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Review Article **Orthopedics**

Orthodontic Treatment and Airway: A Review of Evidence Linking Malocclusion and Sleep Apnea

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Abstract

The orthodontic landscape is evolving beyond occlusion and aesthetics, expanding into realms that intersect with systemic health most notably, the airway. This review explores a compelling paradigm shift: the growing body of evidence that links malocclusion with sleep-disordered breathing, particularly obstructive sleep apnea (OSA). No longer viewed in isolation, craniofacial architecture and dental arch relationships are now recognized as potential contributors to compromised airway volume and function. We synthesize current literature to unravel how sagittal and vertical dysmorphologies—such as retrognathic mandibles, narrow maxillary arches, and deep bites correlate with reduced upper airway dimensions and increased risk of airway obstruction during sleep. Furthermore, this review investigates how orthodontic interventions, including maxillary expansion, mandibular advancement, and functional appliance therapy, may influence airway patency. Rather than presenting orthodontics as a cure for OSA, we critically evaluate the extent to which treatment timing, modality, and individual growth patterns determine outcomes. We also spotlight the need for interdisciplinary synergy between orthodontists, sleep physicians, and ENT specialists, advocating for a patient-centred, airway-conscious approach in diagnosis and treatment planning. While the evidence is promising, we emphasize the gaps that persist especially in longitudinal outcomes and standardization of airway assessment protocols. In rethinking malocclusion through the lens of airway health, this review calls for a new orthodontic responsibility: not merely aligning teeth, but potentially aiding in breath, sleep, and systemic wellness. The implications are profound not only for orthodontic strategy but also for the very definition of oral health.

Keywords: Obstructive sleep apnea (OSA), Upper airway obstruction, Sleep-disordered breathing, Functional appliances, Airway volume, Mini-implant assisted rapid palatal expansion (MARPE), Rapid maxillary expansion (RME), Premolar extraction and airway.

INTRODUCTION

The human upper airway, though anatomically intricate and functionally vital, has often been regarded as a peripheral consideration in orthodontic diagnosis and treatment planning. With an increasing body of literature revealing the influence of craniofacial morphology on respiratory function, particularly during sleep, a paradigm shift is underway—redirecting orthodontic focus from mere alignment and aesthetics to comprehensive orofacial and airway health.

Obstructive sleep apnea (OSA) poses a significant public health burden, with far-reaching implications for patient well-being. Given their intimate involvement with craniofacial structures, orthodontists are in a pivotal position to identify signs of airway obstruction and contribute meaningfully to early diagnosis and intervention. The authors further stress the importance of staying abreast of evolving technologies, including consumer-grade devices for sleep monitoring and diagnostics, which may enhance accessibility and interdisciplinary coordination in managing sleep-disordered breathing [1].

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The concept of airway-centred orthodontics has emerged as a crucial domain, highlighting the orthodontist's potential role in mitigating sleep-disordered breathing, especially obstructive sleep apnea (OSA).

Malocclusion, a deviation from normal occlusal relationships, results from skeletal and dental disharmonies involving an interplay of genetic and environmental factors. It is classified into sagittal, vertical, and transverse discrepancies, each potentially influencing oral functions, esthetics, and, as emerging evidence suggests, airway patency. Obstructive sleep apnea is a chronic condition characterized by repetitive episodes of upper airway obstruction during sleep, leading to intermittent hypoxia, sleep fragmentation, and a cascade of systemic consequences, including cardiovascular, metabolic, and neurocognitive morbidities.

The relationship between malocclusion and OSA is increasingly supported by clinical and radiographic evidence. Retrognathic mandibles, maxillary constriction, deep palatal arches, and elongated lower facial dimensions are among the craniofacial patterns associated with reduced upper airway volume. Orthodontic interventions, particularly in growing individuals, may thus have far-reaching implications beyond dental correction, offering potential benefits in airway maintenance and OSA risk reduction.

Continuous Positive Airway Pressure (CPAP) therapy is the gold standard treatment for obstructive sleep apnea (OSA), a condition where the upper airway repeatedly collapses or becomes blocked during sleep, leading to interrupted breathing and poor oxygenation. CPAP works by delivering a steady stream of pressurized air through a mask that fits over the patient's nose, or nose and mouth. This continuous pressure acts as a pneumatic splint, keeping the airway open and preventing apneic episodes. Patients using CPAP typically report improved sleep quality, reduced snoring, and a significant decrease in symptoms such as daytime sleepiness, morning headaches, and difficulty concentrating. Over time, consistent use of CPAP can lower the risk of serious complications associated with sleep apnea, such as hypertension, stroke, heart disease, and metabolic disorders. Modern CPAP machines are compact and often include features like humidifiers, pressure adjustments, and data tracking, making therapy more comfortable and effective. However, patient compliance can be a challenge due to discomfort, noise, or mask-related issues, highlighting the importance of proper education, follow-up, and customization of the device.

In recent years, airway-focused orthodontics has garnered substantial attention, catalysed by advancements in three-dimensional imaging, enhanced awareness of sleep medicine, and interdisciplinary collaboration. Different treatment methods, such as widening the upper jaw, using growth-modifying devices, and moving the lower jaw forward, have been found to affect the size of the upper airway and how well a person breathes in different ways. These findings have sparked renewed interest in the orthodontist's role as a contributor to systemic health, particularly in paediatric populations where early intervention can be profoundly impactful.

The epidemiological burden of both OSA and malocclusion further emphasizes the clinical relevance of this intersection. In India, the estimated prevalence of OSA is approximately 11%, with a higher incidence reported in males (13%) compared to females (5%) [1]. Concurrently, malocclusion affects a significant proportion of the population, particularly among children and adolescents. A systematic review reported a prevalence rate of 35.4% in Indian children aged 8–15 years, with urban and male populations disproportionately affected [2]. These figures underscore the need for heightened vigilance and early orthodontic assessment with a view to identifying craniofacial risk factors for airway obstruction.

Historically, orthodontic goals have evolved from occlusal function (Angle, 1899) to facial aesthetics (Begg, 1950s) and are now expanding to encompass physiologic functions such as nasal breathing and airway competence. While conventional orthodontics has primarily focused on static relationships of teeth and jaws, contemporary approaches increasingly advocate for dynamic, holistic assessment incorporating airway morphology. The acknowledgment of this evolution is critical for modern orthodontic training and practice.

The objective of this review is to synthesize current evidence elucidating the relationship between malocclusion and obstructive sleep apnea, and to evaluate the influence of various orthodontic modalities on upper airway dimensions. Emphasis will be placed on craniofacial phenotypes associated with airway compromise, the impact of orthodontic interventions across age groups, diagnostic tools, and the need for interdisciplinary management. By integrating the most recent literature, this article aims to support the adoption of airway-centric principles in orthodontic treatment planning, thereby enhancing both orofacial and systemic health outcomes.

Craniofacial Anatomy and Airway Physiology

The upper airway is a complex anatomical structure comprising the nasal cavity, nasopharynx, oropharynx, and hypopharynx. Each segment plays a pivotal role in respiration, phonation, and deglutition. The nasal cavity serves as the primary conduit for airflow, facilitating humidification and filtration. Posteriorly, it communicates with the nasopharynx, which extends to the soft palate. The oropharynx, situated between the soft palate and the epiglottis, is bordered anteriorly by the oral cavity and posteriorly by the pharyngeal wall. Inferiorly, the hypopharynx continues to the larynx and esophagus, completing the upper airway pathway.

Craniofacial morphology significantly influences the dimensions and patency of the upper airway. The position and orientation of the maxilla and mandible determine the spatial configuration of the airway. Mandibular retrusion, frequently associated with Class II skeletal patterns, can contribute to narrowing of the oropharyngeal airway, thereby elevating the likelihood of obstructive sleep apnea (OSA). Conversely, prognathic mandibles, characteristic of Class III malocclusions, may alter airway dimensions differently. Maxillary constriction may result in a deep palatal vault and reduced width of the nasal cavity, thereby elevating airflow resistance through the nose and encouraging mouth breathing.[2]

Facial growth in the vertical dimension can influence airway structure. Hyperdivergent cases usually demonstrate elongated lower facial proportions and a steep mandibular angle, which may contribute to a posterior-inferior mandibular displacement. This rotation can decrease the posterior airway space, elevating the risk for OSA. In contrast, hypodivergent individuals may have a more favourable airway configuration due to a more horizontal mandibular growth pattern.

Advancements in imaging technologies have enhanced our understanding of the relationship between craniofacial structures and airway morphology. Three-dimensional (3D) imaging modalities, such as cone-beam computed tomography (CBCT), allow for precise volumetric assessments of the airway. Studies utilizing CBCT have demonstrated significant differences in airway volumes among individuals with varying skeletal patterns. For instance, research indicates that individuals with Class II skeletal patterns often exhibit reduced airway volumes compared to those with Class I or III patterns [3].

Cephalometric analyses remain a cornerstone in orthodontic diagnostics, offering valuable insights into craniofacial relationships and airway dimensions. Specific cephalometric parameters, such as the ANB angle, mandibular plane angle, and hyoid bone position, have been correlated with airway space measurements. For instance, an increased ANB angle—signifying a Class II skeletal discrepancy—has been linked to reduced pharyngeal airway dimensions. Likewise, an inferiorly positioned hyoid bone may indicate reduced airway openness [4,5].

Understanding the interplay between craniofacial anatomy and airway physiology is crucial for comprehensive orthodontic assessment and treatment planning. Recognizing the potential impact of orthodontic interventions on airway dimensions can inform decisions that not only address dental and skeletal discrepancies but also enhance respiratory function. As the field progresses, integrating airway considerations into orthodontic practice underscores the commitment to holistic patient care.

Types of Malocclusions and Their Relationship to Airway Obstruction

Malocclusion encompasses a range of dental and skeletal discrepancies that can significantly impact the upper airway. Understanding the relationship between different types of malocclusions and airway compromise is crucial for orthodontic treatment planning. This section explores the association between various malocclusions and airway obstruction, highlighting the importance of early diagnosis and intervention [6,7].

Class II Malocclusion: Mandibular Retrusion and Airway Compromise

Class II malocclusion, characterized by a retrusive mandible relative to the maxilla, is commonly associated with reduced upper airway dimensions. Studies have shown that individuals with Class II malocclusion exhibit diminished oropharyngeal and nasopharyngeal airway spaces, potentially predisposing them to obstructive sleep apnea (OSA) [8]. The retro positioned mandible can lead to posterior displacement of the tongue and soft palate, further narrowing the airway. Orthopaedic treatments, such as functional appliances, aim to reposition the mandible, thereby improving airway dimensions and reducing the risk of airway-related complications [9].

Class III Malocclusion: Less Common, but Mention Skeletal and Nasal Resistance

Class III malocclusion, characterized by a prognathic mandible and/or maxillary deficiency, presents a unique set of challenges concerning airway management. While less prevalent than Class II malocclusion, Class III discrepancies can lead to increased nasal resistance due to maxillary atresia and retrusion [10]. This increased resistance may result in altered breathing patterns, with a tendency toward mouth breathing, which can exacerbate airway obstruction. Orthognathic surgical interventions, such as bimaxillary surgery, are often employed to correct skeletal discrepancies; however, these procedures may inadvertently alter oropharyngeal structures and potentially narrow the upper airway, necessitating careful post-operative monitoring for sleep-disordered breathing [11].

Vertical Discrepancies: Deep Bite, Long Face Syndrome

Vertical malocclusions, including deep bite and long face syndrome, can significantly affect airway dimensions. A deep bite, characterized by excessive vertical overlap of the anterior teeth, may lead to a downward and backward rotation of the mandible, reducing the posterior airway space [12].

This reduction in airway volume can increase the risk of airway obstruction during sleep. Conversely, long face syndrome, associated with hyperdivergent growth patterns, often presents with an increased lower anterior facial height and a steep mandibular plane angle. These skeletal features can result in a more open bite and a decreased posterior airway space, further compromising airway patency. Management of vertical discrepancies requires careful consideration of growth patterns and may involve orthodontic and surgical interventions to optimize airway dimensions.

Transverse Discrepancies: Narrow Arches and Nasal Airflow

Transverse malocclusions, such as narrow maxillary arches and crossbites, can impact nasal airflow and overall airway function. A constricted maxillary arch can lead to a high-arched palate and narrowed nasal passages, increasing nasal resistance and promoting mouth-breathing. This alteration in breathing patterns can exacerbate airway obstruction, particularly during sleep. Interventions like rapid maxillary expansion (RME) aim to widen the upper arch, thereby increasing nasal volume and improving nasal airflow. Studies have demonstrated that RME can lead to significant improvements in nasal breathing and reductions in nasal resistance, highlighting its efficacy in managing transverse discrepancies and associated airway concerns.

Table 1: Malocclusion Types and Associated Airway Risks

Malocclusion Type	***Airway Risk Level***	***Key Factors***	***Recommended Interventions***
Class II	High	Mandibular retrusion, reduced airway dimensions	Functional appliances, orthopedic treatment
Class III	Moderate	Maxillary atresia, increased nasal resistance	Orthognathic surgery, post-operative monitoring
Vertical Discrepancies	Moderate to High	Deep bite, long face syndrome, altered mandibular rotation	Orthodontic treatment, surgical intervention
Transverse Discrepancies	Moderate	Narrow maxillary arch, increased nasal resistance	Rapid maxillary expansion, orthodontic treatment

Orthodontic Interventions and Their Impact on Airway

Maxillary Expansion (RME/SARPE)

Rapid Maxillary Expansion (RME) is a common orthodontic procedure aimed at correcting transverse maxillary deficiencies [13]. Beyond dental alignment, RME has been associated with changes in the nasal cavity volume. Studies have reported an average increase of 11.3% in nasal volume post-RME, suggesting potential benefits in nasal airflow and breathing efficiency [14]. However, the impact of RME on the nasopharyngeal and oropharyngeal airway volumes remains inconclusive, with some studies indicating minimal or no significant changes [15].

A meta-analysis demonstrated that Rapid Maxillary Expansion (RME) in growing patients leads to a notable volumetric increase in upper airway space. The average airway volume gain post-expansion was approximately 1218.3 mm³, with sustained improvement of around 1143.9 mm³ after the retention period. Although the quality of evidence was rated low due to the lack of control groups and methodological inconsistencies, the findings suggest a positive short- and long-term impact of RME on nasal cavity volume and breathing function [16].

Another systematic review and meta-analysis focused on the role of RME in modifying upper airway dimensions and its impact on mouth breathing. The findings revealed a consistent and statistically significant increase in nasal cavity volume following RME, which was retained even after the retention phase. However, changes in nasopharyngeal and oropharyngeal volumes were largely non-significant across most studies. The authors emphasize that increased airway volume does not inherently equate to improved respiratory function, especially in mouth-breathing children, and call for further well-designed clinical trials specifically targeting functional outcomes [17].

Surgically Assisted Rapid Palatal Expansion (SARPE) is employed in skeletally mature patients where conventional RME is less effective. While SARPE can achieve greater skeletal expansion, its direct impact on airway dimensions requires further investigation.

A multicentred prospective trial evaluated the effects of MARPE in non-obese adults with obstructive sleep apnea and transverse maxillary deficiency. Six months post-treatment, patients showed a significant reduction in the apnea-hypopnea index (65.3% decrease), improved oxygen saturation, and reduced snoring duration. Additionally, subjective improvements were reported in daytime sleepiness scores and overall OSA-related quality of life. The procedure achieved an 85% success rate without the need for surgical osteotomy, suggesting MARPE as a minimally invasive and effective approach in selected adult OSA cases [18].

Another review assessed the anatomical effects of MARPE in nongrowing individuals. The results showed statistically significant increases in nasal cavity width and volume, as well as in nasopharyngeal and oropharyngeal airway volumes. However, no substantial changes were noted in hypopharyngeal volume. Additionally, MARPE led to minor increases in alar and alar base width, reflecting changes in facial soft tissue structure. While the findings highlight the skeletal and soft tissue expansion potential of MARPE, the authors caution that further randomized studies are needed to confirm these outcomes due to limitations in study design and sample size [19].

Functional Appliances (Twin Block, Herbst, Myobrace)

Functional appliances are designed to modify jaw growth and improve occlusal relationships, particularly in Class II malocclusions. The Twin Block appliance has demonstrated efficacy in advancing the mandible, thereby increasing the pharyngeal airway space. A randomized clinical trial comparing Twin Block and Myobrace appliances found both to be effective in enhancing airway dimensions, with the Twin Block showing a more pronounced effect [20].

A study assessed the role of oral and functional orthopaedic appliances in managing paediatric obstructive sleep apnea (OSA). Despite an extensive literature search, only one randomized clinical trial with 23 participants was eligible for analysis. The findings were inconsistent and rated as very low in quality. While conclusive evidence was lacking, the authors suggested that such appliances may be considered as adjunctive therapies in children with craniofacial anomalies—a known risk factor for OSA. These insights emphasize the need for further robust clinical trials to determine the efficacy and long-term outcomes of these interventions in paediatric populations [21].

The Herbst appliance, a fixed functional device, also contributes to mandibular advancement and has been associated with improvements in airway patency. However, patient compliance and comfort can influence the effectiveness of these appliances. Myobrace, a prefabricated myofunctional appliance, focuses on correcting oral habits and muscle function, indirectly benefiting airway dimensions.

Mandibular Advancement

Mandibular advancement devices (MADs) are primarily used in managing obstructive sleep apnea (OSA) by repositioning the mandible anteriorly to prevent airway collapse during sleep. Clinical studies have shown that MADs can significantly reduce the apnea-hypopnea index (AHI) and improve oxygen saturation levels in patients with OSA [22].

The degree of mandibular advancement is crucial; excessive advancement may lead to temporomandibular joint discomfort, while insufficient advancement might not yield the desired therapeutic outcomes. Therefore, individualized titration of MADs is essential for optimizing airway patency and patient comfort [23].

Extraction vs. Non-extraction Therapy

The decision to extract teeth during orthodontic treatment has long been debated, particularly concerning its impact on airway dimensions. Some studies suggest that premolar extractions do not significantly affect the upper airway volume or the minimum cross-sectional area [24]. Conversely, other research indicates that extractions may lead to a reduction in pharyngeal airway space, potentially increasing the risk of OSA [25].

These conflicting findings highlight the need for a case-by-case assessment when considering extractions, taking into account the patient's airway anatomy, growth patterns, and overall health. Advancements in imaging techniques, such as cone-beam computed tomography (CBCT), have facilitated more accurate evaluations of airway changes associated with orthodontic interventions.

A retrospective study estimated the effects of second premolar extractions on upper airway volume using CBCT analysis. The findings revealed that both extraction and non-extraction groups experienced a statistically significant increase in airway volume, with no meaningful difference between them. The most influential factors contributing to airway change were increases in airway length and the area of minimum constriction—likely attributed to normal growth patterns rather than the orthodontic intervention itself. These results support the notion that second premolar extractions do not adversely impact airway volume in adolescent patients [26].

Others analyzed the impact of premolar extractions on upper airway dimensions using CBCT data from 891 patients. The findings showed no significant differences in airway volume or minimum cross-sectional area (minCSA) across most regions, including the nasopharynx, palatopharynx, glossopharynx, and oral cavity, between extraction and non-extraction groups. Interestingly, a slight increase in oropharyngeal minCSA was observed in the extraction group. These results suggest that premolar extractions have minimal, if any, adverse effects on upper airway space, reinforcing the importance of individualized treatment planning rather than avoidance based on airway concerns alone [23].

Surgical Orthodontics and Orthognathic Surgery

Orthognathic surgery is often indicated in patients with severe skeletal discrepancies that cannot be addressed through orthodontic means alone. Surgical procedures, such as mandibular advancement or maxillomandibular advancement, have been shown to increase upper airway volumes, thereby improving respiratory function [28].

However, certain surgical interventions, like mandibular setback procedures, may reduce airway dimensions, potentially exacerbating or inducing OSA symptoms. Therefore, comprehensive pre-surgical planning, including airway assessment, is critical to minimize adverse outcomes.

Table 2: Orthodontic Interventions and Their Quantitative Impact on Airway

Intervention	***Effect on Airway***	***Quantitative Outcome***	***Controversies/Limitations***	***Reference***
Rapid Maxillary Expansion (RME)	Increases nasal cavity volume	↑ Nasal volume by 11.3%	Limited impact on oropharynx in adults	Zhao *et al.,* Sci Direct, 2010[21]
Surgically Assisted RME (SARPE)	Expands nasal and midpalatal regions in adults	Volume increase variable by patient age	Requires surgical intervention, limited data	Camacho *et al.,* Sleep Med Rev, 2015[22]
Twin Block Appliance	Improves pharyngeal airway space	Significant increase in airway dimensions	Compliance-dependent, long-term retention needed	Ali *et al.,* PMC, 2023[23]
Mandibular Advancement Devices (MADs)	Reduces Apnea-Hypopnea Index (AHI)	↓ AHI from 24.5 to 11.4 events/hr	Possible TMJ discomfort with overuse	Chen *et al.,* PMC, 2024[24]
Premolar Extractions	Potential reduction in pharyngeal airway	↓ Mean pharyngeal area (some studies)	Conflicting evidence across studies	Singh *et al.,* Nature, 2023[25]
Orthognathic Surgery	Improves airway in advancement surgeries	↑ Oropharyngeal volume post-surgery	Mandibular setback may worsen airway	Yoshida *et al.,* PubMed, 2016[26]

Another analysis highlighted the potential of skeletal expansion techniques in managing adult obstructive sleep apnea (OSA). Maxillary expansion resulted in a 59.3% reduction in the apnea-hypopnea index (AHI) and improved oxygen saturation levels, while maxillomandibular expansion showed an even greater AHI reduction of 77.5%. Although based on limited patient samples, these findings underscore the therapeutic value of expansion procedures in improving respiratory function among adult OSA patients [29].

Paediatric Considerations & Early Intervention

The paediatric population represents a critical window for identifying and intervening in airway-related disorders linked to craniofacial development. Early orthodontic assessment transcends aesthetic goals, offering a strategic opportunity to positively influence both the structural and functional dimensions of the upper airway. Emerging evidence underscores the importance of recognizing anatomical and functional deviations early in life, not only to optimize occlusal outcomes but to ensure unobstructed breathing and overall health [30].

One of the foundational elements in paediatric airway health is the position and function of the tongue. Proper tongue posture—resting against the palate—plays an instrumental role in shaping the maxillary arch and maintaining patency of the nasopharyngeal airway [31]. Conversely, low tongue posture and mouth breathing, often precipitated by chronic nasal obstruction or habits such as thumb-sucking, can lead to maxillary constriction, increased palatal vault depth, and a subsequent reduction in nasal airflow [3]. These changes contribute to the development of a high-angle skeletal pattern, increasing the risk of sleep-disordered breathing (SDB) and obstructive sleep apnea (OSA) during formative years [32].

The importance of nasal breathing cannot be overstated. Nasal respiration promotes optimal oxygenation, filters and humidifies air, and supports neuromuscular tone of the pharyngeal structures. When nasal breathing is compromised, children adapt through mouth breathing, which is associated with altered mandibular positioning, adenoid hypertrophy, and postural compensations that negatively affect facial growth and airway dimensions [33].

Interceptive orthodontics aims to address these concerns during the early mixed dentition phase, ideally between ages 6 to 10. Modalities such as maxillary expansion, habit-breaking appliances, and early guidance of eruption patterns are used not just to direct occlusal relationships but also to improve airway volume [34]. Functional orthopaedic appliances like the Myobrace® or Twin Block are increasingly utilized to correct skeletal discrepancies while simultaneously retraining oral musculature, promoting nasal breathing, and facilitating normal jaw growth [35].

Myofunctional therapy (MFT) has emerged as a valuable adjunct in this paradigm, particularly in addressing tongue posture, lip seal, and swallowing patterns. Rooted in neuromuscular re-education, MFT aims to reestablish balance in orofacial musculature, thereby enhancing airway tone and reducing collapsibility during sleep [36]. Its integration into early orthodontic treatment protocols represents a preventive model, reducing the need for more invasive interventions in later life.

From a holistic health perspective, the repercussions of untreated paediatric airway obstruction extend beyond craniofacial morphology. Chronic sleep fragmentation associated with SDB in children has been linked to behavioural disorders, attention deficits, learning difficulties, and stunted somatic growth [37]. Growth hormone, secreted predominantly during deep sleep, is compromised in these cases—highlighting the intersection between airway patency and systemic development [38]. Therefore, improving sleep quality through early airway-centred orthodontic interventions holds the potential to elevate a child's academic performance, emotional regulation, and physical growth.

In essence, paediatric airway-focused orthodontics is a confluence of structural, functional, and behavioural care. Identifying at-risk children through interdisciplinary screening and initiating timely interceptive measures is not merely corrective—it is profoundly preventive. Such an approach reframes orthodontics as a pillar of paediatric health, rather than a siloed dental specialty.

Diagnostic Tools & Evaluation Methods

Accurate assessment of the upper airway is pivotal in orthodontic diagnosis and treatment planning, particularly for patients with suspected sleep-disordered breathing (SDB). A comprehensive evaluation integrates both objective imaging techniques and subjective assessment tools to provide a holistic understanding of airway anatomy and function.

Imaging Modalities: 2D vs. 3D

Traditionally, lateral cephalometric radiographs have been employed to evaluate craniofacial structures and airway dimensions. While cephalometry offers valuable insights into skeletal relationships, its two-dimensional nature imposes significant limitations. Overlapping anatomical structures and the inability to capture transverse dimensions can lead to inaccuracies in airway assessment. For instance, the superimposition of bilateral structures may obscure critical details, potentially leading to misdiagnosis or underestimation of airway constriction.

In contrast, Cone-Beam Computed Tomography (CBCT) provides three-dimensional visualization of the craniofacial complex, allowing for precise measurement of airway volume and cross-sectional areas. CBCT enables clinicians to assess the airway in multiple planes, offering a more comprehensive evaluation of its morphology. However, considerations regarding radiation exposure, especially in paediatric patients, necessitate judicious use of this modality [39].

Polysomnography and Subjective Questionnaires

Polysomnography (PSG) remains the gold standard for diagnosing obstructive sleep apnea (OSA), providing detailed information on sleep architecture, respiratory events, and oxygen saturation levels.[31] Despite its diagnostic accuracy, PSG is resource-intensive and may not be readily accessible in all clinical settings.

Subjective assessment tools, such as the Epworth Sleepiness Scale (ESS) and the paediatric Sleep Questionnaire (PSQ), serve as valuable screening instruments. The ESS evaluates daytime sleepiness, while the PSQ assesses symptoms related to SDB in children.[30] These questionnaires can aid in identifying individuals at risk for OSA, guiding the need for further diagnostic evaluation.

Emerging Technologies: AI Analysis and Wearables

Advancements in artificial intelligence (AI) have introduced automated analysis of CBCT images, facilitating rapid and objective assessment of airway dimensions. AI algorithms can identify patterns and anomalies that may be overlooked in manual evaluations, enhancing diagnostic accuracy [36].

Wearable devices equipped with sensors to monitor sleep patterns, respiratory rate, and oxygen saturation offer a non-invasive means of assessing sleep quality. While these technologies provide valuable data, their diagnostic capabilities are still under investigation, and they should complement, rather than replace, established diagnostic methods [31].

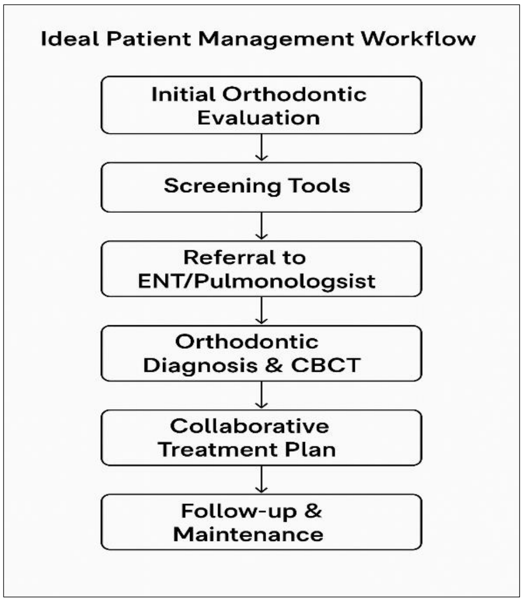
Interdisciplinary Approach

The management of patients with airway-related orthodontic concerns necessitates an interdisciplinary framework involving otolaryngologists (ENTs), pulmonologists, speech-language pathologists, and orofacial myofunctional therapists. These collaborations ensure that both structural and functional dimensions of airway obstruction are comprehensively addressed.

ENT specialists contribute by diagnosing and managing anatomical obstructions such as adenoid hypertrophy, deviated nasal septum, or turbinate hypertrophy, which may compromise nasal airflow and breathing efficiency. Pulmonologists are essential in assessing and managing systemic respiratory conditions, performing and interpreting polysomnography (PSG), and guiding the long-term management of sleep-disordered breathing (SDB) such as obstructive sleep apnea (OSA) [31].

Myofunctional therapists play a critical role in retraining orofacial muscles, addressing dysfunctional tongue posture, low resting tongue position, mouth breathing, and poor swallowing patterns. Evidence suggests that myofunctional therapy, in conjunction with orthodontic or surgical interventions, contributes to sustained improvements in airway patency and function [36].

Recent literature supports the integration of "airway-focused" teams in orthodontic and paediatric dental clinics, where coordinated care leads to earlier diagnosis, improved patient adherence, and more stable outcome [40]. Multidisciplinary airway clinics also promote streamlined referrals and co-management strategies, particularly in paediatric populations where early intervention has long-term health implications.



Limitations in Current Research & Future Directions

Despite increasing interest in airway-focused orthodontics, the current body of evidence is hindered by several methodological limitations. One of the major challenges lies in the inconsistencies in measurement tools across studies. Airway assessments often vary in technique—ranging from 2D cephalometry and CBCT volumetrics to subjective questionnaires—leading to heterogeneity that impedes comparison and meta-analysis [39].

Furthermore, most existing studies are cross-sectional or retrospective, limiting the ability to draw causal inferences between orthodontic interventions and long-term airway improvement. A significant gap persists in the form of well-powered, longitudinal cohort studies or randomized controlled trials (RCTs) that track patients from diagnosis through post-treatment follow-up using standardized outcome measures [30].

Another concern is the lack of consensus on clinically meaningful thresholds for airway changes. For instance, while some studies report volumetric increases post-RME or mandibular advancement, the correlation between these anatomical changes and functional respiratory outcomes (e.g., AHI improvement, quality of life) remains unclear in many cases [36].

A Future Model for Airway Studies

To address these challenges, there is a pressing need for a unified scoring system that combines anatomical (volumetric and linear), physiological (AHI, O2 saturation), and patient-reported (quality of life, sleep quality) metrics. This multidimensional approach would enhance reproducibility, allow for effective comparison across studies, and strengthen the evidence base for airway-focused orthodontic care.

Future studies should ideally incorporate multi-disciplinary collaboration, long-term follow-up, and harmonized imaging protocols to better understand the complex interplay between craniofacial growth, malocclusion, and airway health.

CONCLUSION

The evolving paradigm of airway-focused orthodontics underscores a compelling interrelationship between craniofacial morphology, malocclusion, and sleep-disordered breathing. This review consolidates current evidence indicating that orthodontic interventions—such as rapid maxillary expansion, functional appliance therapy, and mandibular advancement—have demonstrable impacts on upper airway dimensions and, in select cases, on respiratory function.

It is incumbent upon orthodontic practitioners to broaden their clinical perspective beyond dental alignment and facial aesthetics. Recognizing the airway as an integral component of functional diagnosis and treatment planning represents both a clinical opportunity and an ethical imperative. Early identification of airway-related concerns, coupled with interdisciplinary collaboration, can significantly enhance patient outcomes, particularly in paediatric populations where growth modification is feasible.

As the specialty progresses, a shift towards airway-conscious orthodontics is not merely a trend but a necessary evolution in safeguarding systemic health through dental interventions. Increased awareness, standardized diagnostic protocols, and longitudinal research are essential to substantiate clinical practices and guide evidence-based care.

In shaping the craniofacial form, we may indeed be shaping the breath of life—an endeavor that elevates orthodontics from a corrective discipline to a transformative one.

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