Universidad Europea

GRADUATION PROJECT

Degree in Dentistry

THE ROLE OF ORTHODONTICS IN THE MANAGEMENT OF OBSTRUCTIVE SLEEP APNEA. A SYSTEMATIZED REVIEW.

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RESUMEN

Antecedentes: La apnea obstructiva del sueño es un trastorno crónico caracterizado por el colapso repetitivo de las vías respiratorias superiores durante el sueño, provocando desaturación intermitente de oxígeno y fragmentación del sueño. Las intervenciones de ortodoncia pueden modificar las estructuras craneofaciales que influyen en el volumen de las vías respiratorias y los patrones respiratorios, ofreciendo un posible complemento no invasivo al tratamiento médico tradicional; **Objetivo:** Evaluar cómo los tratamientos de ortodoncia influyen en la anatomía de las vías respiratorias superiores, la función respiratoria y la calidad del sueño en pacientes con apnea obstructiva del sueño; **Métodos:** Se realizó una revisión sistematizada utilizando las bases de datos PubMed y Scopus. Se incluyeron estudios que evaluaron los efectos anatómicos y funcionales de los tratamientos ortodóncicos y ortopédicos dentofaciales en los trastornos respiratorios del sueño. Las medidas de resultado incluyeron cambios en la morfología de las vías respiratorias, parámetros respiratorios e indicadores de calidad del sueño; **Resultados:** En niños, la expansión maxilar rápida y los aparatos ortopédicos funcionales aumentaron las dimensiones nasales y faríngeas y redujeron las alteraciones respiratorias relacionadas con el sueño. En adultos, los dispositivos de avance mandibular y los abordajes ortodóncico-quirúrgicos combinados mejoraron el volumen de la vía aérea superior y redujeron los eventos respiratorios en casos seleccionados. Las características morfológicas craneofaciales fueron identificadas como predictoras de la gravedad de la apnea obstructiva del sueño en poblaciones adultas; **Conclusiones:** Los tratamientos de ortodoncia pueden influir positivamente en la estructura de la vía aérea superior, contribuyendo a una mejor calidad del sueño en pacientes con apnea obstructiva del sueño. La magnitud de estos efectos depende de la anatomía del paciente, el tipo de tratamiento y el potencial de crecimiento

PALABRAS CLAVE

odontología, trastornos del sueño, respiración, expansión maxilar, ortodoncia interceptiva

ABSTRACT

Background: Obstructive sleep apnea is a chronic disorder characterized by repetitive upper airway collapse during sleep, leading to intermittent oxygen desaturation and sleep

fragmentation. Orthodontic interventions can modify craniofacial and dental structures that influence airway volume and breathing patterns, offering a potential non-invasive adjunct to traditional medical management; **Objective:** To explore how orthodontic treatments influence upper airway anatomy, breathing function, and sleep quality in patients with obstructive sleep apnea; **Methods:** A systematized review was performed using PubMed and Scopus databases. Studies evaluating the anatomical and functional effects of orthodontic and dentofacial orthopedic treatments on sleep-disordered breathing were included, regardless of patient age. Key outcome measures included changes in airway morphology, respiratory parameters, and sleep quality indicators; **Results:** In children, rapid maxillary expansion and functional orthopedic appliances consistently increased nasal and pharyngeal dimensions and reduced sleep-related breathing disturbances. In adults, mandibular advancement devices and combined orthodontic-surgical approaches enhanced upper airway volume and reduced respiratory events in selected cases. Craniofacial morphological characteristics were also identified as predictors of obstructive sleep apnea severity in adult populations; **Conclusions:** Orthodontic treatments could positively influence upper airway structure and breathing dynamics, contributing to improved sleep quality in patients with obstructive sleep apnea. The magnitude of these effects depends on patient anatomy, treatment type, and growth potential.

KEYWORDS

dentistry, sleep disorders, breathing, maxillary expansion, interceptive orthodontics

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1. INTRODUCTION

1.1 Definition and pathophysiology of Obstructive Sleep Apnea (OSA)

Obstructive Sleep Apnea (OSA) is a sleep-related breathing disorder characterized by recurrent episodes of partial or complete collapse of the upper airway during sleep, leading to airflow reduction or interruption despite preserved respiratory effort (1,2). These events induce intermittent hypoxia and repeated arousals, altering normal sleep architecture and triggering sympathetic activation, oxidative stress, and systemic inflammation (3). The anatomical basis of upper airway collapse in OSA is illustrated in Figure 1. Because of these mechanisms, OSA is now considered a multisystem condition with significant cardiometabolic and neurocognitive implications.

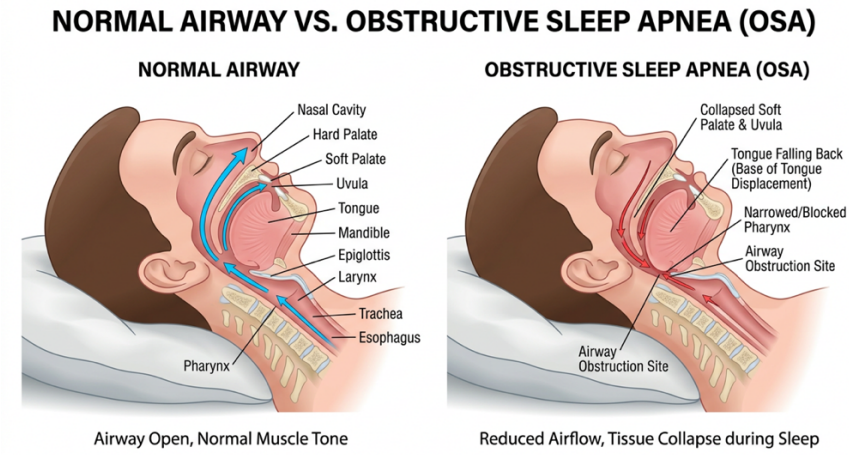


Figure 1: Sagittal cross-section of the upper airway illustrating normal airway patency with open pharyngeal space (left) versus upper airway collapse during sleep in OSA showing tongue displacement, soft palate collapse, and pharyngeal obstruction (right). Generated with AI image tools and modified by the author (Adobe Firefly, 2026).

1.2 Epidemiology and clinical relevance

OSA represents a major global health problem, affecting an estimated 10–20% of adults and 3–5% of children, although many cases remain undiagnosed (4). The condition often goes unnoticed for years, as patients may not be aware of nocturnal symptoms such as loud snoring or witnessed apneas, while daytime manifestations such as fatigue, headaches, irritability, and impaired concentration are easily attributed to lifestyle factors (5) . Clinically, OSA is associated with reduced daytime performance, impaired quality of life, and increased accident risk (5,6).

From a medical perspective, untreated OSA might contribute to hypertension, coronary artery disease, arrhythmias, stroke, and metabolic dysfunction (1,5). The severity of OSA is defined by the apnea–hypopnea index, which represents the number of apneic and hypopneic events per hour of sleep (6). An apnea–hypopnea index of 5–15 events/h indicates mild disease, 15–30 moderate, and >30 severe. This metric remains the foundation for both diagnosis and therapeutic follow-up (1).

1.3 Diagnostic framework used in this review

The diagnosis of OSA primarily relies on overnight polysomnography, which measures airflow, thoraco-abdominal movement, oxygen saturation, and sleep stages. Alternative home sleep apnea testing may be used in selected patients. The apnea–hypopnea index value obtained through polysomnography is interpreted alongside clinical findings such as excessive daytime sleepiness, body-mass index, and craniofacial morphology to determine disease severity and guide management (1).

In the context of this review, studies were included only when OSA diagnosis was confirmed by polysomnography or equivalent validated sleep-monitoring methods, ensuring homogeneity and reliability across the selected evidence.

1.4 Craniofacial and dental factors influencing airway patency

Upper airway patency is strongly influenced by craniofacial morphology. Features such as maxillary constriction, mandibular retrusion, dental arch narrowing, or increased vertical facial dimensions may reduce airway space and predispose individuals to obstruction during sleep (7,8). Since many of these anatomical characteristics fall within the scope of orthodontic diagnosis and treatment, orthodontics has become a key discipline in the multidisciplinary management of OSA. Orthodontic and dentofacial orthopedic interventions such as maxillary expansion, mandibular advancement, or orthognathic surgery can modify skeletal support, tongue posture, and nasal airflow, thereby improving airway function (6,9). This structural perspective constitutes the theoretical framework that supports the role of orthodontic treatment in enhancing respiratory function in OSA patients.

1.5 Current status of the topic

Growing evidence suggests that orthodontic interventions could positively influence airway dimensions, respiratory parameters, and sleep quality in both pediatric and adult OSA patients. Recent studies have evaluated rapid maxillary expansion, functional orthopedic appliances, mandibular advancement devices, clear aligners with mandibular advancement, and orthognathic surgery using three-dimensional imaging and polysomnography (10–14).

However, available data remain heterogeneous, particularly regarding diagnostic criteria, treatment protocols, patient populations, and outcome measures. This fragmentation limits the comparability of studies and reinforces the need for a structured synthesis of primary clinical evidence.

1.6 Justification of the study

Despite increasing clinical interest, the contribution of orthodontic and dentofacial orthopedic treatments to OSA management is still not clearly defined across age groups and therapeutic modalities. Existing reviews often examine isolated techniques or provide narrative summaries without systematically integrating recent primary evidence, particularly studies assessing airway volume, apnea-hypopnea index changes, and systemic outcomes such as cardiovascular parameters.

Given the significant public-health impact of OSA, and the central role of craniofacial morphology in airway patency, a systematized review of primary orthodontic research is needed to clarify current evidence, support clinical decision-making, and guide interdisciplinary collaboration.

This study aims to provide an updated, structured, and clinically oriented synthesis of how orthodontic treatments influence airway structure and function in patients with OSA.

2. OBJECTIVE

The primary objective of this review was to assess the anatomical and functional effects of orthodontic and dentofacial orthopedic treatments on upper airway dimensions and respiratory parameters in patients with obstructive sleep apnea.

The specific objectives are:

1.To determine how orthodontic and dentofacial orthopedic interventions modify upper-

airway anatomy and respiratory function in patients diagnosed with OSA.

2.To compare the clinical effectiveness of different orthodontic treatment modalities—such as rapid maxillary expansion, mandibular advancement devices, functional appliances, clear aligners, and orthognathic surgery—based on pre- and post-treatment outcomes.

3.To assess whether orthodontic treatment contributes to improvements in global sleep parameters like apnea–hypopnea index, oxygen saturation) and systemic outcomes, including cardiovascular markers, in OSA patients**.**

3. MATERIAL AND METHODS

3.1 Study design

The methodology includes:

- a clearly defined research question,
- the use of explicit inclusion and exclusion criteria,
- a structured and replicable search strategy,
- systematic study selection,
- critical evaluation of primary evidence.

3.2 Research question and PICO framework

The research question was formulated using the PICO structure to ensure a focused and clinically relevant approach:

P (Patients)

Children and adults diagnosed with OSA based on polysomnography or validated sleep tests.

I (Intervention)

Orthodontic and dentofacial orthopedic treatments, including rapid maxillary expansion, mandibular advancement devices, functional appliances, clear aligners, and orthognathic surgery.

C (Comparison)

Baseline values, untreated controls, alternative to orthodontic interventions, or pre–post treatment comparisons.

O (Outcomes)

Changes in airway dimensions, breathing function, apnea-hypopnea index reduction, sleep quality, or systemic (including cardiovascular) improvements.

Research question

"How do orthodontic and dentofacial orthopedic treatments contribute to improving airway anatomy, breathing function, and sleep-related outcomes in pediatric and adult patients with OSA?"

3.3 Eligibility criteria

Inclusion criteria

Studies were included if they met the following criteria:

1. Population: Children or adults diagnosed with OSA or sleep-disordered breathing using polysomnography or validated sleep-monitoring methods, or patients undergoing orthodontic or orthopedic interventions with documented airway morphology assessment.

2. Study type: Primary evidence only, including:

- Randomized controlled trials
- Prospective or retrospective cohort studies
- Cross-sectional observational studies
- Clinical trials evaluating orthodontic or orthopedic interventions
- Consecutive case series when full-night polysomnography was performed

3. Intervention: Any orthodontic or dentofacial orthopedic treatment aimed at modifying dental arch morphology, mandibular position, or upper airway dimensions. Cross-sectional and observational studies with no active intervention were also included when they assessed craniofacial morphological predictors of OSA severity directly relevant to orthodontic treatment planning or patient selection.

4. Outcomes: At least one of the following: airway morphology parameters assessed by three-dimensional imaging, polysomnographic respiratory parameters, craniofacial morphological variables, sleep-related outcomes, or systemic parameters associated with OSA

Exclusion criteria

The following were excluded:

- Systematic reviews, meta-analyses, narrative reviews
- Case reports, technical notes, expert opinions
- Studies without primary clinical data
- Animal or in vitro studies
- Studies in which OSA diagnosis was not confirmed by polysomnography or a validated home sleep apnea test, unless the study evaluated an orthodontic intervention with objective three-dimensional airway morphology assessment as the primary outcome
- Studies not evaluating an orthodontic, orthopedic, or surgical intervention affecting dentofacial structures, unless they assessed craniofacial morphological predictors directly relevant to orthodontic management of OSA

Due to the limited availability of polysomnography-based pediatric OSA studies and the clinical relevance of craniofacial morphology in airway patency, pediatric studies investigating airway or skeletal changes without reporting apnea-hypopnea index values were included if they assessed breathing-related anatomical outcomes.

3.4 Sources of information

A structured literature search was performed using the following electronic databases:

- PubMed (MEDLINE)
- Scopus

Only primary studies meeting the inclusion criteria were considered. Additional studies were identified through manual searches of reference lists of relevant articles.
The final search was conducted from October 2025 to December 2025.

3.5 Search strategy

The search strategy followed the UEM guidelines and combined MeSh terms and free terms using Boolean operators (AND/OR).

1. MeSH terms

“Obstructive Sleep Apnea”;*“Orthodontics”*;*“Orthodontic Appliances”*;*“Maxillary Expansion”*;*“Mandibular Advancement”*;*“Orthognathic Surgery”*;*“Airway Obstruction”*

2. Free-text terms

“rapid maxillary expansion”;“clear aligners”;“functional appliances”;“airway volume”;“pharyngeal airway”;“mandibular advancement device”;“upper airway morphology”

("Obstructive Sleep Apnea"[MeSH] OR "sleep disordered breathing" OR "OSA")
AND
("Orthodontics"[MeSH] OR "Orthodontic Appliances"[MeSH] OR "dentofacial orthopedics" OR "orthodontic treatment" OR "rapid maxillary expansion" OR "maxillary expansion" OR "functional appliance" OR "mandibular advancement" OR "mandibular advancement device" OR "clear aligners" OR "orthognathic surgery")
AND
("Airway" OR "airway volume" OR "upper airway morphology" OR "pharyngeal airway" OR "CBCT" OR "apnea hypopnea index" OR "respiratory function"OR "oxygen saturation")
AND
("cardiovascular" OR "blood pressure" OR "systemic outcomes"OR "sleep quality")

3.6 Study selection process

The study selection process followed PRISMA principles. Records from PubMed and Scopus were imported into Rayyan for duplicate removal and title/abstract screening. A total of 135 duplicate records were identified and removed, resulting in 2507 unique records for screening. Titles and abstracts were evaluated according to the inclusion and exclusion criteria. After screening, 232 full texts were assessed for eligibility. Reasons for exclusion were documented for each excluded study. A total of 18 primary studies fulfilled all criteria and were included in the qualitative synthesis, representing exclusively primary research in accordance with the requirements of a systematized review. A PRISMA flow diagram summarizing this process is presented in Figure 2.

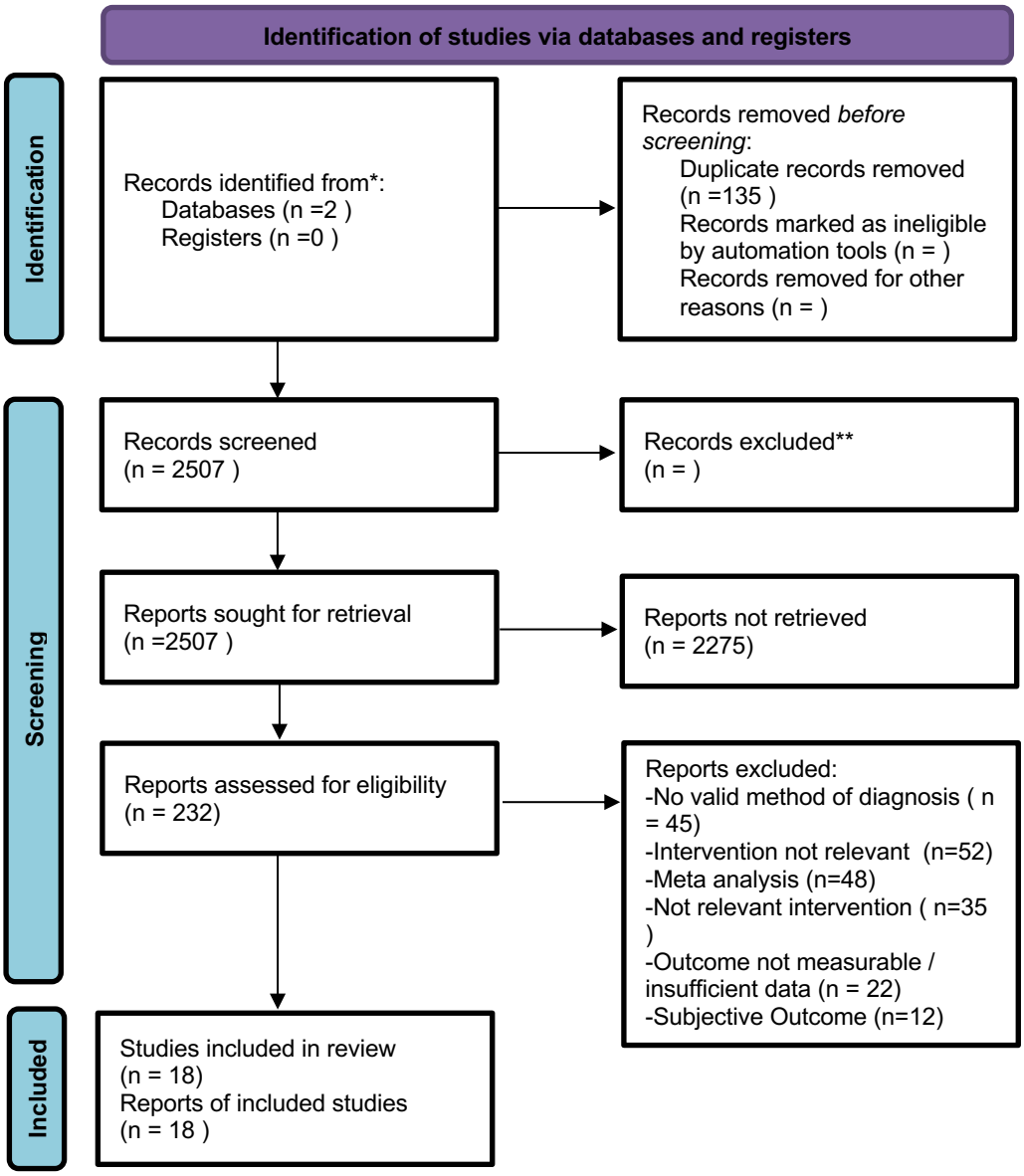


Figure 2 : PRISMA 2020 flow diagram of the study selection process

4. RESULTS

4.1 Overview of the included studies

A total of 18 primary studies met the eligibility criteria and were included in this systematized review, covering pediatric and adult populations. Six studies investigated children or adolescents, and twelve investigated adult patients. Study designs included prospective pre-post clinical studies, retrospective observational studies, cross-sectional morphological analyses, randomized clinical trials, and computational fluid dynamics analyses. Detailed characteristics and outcomes of all included studies are presented in Table 1, and detailed morphological and respiratory outcomes are reported in Tables 2A–2D.

TABLE 1 : DATA EXTRACTION

Reference (Year & Author)	Study design	Population & sample (n=)	Intervention	Outcome assessed	Main findings
Pediatric studies					
Bariani et al., 2022 (15)	Prospective clinical trial; pre–post	Children with snoring/sleep-disordered breathing; n=24	Rapid maxillary expansion	Airway morphology; respiratory parameters	↑ oropharyngeal airway volume; no change in apnea–hypopnea index
Nota et al., 2022 (16)	Retrospective study	Children with sleep-disordered breathing; n=40	Rapid maxillary expansion	Airway dimensions	↑ nasopharyngeal, oropharyngeal, and hypopharyngeal dimensions
Restrepo et al., 2011 (17)	Prospective clinical study; pre–post	Class II retrognathic children; n=50	Functional appliance (Bionator or Klammt)	Pharyngeal airway dimensions	↑ nasopharyngeal dimensions with both appliances
Pan et al., 2025 (18)	Retrospective cohort-controlled study	Children; n=18	Upper arch expansion with clear aligners	Nasal airway volume; dental arch dimensions	↑ nasal airway volume; ↑ intermolar distance
Jiang et al., 2025 (19)	Prospective pre–post study	Adolescents with Class II mandibular	Clear aligner mandibular advancement	Airway morphology; respiratory parameters	↑ total upper airway volume; ↓ apnea–hypopnea index

		retrognathism; n=27			
Kushida et al., 2025 (20)	Multicenter clinical trial; pre–post	Children with OSA; n=55	Removable orthodontic intraoral device	Airway morphology; respiratory and sleep parameters	↑ pharyngeal airway volume; ↓ apnea–hypopnea index
Adult orthodontic and device studies					
Andrén et al., 2009 (21)	Longitudinal case series; pre–post	Adults with OSA; n=29	Mandibular advancement appliance	Respiratory parameters; blood pressure	↓ apnea–hypopnea index; ↓ blood pressure
Paddenberg-Schubert et al., 2025 (22)	Retrospective cohort study	Adults with OSA; n=66	Mandibular advancement device	Respiratory parameters	↓ apnea–hypopnea index in both moderate and severe groups
Özköylü et al., 2024 (23)	Prospective randomized clinical study	Adults with OSA; n=14	Monoblock vs twinblock mandibular advancement devices	Airway morphology; respiratory parameters	↓ apnea–hypopnea index with both designs; monoblock produced greater airway volume increase
Ciavarella et al. (Oral), 2025 (24)	Retrospective pre–post study	Adults with OSA; n=64	Mandibular advancement device	Respiratory and cardiovascular parameters	↓ apnea–hypopnea index; ↓ maximum heart rate
Saleh et al., 2022 (25)	Prospective interventional study; pre–post	Adults with OSA; n=30	Mandibular advancement device	Airway morphology; respiratory parameters	↑ total airway volume; ↓ apnea–hypopnea index
Scarano et al., 2025 (26)	Consecutive case series	Adults with moderate–severe OSA; n=6	Maxillary wedge osteotomy combined with mandibular advancement	Airway morphology; respiratory parameters	↑ upper airway volume; ↓ apnea–hypopnea index (>90% reduction)
Fountoulaki & Thurzo, 2022 (27)	Retrospective pre–post study	Adults with malocclusion; n=86	Clear aligner orthodontic treatment	Airway morphology	↑ upper airway volume in constricted group; no change in non-constricted group
Morphometric, correlation, and surgical studies					

Ciavarella et al. (J Clin Med), 2025 (28)	Cross-sectional study	Adults with OSA; n=40	None (morphometric assessment)	Dental arch dimensions; airway morphology	Reduced arch width correlated with smaller airway volume and higher oxygen desaturation index
Xia et al., 2025 (6)	Retrospective observational study	Severely obese adults with OSA; n=94	None (correlation study)	Craniofacial and airway morphology	Reduced posterior airway space correlated with higher apnea–hypopnea index
Tepedino et al., 2022 (29)	Retrospective observational study	Adults with OSA; n=84	None (correlation study)	Craniofacial morphology	Shorter mandibular length inversely correlated with apnea–hypopnea index
Gen-Yuki Yamane et al., 2007 (30)	Prospective observational study; pre–post	Adults undergoing orthognathic surgery; n=19	Orthognathic surgery	Pharyngeal airway dimensions; respiratory parameters	Pharyngeal airway space influenced by mandible direction; no consistent correlation with apnea–hypopnea index
Zhao et al., 2024 (31)	Prospective pre–post study	Healthy adults; n=15	Molar distalization with clear aligners	Airway morphology; airway aerodynamics	↓ minimum cross-sectional area; ↑ airflow resistance

4.2 Orthodontic management in children

Six studies assessed the effects of orthodontic and orthopedic interventions on upper airway dimensions and respiratory function in pediatric populations. The interventions evaluated included rapid maxillary expansion, functional orthopedic appliances, clear aligner therapies, and a removable intraoral device designed for pediatric OSA. Morphological outcomes are summarised in Table 2A. Respiratory function outcomes are presented in Table 2B.

TABLE 2A : Morphological Changes in Upper Airway Dimensions — Pediatric Studies

Year & Author	Population	Intervention	Measuring instrument	Airway volume	Outcome
2022 Bariani et al. (15)	Children with snoring/sleep-disordered breathing	Rapid maxillary expansion	3D computed tomography + polysomnography	↑ oropharyngeal volume (8656→10632 mm^3, p=0.002)	↑ volume; no change in apnea–hypopnea index
2022 Nota et al. (16)	Children with sleep-disordered breathing	Rapid maxillary expansion	Lateral cephalometry	↑ nasopharynx (11.6→14.1 mm); ↑ oropharynx (10.6→13.4 mm); ↑ hypopharynx (11.1→14.7 mm). Smaller increases in healthy control group.	↑ airway dimensions
2011 Restrepo et al. (17)	Class II retrognathic children	Functional appliance (Bionator or Klammt)	Lateral cephalometry	↑ nasopharyngeal dimensions at adenoid level; no change in oropharyngeal or distal dimensions	↑ nasopharyngeal dimensions only
2025 Pan et al. (18)	Children	Upper arch expansion with clear aligners	Cone-beam computed tomography	↑ nasal airway volume (+15.13%, p<0.001); no change in control group (p=0.274); ↑ intermolar distance (+2.4 mm, p<0.001)	↑ nasal volume; ↑ intermolar distance
2025 Jiang et al. (19)	Adolescents with Class II mandibular retrognathism	Clear aligner mandibular advancement	Cone-beam computed tomography + polysomnography	↑ total upper airway volume; ↑ nasopharyngeal, palatopharyngeal, glossopharyngeal,	↑ airway volumes; ↓ apnea–hypopnea index

				and hypopharyngeal volumes	
2025 Kushida et al. (20)	Children with OSA	Removable orthodontic intraoral device	Cone-beam computed tomography + polysomnography + Pediatric Sleep Questionnaire	↑ pharyngeal airway volume	↑ pharyngeal volume; ↑ maxillary intermolar width

TABLE 2B : Changes in Respiratory Function — Pediatric Studies

Year & Author	Population	Intervention	Apnea–hypopnea index	Oxygen saturation	Outcome
2025 Jiang et al. (19)	Adolescents	Clear aligner mandibular advancement	↓ significant (1.09→0.71 events/h, p=0.001); ↓ supine apnea–hypopnea index	↑ significant (p=0.021)	Improved respiratory function
2025 Kushida et al. (20)	Children with OSA	Removable orthodontic intraoral device	↓ significant (79% of patients showed reduction; 61.7% improved by ≥50%)	↑ significant	Reduced severity
2022 Bariani et al. (15)	Children with snoring	Rapid maxillary expansion	No significant change (p=0.289)	—	No functional improvement

4.2.1 Rapid Maxillary Expansion

Rapid maxillary expansion was investigated in pediatric populations for its effects on upper-airway morphology, as illustrated in Figure 3, showing the transverse expansion of the maxilla.

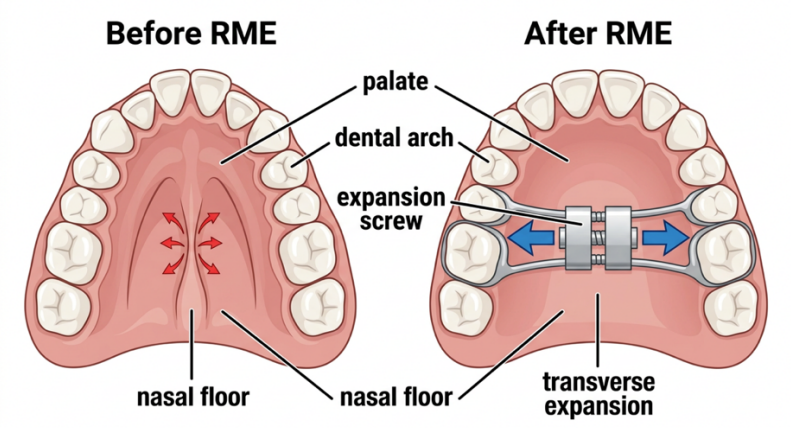


Figure 3: Top-down view of the upper dental arch illustrating the effect of rapid maxillary expansion (RME). Before treatment (left): narrow high-arched palate with restricted nasal floor dimensions. After RME (right): transverse expansion of the maxillary arch via the central expansion screw, widening the nasal floor and increasing nasal airway volume. Generated with AI image tools and modified by the author (Adobe Firefly, 2026).

Increases in upper airway dimensions were reported across nasopharyngeal, oropharyngeal, and hypopharyngeal regions in children with sleep-disordered breathing following rapid maxillary expansion (15,16). Increases were also observed in the healthy control group (16). No changes in polysomnographic respiratory parameters were reported (15).

4.2.2 Functional orthopedic appliances

Functional orthopedic appliances act by repositioning the mandible anteriorly during growth, as illustrated in Figure 4, showing anterior mandibular repositioning and its effect on pharyngeal airway space.

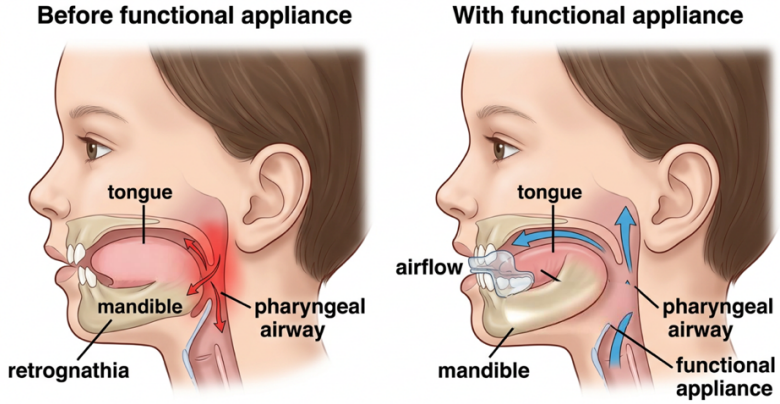


Figure 4 : Lateral view illustrating the mechanism of functional orthopedic appliances (e.g. Activator, Bionator) in pediatric OSA management. Before treatment (left): mandibular retrognathia with posterior tongue displacement and reduced pharyngeal airway space. With functional appliance (right): anterior mandibular repositioning enlarges the oropharyngeal airway and improves airflow during craniofacial growth. Generated with AI image tools and modified by the author (Adobe Firefly, 2026).

In class II retrognathic children treated with functional appliances, increases in nasopharyngeal airway dimensions were reported at the level of the adenoid tissue. No changes in oropharyngeal or more distal airway dimensions were observed (17). Polysomnographic respiratory parameters were not assessed.

4.2.3 Pediatric clear aligner therapies

Two studies evaluated clear aligner approaches in pediatric populations. Maxillary expansion with clear aligners was associated with increases in nasal airway volume and intermolar distance in the treatment group. No equivalent changes were observed in untreated controls (18). Mandibular advancement with clear aligners in adolescents with skeletal Class II malocclusion was associated with increases in total upper airway volume across multiple pharyngeal regions, reductions in apnea–hypopnea index, and improvements in oxygen saturation (19).

4.2.4 Orthodontic devices specifically designed for pediatric OSA

A multicenter trial evaluating a removable intraoral orthodontic device in children with confirmed OSA reported increases in pharyngeal airway volume and maxillary intermolar width. Reductions in apnea–hypopnea index and Pediatric Sleep Questionnaire scores were reported in the majority of participants (20).

4.3 Orthodontic management in adults

Twelve studies investigated orthodontic and dentofacial orthopedic interventions in adult patients. Studies covered mandibular advancement devices, orthognathic surgery, and clear aligner therapies, as well as craniofacial morphological predictors of OSA severity. Morphological outcomes are summarised in Table 2C. Respiratory function outcomes are presented in Table 2D.

TABLE 2C : Morphological Changes in Upper Airway Dimensions — Adult Studies

Year & Author	Population	Intervention	Measuring instrument	Airway volume	Minimum cross-sectional area	Outcome

2022 Saleh et al. (25)	Adults with OSA	Mandibular advancement device	Cone-beam computed tomography + polysomnography	↑ total airway volume	↑	↑ airway volume; ↓ apnea–hypopnea index
2025 Scarano et al. (26)	Adults with moderate–severe OSA	Maxillary wedge osteotomy + mandibular advancement	CAD/CAM computed tomography/cone-beam computed tomography + polysomnography	↑ 20665→27177 mm³	—	↑ volume; ↓ apnea–hypopnea index >90%
2022 Fountoulaki & Thurzo (27)	Adults with malocclusion	Clear aligner therapy	Cone-beam computed tomography	↑ (constricted group only); no change in non-constricted group	↑ (constricted group)	Significant in constricted subgroup only
2024 Zhao et al. (31)	Healthy adults	Molar distalization with clear aligners	Cone-beam computed tomography + computational fluid dynamics	—	↓ minimum area (−0.35 cm²)	↑ airway resistance
2025 Ciavarella et al. (J Clin Med) (28)	Adults with OSA (20 moderate; 20 severe)	None (morphometric assessment)	3D dental models + cone-beam computed tomography	↓ narrow arch associated with smaller airway volume	↓	Significant association with oxygen desaturation index and OSA severity
2025 Xia et al. (6)	Severely obese adults with OSA	None (correlation study)	Lateral cephalometry + polysomnography + body mass index	↓ posterior airway space associated with obesity and craniofacial measures; neck and waist circumference, tongue hypertrophy, and inferior hyoid	—	Significant association with apnea–hypopnea index and oxygen desaturation index

				position also correlated		
2022 Tepedino et al. (29)	Adults with OSA (body mass index <34)	None (correlation study)	Lateral cephalometry + polysomnography	↓ shorter mandible and cranial base associated with smaller airway	—	Inverse correlation between mandibular length and apnea–hypopnea index; ↑ vertical rotation weakly associated with higher apnea–hypopnea index
2007 Gen-Yuki et al. (30)	Adults undergoing orthognathic surgery	Orthognathic surgery	Lateral cephalometry + polysomnography	↑ after mandibular advancement; ↓ after mandibular setback	—	No consistent correlation between jaw movement direction and apnea–hypopnea index

TABLE 2D : Changes in Respiratory Function — Adult Studies

Year & Author	Population	Intervention	Apnea–hypopnea index	Oxygen desaturation index	Oxygen saturation	Outcome
2009 Andrén et al. (21)	Adults with OSA	Mandibular advancement appliance	↓ (16.1→4.1 events/h)	—	—	Significant ↓ apnea–hypopnea index; ↓ blood pressure (3-year follow-up)
2025 Paddenberg-Schubert et al. (22)	Adults with OSA (45 moderate; 21 severe)	Mandibular advancement device	↓ (25.0→10.2 events/h)	↓ significant	↑ (time below 90% reduced)	Significant improvement in both groups
2024 Özköylü et al. (23)	Adults with OSA	Monoblock vs twinblock mandibular advancement devices	↓ (13.4→5.1/5.4 events/h)	↓ significant	—	Significant improvement with both designs
2025 Ciavarella et al. (24) (Oral)	Adults with OSA	Mandibular advancement device	↓ reduction of 21.48 events/h	↓ reduction of 15.05 events/h	—	↓ apnea–hypopnea index; ↓ oxygen desaturation index; ↓ maximum heart rate (−24 bpm); ↑ minimum heart rate (+4.16 bpm)
2022 Saleh et al. (25)	Adults with OSA	Mandibular advancement device	↓ (31.4→13.8 events/h)	—	↑ significant	Significant improvement; ↓ Epworth score
2025 Scarano et al. (26)	Adults with moderate–severe OSA	Maxillary wedge osteotomy + mandibular advancement	↓ 46→3 events/h (>90% reduction)	↓ significant (41→2 events/h)	↑ nadir oxygen saturation (84→97%); ↑ average (94→99%)	Marked improvement across all respiratory parameters
2007 Gen-Yuki et al. (30)	Adults	Orthognathic surgery	No consistent change	—	—	No consistent correlation between surgery and

4.3.1 Craniofacial morphology and predictors of OSA severity

Three observational studies assessed craniofacial and airway characteristics in relation to OSA severity in adults (6,28,29). Reduced dental arch dimensions, smaller airway volumes, inferior hyoid positioning, increased tongue dimensions, and altered mandibular and cranial base morphology were correlated with higher apnea–hypopnea index and oxygen desaturation index values. These associations were observed across populations with varying body mass index profiles. Detailed morphological correlates are presented in Table 2C.

4.3.2 Mandibular Advancement Devices

Mandibular advancement devices reposition the mandible anteriorly during sleep, as illustrated in Figure 5, showing enlargement of the retropalatal and retroglossal space.

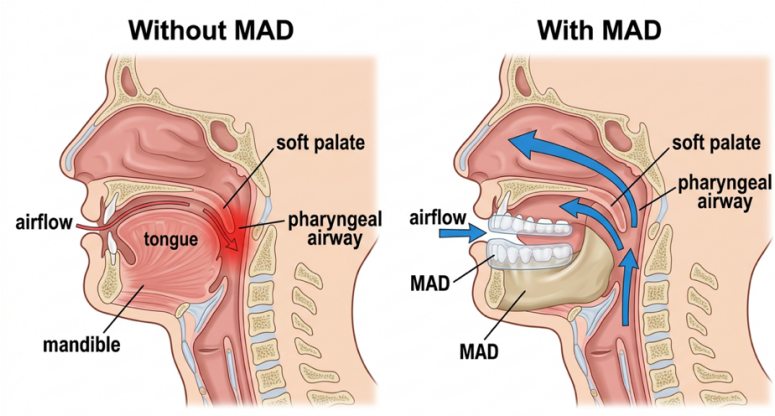


Figure 5: Lateral sagittal view illustrating the mechanism of action of the mandibular advancement device (MAD) in OSA. Without MAD (left): mandibular retrusion causes posterior tongue displacement and pharyngeal airway collapse, blocking airflow. With MAD (right): anterior mandibular repositioning pulls the tongue forward, enlarging the retropalatal and retroglossal space and restoring airflow. Generated with AI image tools and modified by the author (Adobe Firefly, 2026).

Five studies reported reductions in apnea–hypopnea index following mandibular advancement device therapy across a range of disease severities (21–25). Increases in total airway volume and cross-sectional airway areas were also reported (25). Reductions in blood pressure and changes in heart rate parameters were reported in two studies (21–24). Disease severity at baseline and specific craniofacial characteristics were identified as predictors of treatment response (22). Detailed respiratory outcomes are presented in Table 2D.

4.3.3 Maxillomandibular advancement and orthognathic surgery

Two studies assessed the effects of orthognathic surgery on airway dimensions and respiratory parameters (26,30). Maxillary wedge osteotomy combined with mandibular advancement was associated with increases in upper airway volume and reductions in apnea–hypopnea index exceeding 90% (26). In a separate prospective observational study, mandibular advancement was associated with increased pharyngeal airway dimensions while mandibular setback was associated with reduced dimensions. No consistent correlation between the direction of jaw movement and polysomnographic outcomes was reported (30).

4.3.4 Adult clear aligner therapies

Clear aligner therapy with mandibular advancement is illustrated in Figure 6, showing anterior repositioning of the mandible and enlargement of the pharyngeal airway.

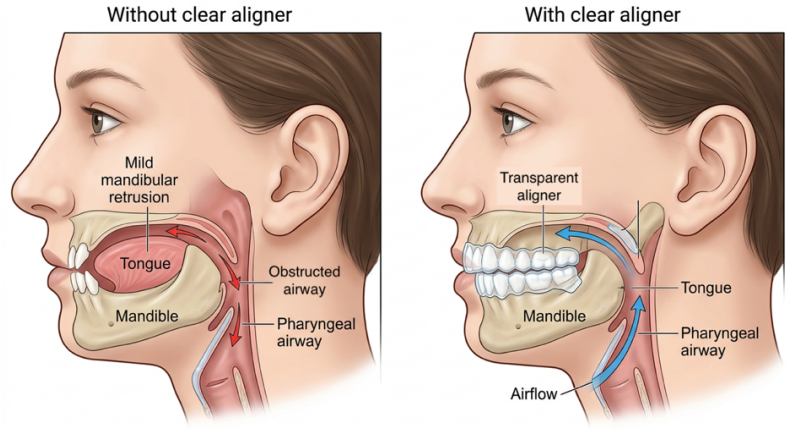


Figure 6 : Lateral view illustrating the mechanism of clear aligner therapy with mandibular advancement in OSA management. Without aligner (left): mild mandibular retrusion with posterior tongue displacement and mildly restricted pharyngeal airway. With clear aligner (right): transparent aligner with precision wings repositions the mandible anteriorly, enlarging the pharyngeal airway and restoring airflow. Generated with AI image tools and modified by the author (Adobe Firefly, 2026).

Two studies evaluated clear aligner therapy in adult patients (27,31). In patients with pre-existing airway constriction, increases in airway volume and minimum cross-sectional area were reported following clear aligner therapy. No volumetric changes were observed in patients with initially adequate airways (27). Following molar distalization with clear aligners, a reduction in minimum cross-sectional area and increased airflow resistance were reported (31).

A comparative overview of the clinical effectiveness of all interventions assessed across the included studies is presented in Table 3

TABLE 3 : Summary of apnea–hypopnea index effects and consistency of findings by treatment modality

Treatment modality	Apnea–hypopnea index effect	Consistency of findings
Pediatric interventions		
Rapid maxillary expansion	No reduction reported	Consistent across 2 studies
Functional orthopedic appliances	Not assessed	Single study; limited data
Clear aligner maxillary expansion	Not assessed	Single study; limited data
Clear aligner mandibular advancement	Reduction reported	Single study; limited data
Removable intraoral orthodontic device	Reduction reported in a high proportion of patients	Single multicenter study
Adult interventions		
Mandibular advancement device	Consistent reduction reported	Consistent across 5 independent studies
Orthognathic surgery	Reduction exceeding 90% reported in one study; no consistent correlation in another	Two studies with contrasting findings
Clear aligner therapy (expansion)	Not assessed	Single study; limited data
Molar distalization with clear aligners	Reduction in airway parameters reported	Single study; limited data

5. DISCUSSION

5.1 Summary and interpretation of the main findings

This systematized review included 18 primary studies evaluating the effects of orthodontic and dentofacial orthopedic interventions on upper airway dimensions and respiratory parameters in patients with OSA or sleep-disordered breathing. The results indicate that orthodontic interventions influence airway morphology across all age groups, although the magnitude and functional significance of these effects vary considerably depending on the treatment modality, patient age, and baseline craniofacial characteristics.

In pediatric patients, rapid maxillary expansion was consistently associated with increases in oropharyngeal volume reported in children with residual snoring (15) and increases across nasopharyngeal, oropharyngeal, and hypopharyngeal regions reported in children with sleep-disordered breathing (16). However, no consistent improvements in polysomnographic respiratory parameters were observed (15), suggesting that morphological airway enlargement does not reliably translate into functional respiratory improvement in this age group. Mandibular advancement approaches in growing patients produced both morphological and functional improvements, with reductions in apnea–hypopnea index reported in a single study of adolescents treated with clear aligner mandibular advancement (19) and in a high proportion of children with OSA treated with a removable intraoral device, based on a single multicenter study (20).

In adult patients, mandibular advancement devices produced the most consistent functional outcomes, with apnea–hypopnea index reductions reported across five independent studies (21) (25). Orthognathic surgery produced the most pronounced anatomical and functional changes, with apnea–hypopnea index reductions exceeding 90% (26). In contrast, molar distalization was associated with a reduction in minimum cross-sectional area and increased airflow resistance (31). Craniofacial morphological studies consistently identified reduced maxillary arch width, shorter mandibular length, inferior hyoid positioning, and increased tongue dimensions as predictors of greater OSA severity in adults (6,28,29).

5.2 Interpretation of the findings

The findings of this review suggest that orthodontic and dentofacial orthopedic interventions influence OSA through distinct mechanisms depending on patient age and treatment modality.

In growing patients, the primary mechanism appears to be modification of craniofacial development. Rapid maxillary expansion increases transverse maxillary dimensions and widens the nasal floor, producing measurable increases in upper airway volume (15,16). However, the absence of consistent polysomnographic improvements following expansion suggests that airway enlargement alone may be insufficient to reduce obstructive events, possibly because neuromuscular airway tone and soft tissue characteristics also contribute to airway collapsibility in children. In contrast, mandibular advancement approaches in growing patients appear to produce more functionally relevant effects by directly enlarging the retroglossal airway space, as reflected by reductions in apnea–hypopnea index reported following clear aligner mandibular advancement (19) and removable intraoral device therapy (20).

In adult patients, the absence of ongoing skeletal growth means that functional improvements must be achieved through direct mechanical repositioning of the airway. Mandibular advancement devices consistently enlarged retropalatal and retroglossal airway dimensions and reduced apnea–hypopnea index across five independent studies (21–25), supporting the well-established mechanism whereby anterior mandibular repositioning reduces pharyngeal collapsibility during sleep. The additional cardiovascular benefits reported by Ciavarella et al. (24), including reductions in maximum heart rate and increases in minimum heart rate, suggest that mandibular advancement devices therapy may extend beyond respiratory improvement to influence autonomic cardiovascular regulation, consistent with the well-established relationship between OSA and sympathetic nervous system overactivation described by Javaheri et al. (1).

Orthognathic surgery produced the most pronounced airway changes by permanently repositioning the skeletal framework of the upper airway. The reduction in apnea–hypopnea index from 46 to 3 events per hour reported by Scarano et al. (26) following maxillary wedge osteotomy combined with mandibular advancement represents the largest functional improvement observed across all included studies. However, the observational finding by Gen-Yuki et al. (30) that morphological airway changes following orthognathic surgery did not consistently correlate with polysomnographic outcomes highlights the complex relationship between skeletal repositioning and functional respiratory improvement, suggesting that factors beyond airway dimensions including soft tissue adaptation and neuromuscular responses may modulate surgical outcomes.

Finally, the contrasting airway effects of different clear aligner mechanics in adults expansion increasing airway volume in patients with preexisting constriction (27) while molar distalization reduced minimum cross-sectional area and increased airflow resistance (31) emphasize that orthodontic tooth movement can have either beneficial or adverse airway consequences depending on the biomechanics applied.

5.3 Implications and relationship with existing literature

The findings of the present review are consistent with a substantial body of existing literature supporting the role of craniofacial morphology in the pathogenesis of OSA. Epidemiological investigations have demonstrated the high global prevalence of OSA, with Benjafield et al. (4) estimating that hundreds of millions of individuals worldwide may be affected, underscoring the importance of identifying effective and accessible treatment strategies. The results of the

present review reinforce this public health perspective by demonstrating that orthodontic and dentofacial orthopedic interventions may represent valuable adjuncts to conventional OSA management.

The association between craniofacial morphology and OSA severity observed across the morphological studies included in this review aligns with previous evidence reported by Gurgel et al. (9), who demonstrated that transverse maxillary dimensions and mandibular ramus morphology are associated with OSA severity and may influence the amount of mandibular protrusion required for successful mandibular advancement devices treatment. Similarly, Ahmad et al.(10) identified steep mandibular plane angle, Class II molar relationship, and reduced nasopharyngeal dimensions as significant predictors of OSA risk in adolescent orthodontic patients, supporting the concept that skeletal anatomical factors may predispose individuals to airway obstruction across different age groups.

In pediatric patients, the absence of consistent polysomnographic improvements following rapid maxillary expansion observed in the present review is consistent with findings reported by Inchingolo et al.(14), whose systematic review noted that while rapid maxillary expansion produced increases in nasal cavity volume and upper airway dimensions in children, the functional respiratory benefits were variable and not uniformly accompanied by reductions in apnea–hypopnea index. This discrepancy between morphological and functional outcomes highlights the multifactorial nature of pediatric OSA and suggests that skeletal expansion alone may be insufficient to address all contributing mechanisms of airway obstruction in growing patients.

Regarding mandibular advancement devices in adults, the consistent apnea–hypopnea index reductions observed across the five studies included in this review ranging from 16.1 to 4.1 events per hour (21) to 31.4 to 13.8 events per hour (25) are in line with the broader literature supporting mandibular advancement devices therapy as a first-line treatment for mild-to-moderate OSA. A systematic review and meta-analysis by Uniken Venema et al. (32) confirmed that both titratable and non-titratable mandibular advancement devices designs produce objectively positive treatment outcomes in most patients with mild-to-moderate OSA, while custom-made devices demonstrated superior compliance and treatment outcomes compared with thermoplastic appliances. The comparison of monoblock and twinblock designs reported by Özköylü et al. (23) in the present review is consistent with this finding, as both designs produced similar reductions in apnea–hypopnea index without clinically relevant differences between them.

The cardiovascular benefits associated with mandibular advancement devices therapy reported by Andrén et al. (21) and Ciavarella et al. (24) in the present review are consistent with the well-established relationship between OSA and cardiovascular comorbidities, including arterial hypertension and endothelial dysfunction, described by Javaheri et al. (1) and Bradicich et al.(2). These findings reinforce the importance of evaluating not only respiratory but also systemic outcomes when assessing the therapeutic benefits of orthodontic interventions in OSA patients.

The role of orthodontists in the multidisciplinary management of OSA has been increasingly recognized in recent literature. Alansari et al. (7) and Faber et al.(8) emphasized that orthodontists are well positioned to identify craniofacial risk factors associated with airway obstruction and to contribute to early diagnosis and management of sleep-disordered breathing. The results of the present review support this perspective by demonstrating that orthodontic interventions targeting craniofacial structures can produce measurable improvements in airway dimensions and, in selected patients, clinically relevant reductions in OSA severity.

5.4 Limitations of the current evidence

Several limitations should be considered when interpreting the results of the present review.

The included studies show considerable heterogeneity in terms of study design, population characteristics, and outcome measurements. The analyzed articles comprised prospective clinical studies, retrospective observational studies, cross-sectional morphological analyses, and a consecutive case series, making direct comparisons between studies difficult. In particular, the consecutive case series by Scarano et al. (26) included only six adults, and the computational fluid dynamics study by Zhao et al. (31) comprised fifteen participants, limiting the generalizability of their findings. Similarly, the multicenter trial by Kushida et al.(20) used home sleep apnea testing rather than in-laboratory polysomnography, which may introduce measurement variability when comparing results with studies that employed full-night polysomnography.

Variability in diagnostic and measurement methods also represents an important limitation. Several pediatric studies, including Bariani et al.(15), Nota et al.(16), and Restrepo et al. (17), relied on cephalometric or computed tomography-based morphological assessment without

reporting polysomnographic outcomes, limiting the ability to draw conclusions regarding the functional respiratory impact of these interventions. The inclusion of three observational studies without active orthodontic intervention Ciavarella et al. (28), Xia et al. (6), and Tepedino et al.(29) provided relevant morphological context but did not allow evaluation of treatment effects, introducing a degree of heterogeneity in the types of evidence synthesized.

Sample sizes varied considerably across studies, ranging from six patients in the surgical case series (26) to ninety-four participants in the morphological study by Xia et al. (6). Such variability may affect the statistical power and external validity of individual studies. Furthermore, patient characteristics differed widely, including differences in age, body mass index, craniofacial morphology, and OSA severity, all of which may influence treatment outcomes and limit comparability between studies.

Follow-up duration also differed considerably. While Andrén et al. (21) provided a three-year follow-up assessment, most included studies evaluated short-term outcomes at three to six months, and long-term stability of airway changes and respiratory improvements remains insufficiently documented.

Finally, OSA is a multifactorial condition influenced by factors beyond craniofacial morphology, including obesity, neuromuscular tone, and upper airway soft tissue characteristics. The observational finding by Gen-Yuki et al. (30) that morphological airway changes following orthognathic surgery did not consistently correlate with polysomnographic outcomes illustrates that anatomical enlargement alone may not be sufficient to fully address the functional complexity of OSA, highlighting the importance of multidisciplinary management.

5.5 Recommendations and future perspectives

Based on the findings of the present review, several recommendations for future research and clinical practice can be proposed.

Future investigations should prioritize well-designed randomized controlled trials with larger and more homogeneous patient populations, standardized diagnostic protocols, and combined assessment of morphological and functional outcomes. The systematic use of full-night polysomnography alongside three-dimensional airway imaging, as employed in studies such as Jiang et al. (19) and Scarano et al. (26), would improve comparability across studies and allow

more reliable evaluation of the relationship between anatomical airway changes and respiratory function.

Long-term follow-up studies are also needed to evaluate the stability of airway improvements associated with orthodontic interventions. Given that craniofacial growth in children and aging in adults may influence airway morphology over time, longitudinal research would help determine whether the morphological and functional benefits observed following interventions such as rapid maxillary expansion or mandibular advancement device therapy remain stable beyond the short-term assessment periods reported in the majority of included studies.

Future research should also investigate the role of patient-specific craniofacial phenotyping in predicting treatment response. The morphological associations identified by Ciavarella et al. (28), Xia et al. (6), and Tepedino et al. (29) suggest that individual anatomical characteristics may influence the effectiveness of orthodontic interventions, supporting the development of more personalized treatment strategies based on pretreatment airway and craniofacial assessment.

From a clinical perspective, the findings of this review support the integration of airway evaluation into routine orthodontic diagnosis and treatment planning. Orthodontists may play a relevant role in the early identification of craniofacial risk factors associated with airway obstruction, as emphasized by Alansari et al. (7) and Faber et al. (8), contributing to earlier referral for multidisciplinary evaluation and management of OSA.

6. CONCLUSIONS

1. Craniofacial anatomical characteristics including maxillary constriction, mandibular retrognathia, and reduced dental arch dimensions are closely associated with upper airway dimensions and contribute to airway obstruction in susceptible individuals. Orthodontic and dentofacial orthopedic treatments targeting these structures can modify airway morphology and respiratory parameters in selected patients with OSA, supporting their role as a non-invasive or minimally invasive adjunct to conventional medical management.

2. The clinical effectiveness of orthodontic interventions varies considerably according to treatment modality and patient age. In children, rapid maxillary expansion and functional orthopedic appliances consistently increase nasal and pharyngeal dimensions, though

morphological improvements are not always accompanied by measurable reductions in apnea–hypopnea index. In adults, mandibular advancement devices produce consistent and clinically significant reductions in apnea–hypopnea index and oxygen desaturation index across multiple studies, representing the strongest functional evidence among the modalities reviewed. Orthognathic surgery produces the most pronounced anatomical enlargement of the airway, while clear aligner therapies and tooth movement alone yield more variable and limited effects.

3. Orthodontic treatment contributes to improvements in global sleep parameters and systemic outcomes in selected OSA patients. Mandibular advancement devices were associated with reductions in apnea–hypopnea index, improvements in oxygen saturation, and favorable changes in cardiovascular parameters including blood pressure. These findings reinforce the importance of integrating airway evaluation into routine orthodontic diagnosis and treatment planning, and highlight the value of interdisciplinary collaboration between orthodontists, sleep physicians, and otolaryngologists in the comprehensive management of OSA.

7. SUSTAINABILITY

This review is aligned with the Sustainable Development Goals, particularly SDG 3 (Good Health and Well-being) and SDG 4 (Quality Education). OSA is a highly prevalent and frequently underdiagnosed disorder associated with cardiovascular, metabolic, and neurocognitive consequences. By summarising the available evidence on orthodontic and dentofacial orthopedic interventions, this work supports earlier recognition of airway-related problems and promotes a more preventive approach to patient care.

From a social perspective, orthodontists may contribute to earlier identification of patients at risk of OSA and facilitate referral for multidisciplinary assessment, which may improve access to diagnosis and treatment. From an economic perspective, earlier detection and management may help reduce the long-term healthcare burden associated with untreated OSA and its complications. In addition, this review has an educational value, as it reinforces the importance of airway evaluation in orthodontic training and clinical decision-making. Overall, integrating orthodontics into the multidisciplinary management of OSA may contribute to more sustainable and equitable healthcare.

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