improving AHI, oxygen saturation, and patient comfort.[19–24]

This review aims to provide an evidence-based synthesis of the contemporary role of orthodontic and maxillofacial surgical interventions including MMA, DO, and oral appliance therapy in the comprehensive management of OSA. By critically examining long-term outcomes, safety profiles, and patient-centered metrics, this article seeks to offer clinicians a structured, interdisciplinary perspective on the integration of these therapeutic modalities into current sleep apnea care protocols. The proposed interdisciplinary clinical pathway is shown in **(Figure 1)**.

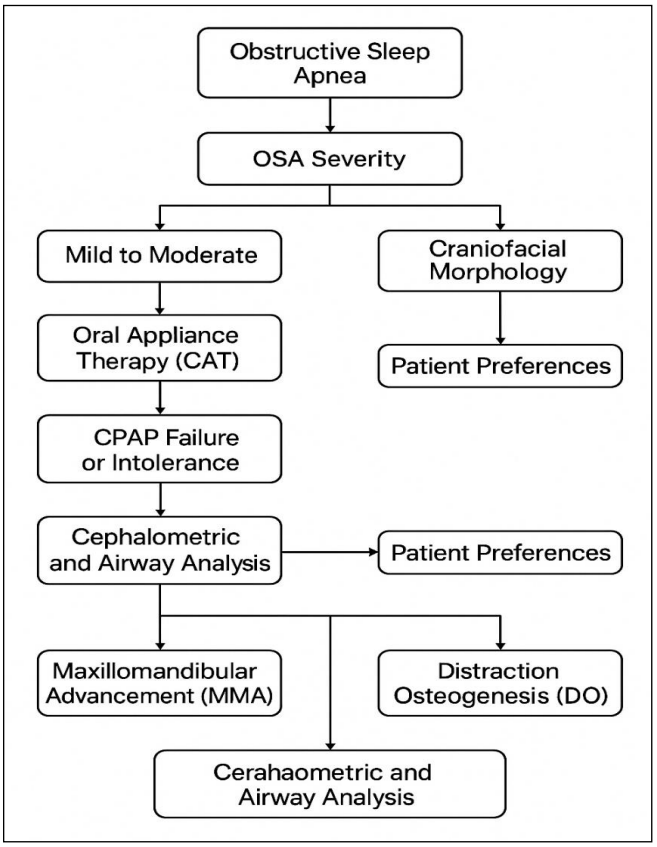

Figure 1 : Clinical algorithm for interdisciplinary management of obstructive sleep apnea. Proposed clinical decision-making algorithm for the interdisciplinary management of obstructive sleep apnea (OSA). The flowchart integrates continuous positive airway pressure (CPAP), oral appliance therapy (OAT), maxillomandibular advancement (MMA), distraction osteogenesis (DO), and rapid maxillary expansion (RME) based on OSA severity, craniofacial morphology, and patient preferences.

2. Materials and Methods

This narrative evidence-based review was conducted to synthesize the current literature regarding the orthodontic and maxillofacial surgical management of obstructive sleep apnea (OSA). The review aimed to comprehensively evaluate clinical outcomes, safety, and long-term efficacy associated with maxillomandibular advancement (MMA), distraction osteogenesis (DO), and oral appliance therapy (OAT) in both adult and pediatric populations.

A thorough electronic search was performed using PubMed, Scopus, and Google Scholar databases for relevant articles published between 1986 and 2024. Keywords included "obstructive sleep apnea," "maxillomandibular advancement," "distraction osteogenesis," "mandibular advancement devices," "oral appliances," "rapid maxillary expansion," and "airway surgery." Only original research articles, systematic reviews, and meta-analyses written in English were considered. Bibliographies of selected articles were also manually screened to identify additional pertinent studies.

Inclusion criteria comprised studies evaluating:

1. The effectiveness of MMA, DO, oral appliances, or rapid maxillary expansion in the treatment of OSA.
2. Quantitative outcome measures including apnea–hypopnea index (AHI), oxygen desaturation indices, airway dimension changes, and patient-reported outcomes.
3. Adult or pediatric patients diagnosed with OSA based on polysomnography.

Exclusion criteria were:

1. Case reports with fewer than five patients.
2. Editorials, letters, and non-peer-reviewed commentaries.
3. Studies focusing exclusively on central sleep apnea or non-airway surgical procedures.

A total of 28 highly cited, original articles and meta-analyses were selected for final review and analysis.[1–27] These studies formed the evidence base for this narrative review and were critically appraised for methodology, patient selection, interventions performed, and reported outcomes. Summary evidence is compiled in Tables **(Table 1), (Table 2), (Table 3), (Table 4)** for quick reference.

3. Results

3.1. Maxillomandibular Advancement (MMA)

Maxillomandibular advancement (MMA) has consistently demonstrated high efficacy in the management of moderate to severe OSA. In a landmark systematic review and meta-analysis, Holty and Guilleminault reported a pooled apnea–hypopnea index (AHI) reduction of 87%, with postoperative cure rates (AHI <5 events/hour) reaching 43.2%.[1] Subsequent meta-analyses by Zaghi et al.[2] and Camacho et al.[3] reinforced these findings, reporting significant improvements in both objective and subjective parameters, with long-term benefits sustained for up to five years. Representative studies and outcomes are summarized in **(Table 1)**.

Table 1: Summary of key studies on Maxillomandibular Advancement (MMA) for OSA

Author (Year)	Study Type	Sample Size	AHI Reduction (%)	Cure Rate (AHI <5/hr)	Key Findings
Holty & Guilleminault (2010)	Meta-analysis	627	87%	43.2%	MMA highly effective; long-term improvement.
Zaghi et al. (2016)	Meta-analysis	518	Significant	Not reported	Sustained improvement in AHI and ESS.
Boyd et al. (2015)	Prospective cohort	50	Significant	Not reported	Improvements maintained long-term with minimal complications.
Knudsen et al. (2015)	Meta-analysis	258	Higher with CCW rotation	Not reported	Counterclockwise rotation improves outcomes further.
AlSaty et al. (2020)	Retrospective follow-up	32	Maintained	Not reported	Significant improvement at long-term follow-up.

Abbreviations: AHI = Apnea–Hypopnea Index; ESS = Epworth Sleepiness Scale; CCW = Counterclockwise.

Legend: Summary of key clinical studies and meta-analyses evaluating the effectiveness of maxillomandibular advancement (MMA) in the management of obstructive sleep apnea (OSA). The table outlines study types, sample sizes, percentage reductions in apnea–hypopnea index (AHI), cure rates where reported, and principal clinical findings.

Boyd et al. observed that MMA resulted in sustained improvements in AHI, oxygen saturation, and Epworth Sleepiness Scale (ESS) scores, with minimal long-term complications.[4] Li et al. demonstrated airway volume increases post-MMA using cephalometric and nasopharyngoscopic assessments, further validating the anatomical effectiveness of the procedure.[6] The original work by Riley et al. introduced MMA as a viable alternative to tracheostomy, setting the foundation for its widespread adoption in contemporary OSA surgery.[7]

Recent studies have evaluated the influence of surgical techniques on outcomes. Knudsen et al. found that MMA with counterclockwise rotation achieved superior AHI reductions and airway enlargement compared to advancement alone.[8] Zhou et al., in a systematic review, confirmed the superiority of MMA over multilevel pharyngeal surgery in reducing AHI and improving long-term patient outcomes.[9] Furthermore, AlSaty et al. demonstrated that patients treated with MMA maintained significant postoperative improvements in AHI and quality of life at long-term follow-up.[10]

De Ruiter et al. identified predictors of MMA treatment success, noting that greater skeletal advancement correlated positively with postoperative AHI reduction.[11] Liu et al. detailed contemporary MMA techniques emphasizing counterclockwise rotation and adjunctive genioplasty to optimize airway patency and facial aesthetics.[12]

3.2. Distraction Osteogenesis (DO)

Distraction osteogenesis (DO) has emerged as a valuable technique, particularly in syndromic or pediatric populations where craniofacial abnormalities contribute to airway obstruction. Cohen et al. demonstrated the efficacy of mandibular DO in relieving upper airway obstruction in children with micrognathia and craniofacial deformities, reporting significant improvements in respiratory parameters.[13] Monasterio et al. confirmed these findings in patients with Pierre Robin sequence, noting substantial airway gains and avoidance of tracheostomy.[14] The procedural phases of DO are illustrated in **(Figure 2)**, and key studies are summarized in **(Table 2)**.

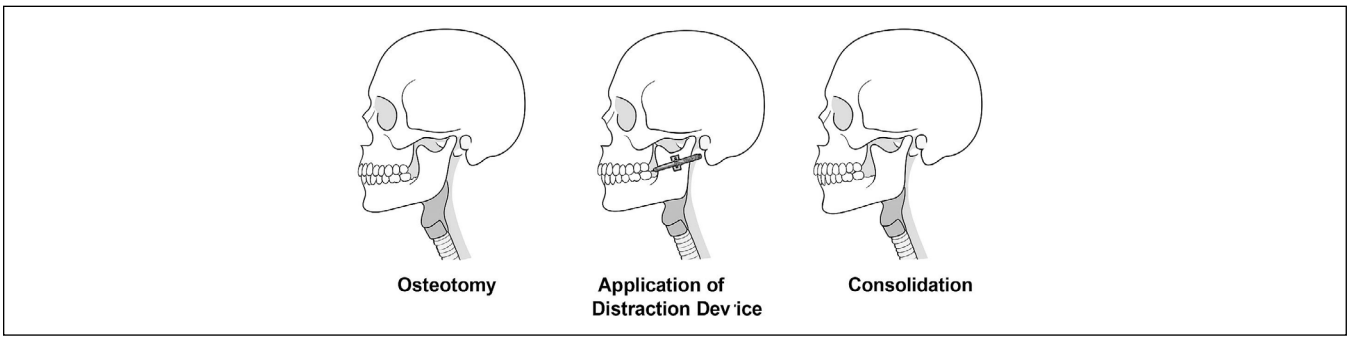

Figure 2: Schematic illustration of mandibular distraction osteogenesis. Schematic diagram illustrating the distraction osteogenesis (DO) process for mandibular advancement. Sequential phases include osteotomy, application of distraction device, gradual mandibular elongation, and consolidation, leading to increased posterior airway space and symptom resolution in patients with micrognathia-associated obstructive sleep apnea

Table 2: Summary of key studies on Distraction Osteogenesis (DO) for OSA

Author (Year)	Population	Indication	Outcome	Notes
Cohen et al. (1998)	Pediatric syndromic	Micrognathia, airway obstruction	Significant respiratory improvement	Avoided tracheostomy
Monasterio et al. (2002)	Pierre Robin sequence	Severe airway obstruction	Substantial airway gain, symptom relief	Early intervention crucial
Mandell et al. (2004)	Neonates, children	Micrognathia	Reduction in respiratory events	Improved feeding, growth trajectories
Li et al. (2002)	Adults	OSA intolerant to CPAP	Preliminary AHI reduction, airway improvement	Alternative to MMA in select cases
Tahiri et al. (2014)	Pediatric	Mandibular hypoplasia	Significant airway dimension increase	Resolution of OSA symptoms

Summary of key clinical studies evaluating the role of distraction osteogenesis (DO) in the management of obstructive sleep apnea (OSA). The table details study populations, indications for DO, clinical outcomes, and notable findings. DO has shown significant efficacy in improving airway patency and resolving OSA symptoms, particularly in pediatric and syndromic populations with craniofacial anomalies.

Mandell et al. validated the role of mandibular DO in severe upper airway obstruction secondary to micrognathia, reporting notable reductions in respiratory events and improved feeding outcome.[15] In a recent case report, Wang et al. documented improved airway dimensions and AHI reduction in a hemifacial microsomia patient following mandibular DO.[16] In adult OSA patients, Li et al. presented preliminary evidence supporting DO as an alternative to MMA in select cases, with notable improvements in AHI and airway volume.[17] Tahiri et al., in a pediatric cohort, demonstrated that mandibular DO led to significant increases in airway dimensions, resolution of OSA symptoms, and improved growth trajectories.[18]

3.3. Oral appliance therapy

Oral appliance therapy, particularly mandibular advancement devices (MADs), has gained recognition as an effective non-invasive treatment for mild to moderate OSA. Serra-Torres et al. conducted a systematic review confirming that MADs significantly reduce AHI, improve oxygen saturation, and enhance patient-reported outcomes.[19] Sharples et al., through a meta-analysis of randomized controlled trials, demonstrated that MADs, although slightly less effective than CPAP in reducing AHI, resulted in better adherence and comparable improvements in daytime sleepiness.[20] Core randomized trials and meta-analyses are summarized in **(Table 3)**.

Table 3: Effectiveness of oral appliance therapy in OSA

Author (year)	Device type	Sample size	AHI reduction	Key outcomes
Serra-Torres et al. (2016)	MAD	657	Significant	Improved AHI, oxygen saturation, quality of life
Sharples et al. (2016)	MAD vs. CPAP	1,100+	MAD slightly less than CPAP	Better adherence with MAD
Zhu et al. (2015)	Custom vs. Prefab MADs	22 studies	Custom superior	Custom-fitted devices better outcomes
Chang et al. (2017)	Tongue Retaining Device (TRD)	350+	Modest	Effective in positional OSA, edentulous patients
Liao (2024)	MAD (mild–severe OSA)	750+	Effective even in severe cases	Valuable first-line/ adjunctive therapy

Abbreviations: MAD = Mandibular Advancement Device; CPAP = Continuous Positive Airway Pressure; TRD = Tongue Retaining Device.

Summary of major studies assessing the effectiveness of oral appliance therapy in obstructive sleep apnea (OSA) management. This table includes device types, sample sizes, apnea–hypopnea index (AHI) reduction outcomes, and key clinical findings. Mandibular advancement devices (MADs) consistently demonstrated significant improvements in AHI and patient-reported outcomes, with better long-term adherence compared to continuous positive airway pressure (CPAP). Tongue retaining devices (TRDs) also showed modest benefits, particularly in positional OSA and edentulous patients.

Table 4: Role of Rapid Maxillary Expansion (RME) and adjunctive therapies

Author (Year)	Population	Intervention	Outcome	Key findings
Villa et al. (2011)	Children	RME	Sustained AHI reduction (36 months)	Effective first-line in pediatric OSA
Machado Júnior et al. (2016)	Children	RME	Significant airway increase	Meta-analysis confirmed efficacy
Abdullatif et al. (2016)	Adults	RME + MMA	Additive benefit in AHI reduction	Particularly useful with maxillary constriction

Summary of selected studies evaluating the role of rapid maxillary expansion (RME) and adjunctive therapies in the management of obstructive sleep apnea (OSA). The table outlines study populations, interventions performed, treatment outcomes, and key findings. RME demonstrated sustained improvements in airway dimensions and apnea–hypopnea index (AHI) reduction in pediatric patients, while combined RME and maxillomandibular advancement (MMA) provided additive benefits in adults with maxillary constriction.

Zhu et al. performed a comprehensive meta-analysis highlighting the effectiveness of oral appliances in reducing AHI and oxygen desaturation indices in mild to moderate OSA, with custom-fitted devices outperforming prefabricated options.[21] Chang et al. assessed tongue-retaining devices (TRDs), reporting modest improvements in respiratory parameters, particularly in patients with positional OSA or edentulism.[22] Lazard et al. corroborated these findings, documenting significant reductions in AHI and subjective sleepiness with TRD use, although side effects such as tongue discomfort were reported.[23]

A recent meta-analysis by Liao affirmed the efficacy of oral appliances across mild, moderate, and even select severe OSA cases, positioning them as a valuable first-line or adjunctive option, especially in CPAP-intolerant patients.[24]

3.4. Rapid maxillary expansion and adjunctive therapies

In pediatric populations, rapid maxillary expansion (RME) has shown promise in improving airway patency. Villa et al. demonstrated sustained AHI reductions and symptomatic relief at a 36-month follow-up in children undergoing RME for OSA.[25] Machado Júnior et al. corroborated these outcomes in a meta-analysis, reporting significant airway dimensional increases and reductions in respiratory events.[26]

In adult patients, Abdullatif et al. investigated the combination of maxillary expansion and MMA, observing additive benefits in airway enlargement and AHI reduction, particularly in cases with maxillary constriction.[27] The evidence bases for RME and adjunctive approaches is summarized in **(Table 4)**.

4. Discussion

The management of obstructive sleep apnea (OSA) has evolved considerably in recent decades, driven by a growing understanding of the anatomical, physiological, and behavioral contributors to airway collapse. While continuous positive airway pressure (CPAP) remains the established first-line therapy for moderate to severe OSA, its limitations in long-term adherence have highlighted the importance of effective alternative and adjunctive therapies.[5]

Maxillomandibular advancement (MMA) continues to be one of the most consistently effective surgical options for the management of OSA, especially in patients with craniofacial skeletal deficiencies or those intolerant to CPAP. Holty and Guilleminault's meta-analysis established MMA as a procedure capable of achieving near-curative outcomes in a significant proportion of cases, with an 87% reduction in AHI and over 40% achieving complete resolution of OSA.[1] Subsequent studies, including those by Zaghi et al.[2] and Camacho et al.[3], reinforced these outcomes, demonstrating that MMA not only reduces AHI but also improves oxygen saturation, sleep architecture, and quality of life. The addition of counterclockwise rotation and genioplasty, as highlighted by Knudsen et al.[8] and Liu et al.[12], further enhances postoperative outcomes by optimizing airway patency and facial harmony.

The role of distraction osteogenesis (DO) has gained prominence in pediatric OSA and craniofacial syndromes associated with mandibular hypoplasia and upper airway obstruction. Cohen et al.[13] and Monasterio et al.[14] demonstrated significant improvements in airway dimensions, avoidance of tracheostomy, and resolution of OSA symptoms following DO in neonates and children. Mandell et al.[15] further corroborated these outcomes, highlighting the importance of early intervention in preventing long-term complications. Emerging evidence also supports the utility of DO in adult OSA management in select cases, with Li et al.[17] and Tahiri et al.[18] reporting substantial improvements in AHI and airway volume. The typical workflow and biological phases are depicted in **(Figure 2)**.

Oral appliance therapy (OAT), particularly mandibular advancement devices (MADs), represents an essential non-surgical option for managing mild to moderate OSA. Meta-analyses by Serra-Torres et al.[19] and Sharples et al.[20] confirmed the effectiveness of MADs in reducing AHI and improving patient-reported outcomes, with better long-term adherence compared to CPAP. While oral appliances may not achieve the same AHI reductions as CPAP, their superior tolerability makes them a valuable first-line or adjunctive treatment option, particularly in CPAP-intolerant or non-compliant patients.[21,22] Recent studies by Liao[24] demonstrated their utility even in selected severe OSA cases, underscoring the importance of patient-specific treatment planning.

In children, rapid maxillary expansion (RME) has proven effective in increasing nasal cavity volume and improving upper airway patency. Villa et al.[25] reported sustained AHI reductions over 36 months post-expansion, while Machado Júnior et al.[26] confirmed these benefits in a meta-analysis, suggesting RME as a first-line orthodontic intervention for pediatric OSA associated with maxillary constriction. In adults, combining maxillary expansion with MMA, as investigated by Abdullatif et al.[27], offers additional airway improvements, particularly in cases with transverse discrepancies.

This review underscores the critical role of interdisciplinary collaboration between sleep physicians, orthodontists, and maxillofacial surgeons in delivering personalized, evidence-based care for OSA patients. Careful selection of patients based on clinical severity, craniofacial morphology, airway assessments, and patient preferences remains fundamental to optimizing outcomes.

5. Conclusion

The contemporary management of obstructive sleep apnea (OSA) has moved beyond a one-size-fits-all approach, embracing a multidisciplinary model that combines medical, orthodontic, and surgical interventions. While continuous positive airway pressure (CPAP) remains the gold standard for moderate to severe cases, patient intolerance and poor adherence necessitate effective alternative strategies.

Maxillomandibular advancement (MMA) has consistently demonstrated high success rates in improving objective respiratory parameters, oxygenation, and patient-reported outcomes, with long-term durability and low complication profiles. Distraction osteogenesis (DO), particularly in pediatric and syndromic populations, offers a safe and effective means of alleviating airway obstruction and preventing the need for tracheostomy. Additionally, oral appliance therapy, especially mandibular advancement devices (MADs), remains a valuable non-invasive option for mild to moderate OSA, with emerging evidence supporting its use in severe cases where CPAP is contraindicated or poorly tolerated.

Adjunctive procedures such as rapid maxillary expansion (RME) further expand the therapeutic armamentarium, particularly in pediatric patients with transverse maxillary deficiencies contributing to airway narrowing.

This evidence-based review highlights the importance of individualized, anatomy-driven treatment planning for OSA patients, with orthodontists and maxillofacial surgeons playing integral roles within the interdisciplinary care team. Future research focusing on long-term outcomes, patient-centered metrics, and comparative effectiveness of combined modalities will continue to refine best practices in OSA management. Practical, implementation-ready takeaways are consolidated in **(Figure 3)** (Key Clinical Points).

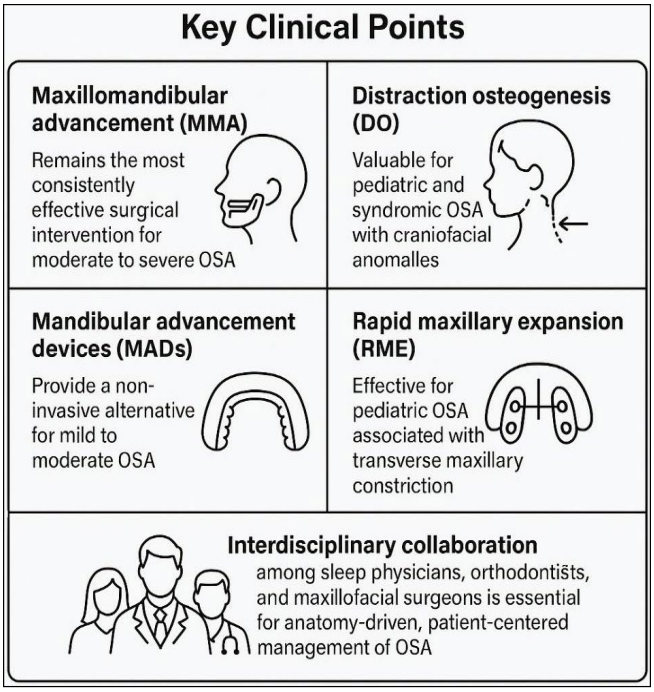

Figure 3: Key clinical approaches for obstructive sleep apnea. Key clinical approaches for obstructive sleep apnea: maxillomandibular advancement (MMA), distraction osteogenesis (DO), mandibular advancement devices (MADs), rapid maxillary expansion (RME), and the importance of interdisciplinary collaboration.

6. Limitations

As a narrative evidence-based review, this study is limited by its dependence on existing literature, without new patient data or meta-analysis. Selection bias may exist due to the inclusion of predominantly English-language publications and highly cited studies. Future systematic reviews or prospective studies with standardized methodologies are encouraged to validate and expand upon these findings.

7. Graphical Abstract

Graphical abstract depicting the interdisciplinary management of obstructive sleep apnea through maxillomandibular advancement (MMA), distraction osteogenesis (DO), mandibular advancement devices (MADs), and rapid maxillary expansion (RME), with emphasis on personalized, anatomy-driven care.

8 Ethical Approval

This article is a narrative review and does not contain any studies involving human participants or animals performed by the author.

9. Source of Funding

No financial support or sponsorship was received for this study.

10. Conflict of Interest

None.

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