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Review Article

Respiratory orthodontics: Bridging airway health and orthodontic care

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Abstract

Respiratory orthodontics explores the link between craniofacial growth, dental occlusion, and airway health. Advances in cone-beam computed tomography (CBCT) have improved airway assessment, supporting orthodontic management of conditions such as pediatric obstructive sleep apnea. Treatments including rapid maxillary expansion, Alt-RAMEC, mandibular advancement appliances, and myofunctional therapy can increase airway volume and improve breathing efficiency, particularly in growing patients.

Despite promising findings, challenges remain. There is no standard diagnostic threshold for airway compromise, and long-term results are limited. Evidence is mostly from small or heterogeneous studies, making it difficult to form clear clinical guidelines. This review summarizes current high-quality research, identifies persistent gaps, and highlights priorities for future studies. Establishing validated, age-specific airway assessment protocols and fostering collaboration with sleep medicine specialists will help strengthen respiratory orthodontics as an integral part of comprehensive patient care.

Keywords: Orthodontics, Airway management, Obstructive sleep apnea, Maxillary expansion, Mandibular advancement, Cone-beam computed tomography, Myofunctional therapy, Cephalometry, Polysomnography, Nasal obstruction.

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1. Introduction

The relationship between craniofacial development, occlusion, and airway function has gained increasing attention in orthodontic research and clinical practice. Traditionally, orthodontics has focused on achieving optimal occlusal relationships and facial esthetics; however, emerging evidence highlights the crucial role of airway health in overall patient well-being, particularly in the context of breathing and sleep-related disorders.[1-3] This shift toward an airway-centered approach termed respiratory orthodontics recognizes that skeletal and dental interventions can influence upper airway morphology and function, potentially reducing the burden of conditions such as pediatric obstructive sleep apnea (OSA).[4,5]

Advances in imaging technology, notably cone-beam computed tomography (CBCT), have revolutionized the evaluation of airway dimensions by providing three-dimensional volumetric data with high spatial accuracy.[12,16] These tools, alongside complementary modalities such as cephalometry, acoustic rhinometry, and polysomnography, allow clinicians to objectively assess the impact of orthodontic interventions on airway patency.[13,28] Interventions including rapid maxillary expansion (RME),[23,24] alternate rapid maxillary expansion and constriction (Alt-RAMEC),[13] mandibular advancement appliances,[7,20] and myofunctional therapy[11] have been associated with measurable improvements in airway volume and morphology, particularly in growing patients. Summary of diagnostic modalities used in respiratory orthodontics are presented in **Table 1**.

Despite encouraging outcomes, the field is limited by a lack of standardized diagnostic thresholds for clinically significant airway compromise,[6,9] heterogeneous study designs, and insufficient long-term follow-up data.[8,21] Furthermore, integration between orthodontic treatment protocols and objective sleep medicine outcomes such as

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polysomnographic parameters remains minimal in most clinical studies.[10,29] There is also a paucity of high-quality, multicentre randomized controlled trials (RCTs) that can definitively link orthodontic skeletal changes to sustained functional breathing improvements.[9]

This review synthesizes current evidence on respiratory orthodontics, identifies critical gaps in knowledge, and proposes directions for future research. By integrating orthodontic and respiratory health considerations, clinicians can expand treatment objectives beyond occlusion and esthetics, ultimately aiming for comprehensive patient health outcomes. Key literature gaps and future research priorities in respiratory orthodontics are presented in **Table 2**.

Recent advances (2022–2024) include AI-assisted CBCT airway segmentation for improved reproducibility,[12,16] computational fluid dynamics (CFD) for correlating morphology with airflow resistance,[17,19] and updates in skeletal expansion techniques such as maxillary skeletal expansion (MSE/MARPE) in adults.[14,22] Clear aligner–based transverse expansion has also been shown to produce measurable skeletal and airway changes on CBCT.[14,22]

Overview of the primary diagnostic tools applied in airway-focused orthodontics, including their measurement focus, advantages, limitations, and key literature references. The table highlights both morphological and functional assessment methods, emphasizing the strengths and weaknesses of each modality.

Consolidated summary of current evidence, persistent knowledge gaps, and recommended future research directions in respiratory orthodontics. The table integrates diagnostic, therapeutic, and interdisciplinary domains to guide clinical and research priorities.

Hypothetical line chart depicting changes in airway volume at 1-, 3- and 5-years post-intervention, illustrating initial improvement followed by slight decline, representing long-term stability trends in respiratory orthodontics.(**Figure 1**)

Table 1: Summary of diagnostic modalities used in respiratory orthodontics

Modality	Measurement Focus	Advantages	Limitations	Key References
CBCT	3D airway volume, skeletal width	High accuracy, multiplanar analysis	Radiation exposure, lacks functional data	1-4,12,16
Cephalometry	Linear airway dimensions	Low cost, low radiation	2D projection errors, less sensitive to change	5,7,20,37
Rhinomanometry	Nasal airflow resistance	Functional assessment	Technique sensitive, requires cooperation	1,8,10
Acoustic rhinometry	Cross-sectional nasal area	Quick, non-invasive	Less accurate in posterior airway	28,29
Polysomnography (PSG)	Apnea–hypopnea index, oxygen sat	Gold standard for OSA diagnosis	Costly, requires sleep lab	10,11,29

Table 2: Key literature gaps and future research priorities in respiratory orthodontics

Domain	Current Evidence	Gap	Future Research Need
Diagnostic standards	Multiple imaging modalities used	No age-specific airway thresholds	Develop validated diagnostic cut-offs
Outcome durability	Short-term airway gains post-treatment	Long-term relapse unknown	≥5-year prospective studies
High-quality evidence	Mostly small case series, cross-sectional data	Lack of large RCTs	Multicenter randomized controlled trials
Integration with sleep med.	Some PSG use, mainly in OSA studies	Minimal inclusion in orthodontic trials	Interdisciplinary PSG-based protocols
Mechanistic understanding	Skeletal expansion linked to volume increase	Airflow correlation unclear	Imaging + CFD + functional airflow studies
Myofunctional therapy	Growing evidence as adjunct	Independent role unconfirmed	RCTs orthodontics vs orthodontics+MFT
Adult airway orthodontics	Pediatric data dominates	Sparse non-surgical adult data	Evaluate MARPE, aligner expansion, adjunctive therapies

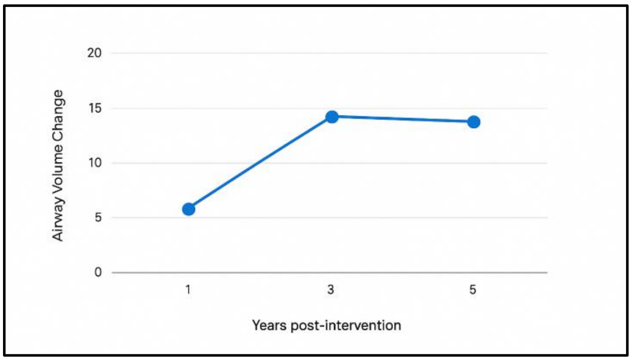

Figure 1: Longitudinal stability graph - Hypothetical line chart comparing airway volume change across 1-, 3- and 5-years post-intervention.

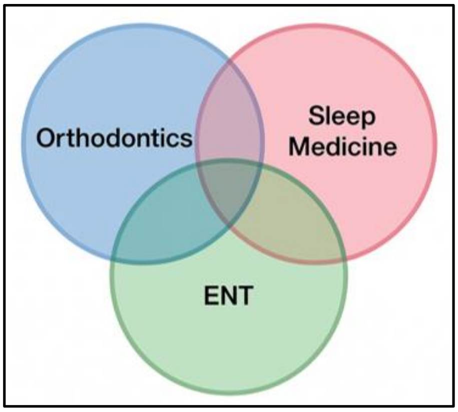

Figure 2: Interdisciplinary treatment model - Venn diagram showing orthodontics, ENT, and sleep medicine overlap in airway management.

Venn diagram illustrating the relationship between Orthodontics, ENT, and Sleep Medicine in airway management. The overlapping central area represents integrated, collaborative care strategies for diagnosis and treatment.

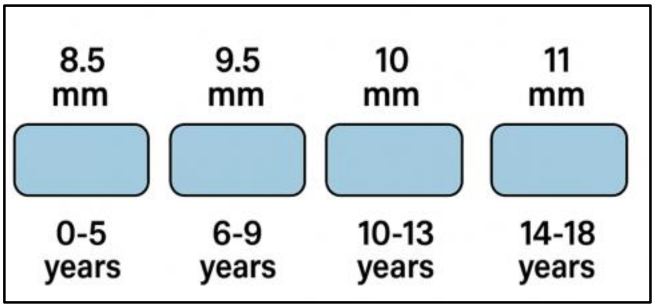

Figure 3: Age-Specific Airway Assessment Proposal - Diagram of proposed cut-off thresholds by age group.

Proposed airway measurement cut-off values by age group to identify potential airway compromise during growth.

2. Review of Evidence

2.1. Diagnostic standards in airway-oriented orthodontics

Objective assessment of the upper airway is fundamental to respiratory orthodontics. Current diagnostic tools include CBCT, lateral cephalometry, rhinomanometry, acoustic rhinometry, and polysomnography.[12,28] Among these, CBCT has become the gold standard for volumetric airway analysis, offering three-dimensional visualization and precise measurement of naso-, oro-, and hypopharyngeal spaces.[23,24] However, there is no universally accepted set of cut-off values for diagnosing clinically significant airway obstruction in orthodontics.[1,9] The proposed cut-off thresholds for airway assessment in different age groups are illustrated in **Figure 3**. Variations in voxel size, head positioning, segmentation thresholds, and landmark definitions contribute to inconsistent results across studies.[16,19]

This lack of standardization hampers cross-study comparison and hinders the establishment of evidence-based treatment protocols. Future research must focus on developing validated, age-specific airway measurement standards with reproducible protocols that can be consistently applied across imaging modalities and research centers.[1,6] The proposed age-specific diagnostic cut-off thresholds for airway assessment are illustrated in **Figure 3**.

2.2. Outcome durability and relapse risk

Interventions such as RME, Alt-RAMEC, and mandibular advancement appliances have shown short-term airway improvements in both pediatric and adolescent patients.[24,38] These changes are often attributed to increased transverse maxillary dimensions, anterior repositioning of the mandible, and expansion of nasal and pharyngeal spaces.[13,37] However, the long-term stability of these improvements remains unclear. The mean changes in upper airway volume following intervention are illustrated in **Figure 1**.

Few studies provide follow-up beyond two years, and those that do often report partial relapse in airway volume or function.[30] For example, long-term follow-up after Herbst appliance therapy demonstrated persistent skeletal changes but variable airway outcomes.[35] Similarly, post-surgical airway gains after bimaxillary advancement or mandibular setback procedures have shown regression over time.[16,33] This underlines the need for ≥5-year longitudinal studies that track not only skeletal changes but also functional breathing outcomes through objective testing.

Recent studies report that MSE/MARPE in late adolescents and adults can significantly increase nasal width and retropalatal airway volume.[14,22] Similarly, clear aligner–based expansion has shown CBCT-verified increases in nasal floor width. However, the long-term stability of these airway changes remains unclear due to limited ≥5-year follow-up data.

2.3. Quality of evidence and study design limitations

Much of the current literature consists of case series, cross-sectional analyses, and small single-center trials.[1,6] While these studies are valuable for hypothesis generation, they lack the statistical power and control necessary to establish causal relationships between orthodontic interventions and airway improvement.[8,9]

A shift toward large, multicenter RCTs is critical. Such studies should use standardized treatment protocols, uniform outcome measures, and include both morphologic and functional endpoints.[6,8] Inclusion of validated breathing tests, patient-reported outcomes, and quality-of-life metrics will help translate morphological findings into clinically meaningful evidence.

AI-driven three-dimensional airway segmentation tools have been introduced to reduce inter-observer variability and improve volumetric accuracy in CBCT-based airway studies.[12,16] Although promising, these technologies require multi-center validation and standardized protocols before routine clinical adoption.

2.4. Integration with sleep medicine

While orthodontic interventions such as RME, mandibular advancement, and maxillomandibular expansion have been shown to enlarge airway dimensions, their integration into formal sleep medicine protocols is limited.[10,29] Pediatric OSA management often involves adenotonsillectomy, but relapse or persistence of symptoms may occur in children with craniofacial constriction.[15-32] Orthodontic airway expansion can serve as an adjunct or alternative, yet few studies incorporate pre- and post-treatment polysomnography (PSG) to objectively quantify improvement.[8]

Polysomnography remains the gold standard for diagnosing OSA and assessing treatment efficacy.[10,11] Without its inclusion, claims of improved respiratory function remain largely inferential, based on morphologic change alone.[3,4] Interdisciplinary trials involving orthodontists, otolaryngologists, and sleep physicians are needed, with PSG performed before and after orthodontic airway interventions. Such collaboration would help establish clear therapeutic pathways and patient selection criteria.[29]

Recent randomized and prospective pediatric studies incorporating polysomnography demonstrate significant reductions in apnea-hypopnea index (AHI) after orthodontic expansion protocols, supporting functional respiratory improvement beyond morphological gains.[9,28] However, such PSG-integrated protocols remain limited to research settings, with minimal uptake in routine orthodontic practice.

2.5. Mechanistic understanding of airway changes

Most authors attribute airway improvements to skeletal expansion, anterior displacement of the maxilla or mandible, and subsequent soft tissue remodeling.[37,38] However, the exact correlation between these skeletal changes and functional airflow improvement remains unclear.[1,9] Computational fluid dynamics (CFD) studies suggest that increased airway volume does not always translate into reduced airflow resistance or improved oxygen saturation.[17,19]

This discrepancy highlights the role of compensatory mechanisms, neuromuscular adaptation, and tongue posture.[11,29] Future research should combine imaging (CBCT, MRI) with objective airflow measurements such as spirometry, rhinomanometry, and CFD modelling.[17,19,27] Only then can we clarify which skeletal and soft tissue changes are most predictive of functional respiratory gains.

CFD-CBCT combined studies have shown that increases in airway volume do not uniformly translate to reduced airflow resistance, highlighting the importance of dynamic airflow modelling in addition to static volumetric assessment.[17,19] These findings emphasize the need for future studies integrating CFD, CBCT, and functional airflow tests to better understand the mechanisms underlying airway improvement.

2.6. Myofunctional therapy in orthodontic airway management

Myofunctional therapy (MFT), aimed at correcting tongue posture and orofacial muscle function, has emerged as a valuable adjunct in respiratory orthodontics.[11,29] When combined with expansion or mandibular advancement, MFT may help stabilize airway improvements by reducing maladaptive oral breathing patterns.[10,11]

Despite promising results particularly in pediatric OSA[29] evidence remains limited, with few RCTs assessing MFT's independent contribution. Long-term data are scarce, and heterogeneity in exercise protocols makes reproducibility difficult.[10] Standardized, protocol-driven trials comparing orthodontics alone versus orthodontics plus MFT, with extended follow-up, are needed to determine its sustained benefit.

2.7. Adult airway orthodontics

Most airway-focused orthodontic research is pediatric, targeting growth modification windows.[7,8] In adults, skeletal maturity limits orthopedic expansion, and surgical approaches are often required for significant airway enlargement.[34,36,40] However, non-surgical adult airway orthodontics such as miniscrew-assisted rapid palatal expansion (MARPE) and clear aligner expansion has shown encouraging results in select cases.[14,22]

Literature on long-term stability, functional improvement, and quality-of-life outcomes in adults remains sparse.[14,22] Exploring non-surgical airway-centered protocols for borderline surgical candidates could significantly expand treatment options, particularly when combined with adjuncts such as MFT or low-level laser therapy.

Recent studies demonstrate that MSE/MARPE can achieve true skeletal expansion in adults, resulting in increased nasal cavity volume and improved pharyngeal airway metrics on CBCT. [14,22] Additionally, clear aligner–based expansion has shown modest but measurable airway improvements on three-dimensional evaluation.[14] Despite these advances, long-term functional outcomes such as sleep parameters and airflow efficiency remain under-reported.

3. Conclusion

Respiratory orthodontics has evolved from a niche adjunct to a multidisciplinary field with significant implications for craniofacial development, airway function, and overall health. Advances in three-dimensional imaging and computational modeling have improved diagnostic accuracy, while interventions such as rapid maxillary expansion, mandibular advancement, and myofunctional therapy have demonstrated measurable effects on airway morphology and, in some cases, respiratory outcomes.[29]

However, persistent gaps remain in the form of non-standardized diagnostic thresholds, limited long-term follow-up, and insufficient integration with gold-standard sleep medicine assessments.[8,10] The current evidence base is dominated by small-scale studies, heterogeneous methodologies, and morphologic rather than functional endpoints.

Future progress will depend on large, multicenter randomized controlled trials incorporating standardized imaging, objective airflow measurements, and polysomnography. Equally important is the development of validated, age-specific airway assessment protocols and collaborative treatment models involving orthodontists, otolaryngologists, and sleep physicians. By bridging these gaps, respiratory orthodontics can solidify its role as a cornerstone of holistic, patient-centered care. Interdisciplinary treatment showing orthodontics, ENT, and sleep medicine overlap in airway management are presented in **Table 2**.

4. Conflict of Interest

The author declares no conflict of interest.

5. Source of Funding

No external funding was received.

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