

Craniofacial and Malocclusion Characteristics Associated with Polysomnography-Confirmed Obstructive Sleep Apnea in Pediatric and Adolescent Patients: A Systematic Review

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ABSTRACT

Obstructive Sleep Apnea (OSA) is a sleep-related breathing disorder estimated to affect 1–5% of children worldwide, with untreated cases associated with neurocognitive impairment, behavioral disorders, and long-term cardiovascular risks. Although adenotonsillar hypertrophy is the most common soft tissue etiology, dentofacial and craniofacial structures, particularly Class II malocclusion, transverse maxillary narrowing, and hyperdivergent vertical facial patterns, can independently narrow the pharyngeal airway. Whether this malocclusion is a predisposing factor for OSA or develops secondary to chronic mouth breathing is still debated. This review was conducted according to PRISMA 2020 guidelines. Eligible studies enrolled non-syndromic children under 16 years of age with PSG-confirmed OSA and reported malocclusion parameters via clinical/dental model examination or cephalometric analysis. Methodological quality was assessed using the Joanna Briggs Institute (JBI) critical appraisal tool. Of the 386 records identified, seven studies (4,717 children; six countries; 2023–2026) met all eligibility criteria. Class II sagittal skeletal discrepancy was reported in six of seven studies and was significantly associated with the presence or severity of OSA in the majority of studies. Class II sagittal skeletal discrepancy and a hyperdivergent vertical facial pattern were the malocclusion phenotypes most consistently associated with PSG-confirmed pediatric OSA, supporting their use as clinical indicators for sleep referral during routine orthodontic examinations.

Keywords: obstructive sleep apnea; malocclusion; polysomnography; pediatrics; craniofacial morphology

INTRODUCTION

Obstructive Sleep Apnea (OSA) is a respiratory disorder occurring during sleep, characterized by recurrent episodes of partial or complete airway obstruction, resulting in reduced airflow (hypopnea) or a total cessation of airflow (apnea) despite ongoing respiratory effort, which leads to oxygen desaturation and arousal. This condition causes sleep fragmentation, intermittent hypoxia, and hypercapnia, resulting in increased sympathetic nervous system activity [1]. Globally, the prevalence of OSA in children is estimated to be between 1% and 5% of the pediatric population, making it one of the most common sleep-related breathing disorders of childhood. If left untreated, it can lead to severe neurocognitive impairment, behavioral disturbances, and long-term cardiovascular risks. This underscores

the clinical importance of early recognition, timely referral, and effective management [2].

Although adenotonsillar hypertrophy is considered the most common soft-tissue etiology of pediatric OSA, dentofacial and craniofacial anatomical structures also play a crucial role in upper airway patency. Specific dental and skeletal phenotypes, particularly Class II Angle malocclusion, transverse maxillary constriction, and hyperdivergent vertical facial patterns, directly limit the physical space available for the tongue and soft tissues [3]. The space limitation promotes posterior glossoptosis and narrows the retroglossal and retropalatal pharyngeal spaces, exponentially increasing airway resistance during neuromuscular relaxation during sleep [4].

During the mixed dentition phase, abnormal airway resistance induces compensatory mouth breathing and alters tongue position and neuromuscular function, subsequently directing jaw growth vertically and posteriorly. This illustrates a bidirectional anatomical relationship in which airway compromise and craniofacial development may each influence the other [5].

The current body of evidence on the malocclusion-OA relationship remains heterogeneous. Malocclusion itself is highly prevalent in the general pediatric population, with the World Health Organization estimating a prevalence ranging from 20% to 100% across the global population, and normative studies further indicate that the distribution of malocclusion classes and facial proportions differs across ethnic and regional populations, which may partly explain the inconsistent transverse and isolated occlusal findings reported across studies [6]. Whether malocclusion acts primarily as a predisposing factor underlying OA or develops secondarily as a consequence of chronic mouth breathing also remains a subject of ongoing clinical debate [3,4]. Age-related developmental status appears to modulate these associations: children under 16 years, marked by active pubertal skeletal growth spurts and high craniofacial neuroplasticity, represent a sensitive window in which malocclusion and airway anatomy interact most closely and during which interceptive treatment may still alter growth trajectories [5,6]. However, much of the existing literature does not account for this developmental sensitivity, which likely contributes further to the inconsistent findings observed across the wider age spectrum.

Overnight polysomnography (PSG) is the absolute gold standard for diagnosing pediatric OA, providing definitive quantitative diagnostic metrics such as the Apnea-Hypopnea Index (AHI) and Oxygen Desaturation Index (ODI) [7]. Despite this, many previous reviews have aggregated broad age demographics, ranging from toddlers to adults, thereby conflating the early regression of adenotonsillar tissue with delayed skeletal maturation and obscuring age-specific malocclusion phenotypes. Determining the specific types and combinations of malocclusion most strongly correlated with upper airway obstruction is crucial for identifying children at high risk for sleep-disordered breathing during routine dental examinations, yet this question has not been rigorously addressed within a homogeneous, PSG-confirmed pediatric population. Consequently, there remains an objective and unresolved knowledge gap: the need to synthesize research that evaluates PSG-confirmed OA specifically within children aged under 16 years, using consistent diagnostic and malocclusion-assessment criteria. Therefore, the aim of this systematic review is to analyze and synthesize scientific evidence regarding the types of malocclusions and dentofacial characteristics directly associated with OA events confirmed via polysomnography (PSG) in children under 16 years of age.

METHODS

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines [8]. A research protocol was established a priori to ensure a transparent, systematic, and reproducible process for literature searching study selection, data extraction, quality assessment, and evidence synthesis. Ethical approval was not required as all information contained in the manuscript was derived from previously published literature.

Study selection criteria were structured using the population, exposure, and outcome framework. The population consisted of non-syndromic children aged 16 years or younger. The exposure was Obstructive Sleep Apnea (OSA), strictly diagnosed via overnight polysomnography (PSG). Outcomes included objective assessments of dental malocclusion parameters, specifically sagittal discrepancies (Angle Class II/III, overjet), vertical discrepancies (anterior open bite, deep bite), and transverse discrepancies (maxillary constriction, posterior crossbite), evaluated through clinical examination, dental models, or cephalometric analysis.

Inclusion criteria regarding study design encompassed observational studies in humans (cross-sectional, case-control, cohort, or longitudinal studies). Publication characteristics included full-text original research published in English between January 2021 and August 2026. Exclusion criteria covered children with craniofacial anomalies, cleft lip/palate, genetic syndromes (e.g., Down syndrome), neuromuscular disorders, or a history of orthodontic interventions, as well as non-original publications, including narrative reviews, systematic review protocols, case reports, editorials, letters to the editor, book chapters, conference abstracts, and animal or in vitro models.

A comprehensive and independent literature search was conducted across major electronic databases such as PubMed/MEDLINE, PubMed Central, and Google Scholar to identify articles published between 2021 and 2026. The search strategy combined relevant Medical Subject Headings (MeSH) terms and free-text keywords linked using Boolean operators (AND, OR). Search terms were grouped into three core conceptual blocks: Population ("Child", "Pediatric", "Pediatric", and "School-Age Child"); Exposure ("Obstructive Sleep Apnea", "OSA", "Obstructive Sleep Apnoea", "Sleep-Disordered Breathing", "SDB", "Polysomnography", and "PSG"); and Outcome ("Malocclusion", "Dental Occlusion", "Orthodontic Characteristics", "Crossbite", "Open Bite", "Overjet", "Maxillary Constriction", and "Overbite").

The study selection process is carried out through four main stages in accordance with the PRISMA Flow Diagram. In the identification stage, all initial search results from various databases are entered into reference management software. Duplicate items that are identified automatically are immediately excluded and checked again manually.

At the screening stage, the authors screened the titles and abstracts of all remaining manuscripts to assess initial suitability for the research topic. At this stage, all manuscripts that do not match the topic are immediately removed. Next, at the eligibility stage, articles that pass abstract screening are downloaded in full-text form, and the entire full-text content is reviewed based on the research inclusion and exclusion criteria. Each study excluded at this stage was recorded along with specific reasons. In the final stage, namely determining inclusion, studies that met all eligibility criteria were included in the final qualitative synthesis.

A total of 386 articles were obtained from searches in the database used (Table 1); 26 records were excluded before the screening stage due to duplicate manuscripts. 360 records entered the screening stage, with 204 records excluded due to non-original publication. 156 articles were sought for retrieval; 50 studies were excluded because they did not

match the type of study design. 106 reports were assessed for eligibility; 86 reports were excluded because they did not meet the study inclusion criteria. 20 studies were included in the review. The methodological quality and risk of bias of each included study were assessed using critical instruments, namely the Joanna Briggs Institute (JBI) for cross-sectional and case-control studies [9]. The assessment domains included clarity of sample inclusion criteria, diagnostic validity of overnight PSG quantification (AHI/ODI cut-off reliability), methodological accuracy and reliability of intra/inter-examiner malocclusion characterization, control of confounding variables (e.g., body mass index [BMI], tonsil level), as well as precision of statistical analysis. Studies were categorized as having low, moderate, or high risk of bias. The results of the risk of bias assessment were used to interpret the strength of the synthesized scientific evidence.

TABLE 1: Details of the search strategy and results based on electronic databases.

Database	Search	Items Found
Pubmed/MEDLINE	((("Child" OR "Pediatric" OR "Paediatric" OR "School-Age Child") AND ("Obstructive Sleep Apnea" OR "OSA" OR "Obstructive Sleep Apnea" OR "Sleep-Disordered Breathing" OR "SDB" OR "Polysomnography" OR "PSG")) AND ("Malocclusion" OR "Dental Occlusion" OR "Orthodontic Characteristics" OR "Crossbite" OR "Open Bite" OR "Overjet" OR "Maxillary Constriction" OR "Overbite"))	71
PubMed Central	"Child" OR "Pediatric" OR "School-Age Child" AND "Obstructive Sleep Apnea" OR "OSA" OR "Obstructive Sleep Apnoea" OR "Polysomnography" OR "PSG" AND "Malocclusion" OR "Dental Occlusion" OR "Orthodontic Characteristics"	163
Google Scholar	"Child" OR "Pediatric" AND "Obstructive Sleep Apnea" OR "OSA" OR "Polysomnography" OR "PSG" AND "Malocclusion" OR "Orthodontic Characteristics"	261

RESULTS

Study Selection

The database search retrieved a total of 386 records, consisting of 71 from PubMed/MEDLINE, 163 from PubMed Central, and 152 from Google Scholar. After removing 26 duplicate manuscripts, 360 manuscripts continued to the title and abstract screening stage. During the screening process, 206 manuscripts were excluded because they were not original research articles, including 135 review articles, 18 protocols, and 53 case reports. Of the remaining 154 manuscripts that were attempted to be obtained, 50 were excluded because they used an interventional or therapeutic study design, rather than an observational design.

The remaining 104 full-text manuscripts were assessed in detail to determine eligibility; of these, 97 manuscripts were excluded for the following reasons: no confirmation of the diagnosis of OSA based on polysomnography (n = 45), available malocclusion data did not meet the predefined inclusion criteria (n = 21), and the presence of a craniofacial syndrome or congenital abnormality (n = 30). Following this four-stage selection process, seven manuscripts met all eligibility criteria and were included in the qualitative synthesis of this systematic review (Figure 1).

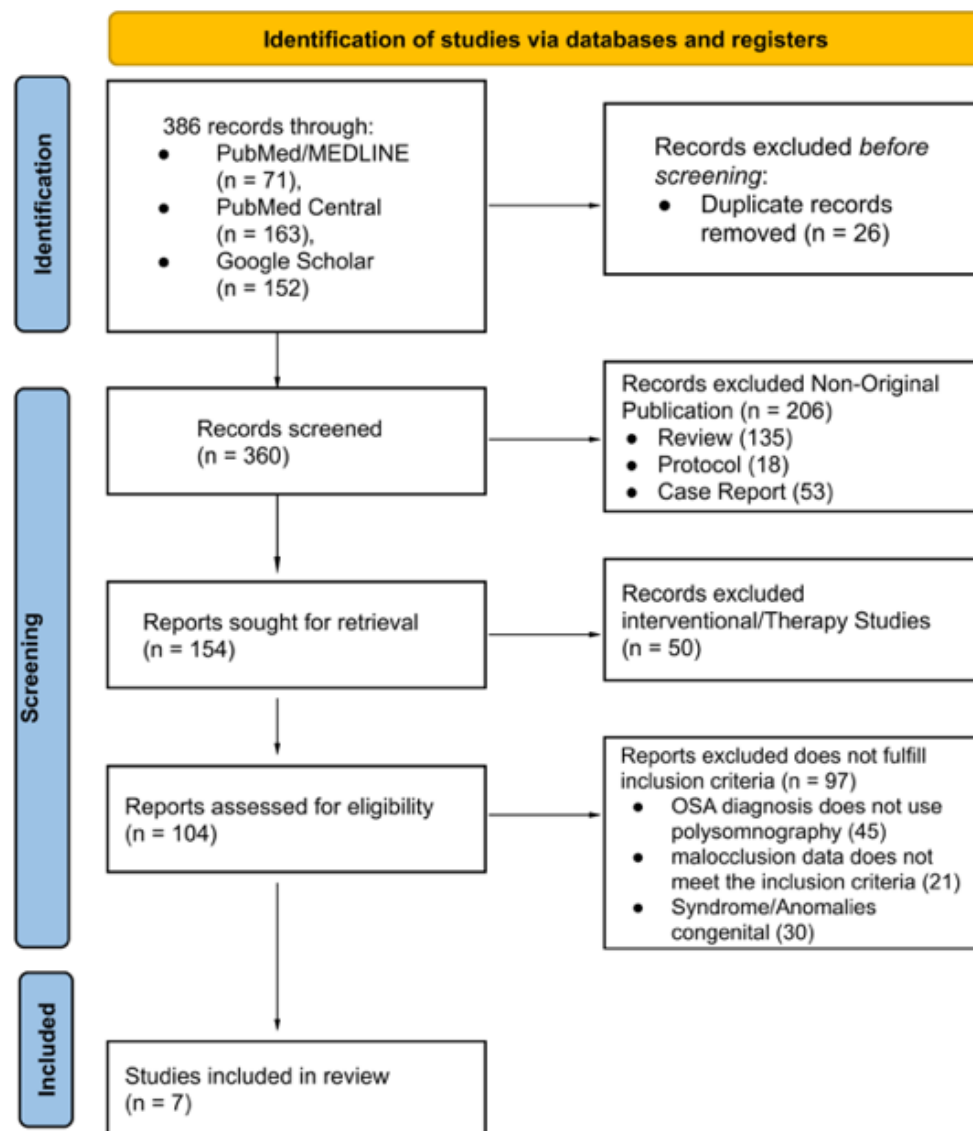


FIGURE 1: Flowchart of the process of screening and selection of articles.

Study Characteristics

The seven studies used, published between 2023 and 2026, included a total of 4,717 children and were conducted in six countries: Australia, China (two studies), Canada, the United States, Turkey, and Armenia. The study designs used included four cross-sectional studies, one retrospective cross-sectional study, one other retrospective study, and one cohort study. Collectively, these studies involved combined samples ranging from 39 to 3,671 children per study, with sample ages ranging from 4 to 16 years, although most of the samples were concentrated in the late mixed dentition range of 7–13 years.

All seven studies confirmed the diagnosis of OSA using overnight or in-laboratory polysomnography, although the apnea-hypopnea index (AHI) threshold used to define OSA varied slightly between studies, ranging from AHI > 1 event/hour (used in five studies) to AHI > 2 events/hour, with some studies further classifying severity into mild, moderate, and severe categories. Malocclusion results were assessed using a combination of clinical/dental model examination (angle classification, overjet, overbite, crossbite, open bite) and lateral cephalometric analysis (ANB, SNA, SNB, mandibular plane angle, facial pattern). A summary of the characteristics of the included studies is presented in Table 2.

TABLE 2: Characteristics of included studies.

Author, Year	Country	Study Design, Journal Index	Sample Size / Age	OSA Diagnostic Criteria	Craniofacial and Malocclusion Characteristics Related to OSA	Risk of Bias (JBI)
Mahony et al., 2025/2026	Australia	Retrospective study (Q1)	n = 3671; 7–9 years	AHI = 0 (none) to ≥ 11 (severe), PSG-based	Class II was the predominant sagittal pattern overall (74.7%). Among children with severe OSA (AHI ≥ 11), 53.6% presented with Class II and 46.4% with bimaxillary retrusion; 87.3% exhibited a long/hyperdivergent facial pattern. Sagittal malocclusion distribution differed significantly across AHI severity groups ($p < 0.001$).	Moderate – large sample (n=3671) and PSG-based severity strata are strengths, but the retrospective design and lack of reported BMI / adenotonsillar cofounder control limit certainty.
Liu et al., 2026	China	Cross-sectional study (Q2)	n = 228; 4–16 years	AHI > 1 event/h	Mean ANB was significantly larger in the OSA group ($5.8^\circ \pm 1.9^\circ$) than in non-OSA children ($3.9^\circ \pm 1.4^\circ$, $p < 0.01$), with increased SNA and decreased SNB. Malocclusion was present in 55.9% of the cohort, and ANB correlated positively with AHI ($r = 0.48$, $p < 0.001$).	Moderate – clear PSG diagnostic threshold and OSA vs. non-OSA comparison, but confounders (BMI, tonsil grade) not reported.
Huynh et al., 2025	Canada	Cross-sectional study (Q1)	n = 315	AHI > 2/h (OSA); moderate–severe: AHI > 5/h	Despite a marked AHI difference between groups (OSA 9.51 ± 10.94 vs. non-OSA 0.84 ± 0.50), no statistically significant differences were found in any intraoral or facial characteristic between OSA and non-OSA children.	Moderate – adequate sample size and clinical/cephalometric assessment, but no cofounder adjustment reported and null findings may partly reflect limited power.
Kitagaito et al., 2023	USA	Cross-sectional study	n = 95; 9–13 years	oAHI > 1 to ≤ 5 (mild); > 5 (moderate–severe)	Distribution was Class I 47.4%, Class II 44.2%, Class III 8.4%; increased overjet 69.5%, deep bite 56.8%, open bite 11.6%, crossbite 20.0%. No significant differences across OSA severity groups were found for Angle classification, crossbite, overjet, or overbite, but facial profile differed significantly in moderate–severe OSA ($p = 0.02$).	Moderate – moderate sample size and multiple malocclusion parameters assessed, but confounders not controlled and non-OSA comparison group relatively small.
Deng & Song, 2026	China	Retrospective cross-sectional (Q1)	n = 299 (Class II n = 150, Class III n = 149); 10–12 years	AHI > 1 event/h	Class II patients had a significantly larger ANB ($5.6^\circ \pm 1.9^\circ$) than Class III patients ($-2.8^\circ \pm 2.6^\circ$, $p < 0.001$). The Class II group showed a high-angle/long-face morphology with clockwise growth rotation, whereas Class III showed a distinct mandibular growth pattern.	Moderate – large combined sample and clear cephalometric criteria but compares Class II vs. Class III subgroups rather than an OSA vs. non-OSA contrast, and cofounders not reported.
Gorucu-Coksuner et al., 2025/2026	Türkiye	Cross-sectional study (Q1)	n = 70 (35 OSA + 35 control); 9–16 years	AHI > 1/h	Class II malocclusion was more prevalent in the OSA group (65.7%) than controls (60.0%), and Class I was more common among controls. The association between group (OSA vs. control) and malocclusion class was statistically significant ($p = 0.031$).	Moderate – matched case-control design (35 OSA + 35 controls) is a strength, but small overall sample limits precision and cofounders not reported.
Manrikyan et al., 2024	Armenia	Cohort study (Q2)	n = 39; 7–13 years	Mild: AHI 1–4/h; Moderate–severe: AHI > 4/h	Mean AHI was 4.6/h (ODI 3.9/h). Children showed ANB $9.2^\circ \pm 1.7^\circ$, SNB $74.07^\circ \pm 2.07^\circ$, and mandibular plane angle $58.7^\circ \pm 5.8^\circ$, indicating mandibular retrusion/posterior mandibular positioning, increased mandibular plane angle, and skeletal Class II characteristics.	High – cohort design is a strength, but very small sample (n=39), no explicit non-OSA comparison group, and cofounders not reported.

Synthesis of Results

• Sagittal malocclusion (Class II) and bony discrepancy

Six of the seven included studies reported an association between Class II sagittal malocclusion or Class II skeletal pattern and the presence or severity of OSA confirmed by PSG. Studies by Mahony reported that Class II malocclusion was the predominant facial pattern across the group (74.7%), and among children with severe OSA ($AHI \geq 11$), 53.6% had Class II malocclusion and 46.4% had bimaxillary retrusion, with sagittal malocclusion significantly different between AHI severity groups ($p < 0.001$) [10]. Likewise, studies by Gorucu found that Class II malocclusions were more common in the OSA group than controls (65.7% vs. 60.0%), with a significant association between group allocation and type of malocclusion ($p = 0.031$) [11]. Studies by Liu demonstrated a significantly greater ANB angle in the OSA group compared with the non-OSA group ($5.8^\circ \pm 1.9^\circ$ vs. $3.9^\circ \pm 1.4^\circ$, $p < 0.01$), along with a positive correlation between ANB and AHI ($r = 0.48$, $p < 0.001$), showing that a greater sagittal maxillomandibular discrepancy was associated with higher OSA severity [12].

Studies by Manrikyan reported a marked increase in ANB angle ($9.2^\circ \pm 1.7^\circ$) and decrease in SNB angle ($74.07^\circ \pm 2.07^\circ$) in children with OSA, consistent with mandibular retrusion and posterior positioning of the mandible [3]. Studies by Deng and Song, comparing children with Class II versus Class III malocclusion who also suffered from OSAHS, found significantly greater ANB angles in the Class II group ($5.6^\circ \pm 1.9^\circ$) than in the Class III group ($-2.8^\circ \pm 2.6^\circ$, $p < 0.001$), with the Class II group also exhibiting high angle/long face morphology and clockwise rotation of mandibular growth [13]. In contrast, Studies by Kitagaito obtained an Angle classification distribution (Class I 47.4%, Class II 44.2%, Class III 8.4%) which did not differ significantly between OSA severity groups, although the facial profile itself was significantly different in moderate-severe OSA ($p = 0.02$) [4].

• Vertical face pattern

A hyperdivergent vertical growth pattern or long face is consistently identified as a more severe feature of OSA. Studies by Mahogany reported that 87.3% of children with severe OSA showed a long/hyperdivergent facial pattern, along with an increase in lower anterior facial height. These findings were corroborated by study by Deng and Song, who observed facial height/length angle skeletal morphology specifically in the Class II subgroup of children with OSAHS, and studies by Manrikyan, who reported increased mandibular plane angles ($58.7^\circ \pm 5.8^\circ$) in children with OSA [10,13,3].

• Transverse and other occlusal parameters (crossbite, overjet, overbite, open bite)

Findings regarding transverse occlusal and other clinical parameters were more heterogeneous and, in some studies, did not reach statistical significance. Studies by Kitagaito reported a high prevalence of

increased overjet (69.5%), deep bite (56.8%), posterior crossbite (20.0%), and open bite (11.6%) among children appointed for sleep studies, but none of these parameters differed significantly between OSA severity strata [4]. Studies by Huynh also did not find any statistically significant differences in open bite, crossbite/maxillary constriction, overjet, overbite, dental crowding, or mandibular retrognathia between children with and without OSA, although the average AHI was much higher in the OSA group (9.51 ± 10.94) compared to the non-OSA group (0.84 ± 0.50) [14]. Studies by Liu in contrast, reported malocclusion in 55.9% of their entire cohort, with skeletal class II discrepancies specifically correlating with AHI, not transverse parameters [12].

• Overall pattern across studies

Overall, evidence synthesized from the seven included studies most consistently suggests an association between PSG-confirmed OSA and (1) Class II sagittal skeletal discrepancy, characterized by increased ANB angle and mandibular retrognathia/retrusion, and (2) hyperdivergent long face vertical growth pattern with increased mandibular plane angle, especially among children with more severe OSA. The association between OSA and transverse discrepancies (posterior crossbite, maxillary narrowing) or isolated occlusal parameters (overjet, overbite, open bite, dental crowding) is less consistent, with two studies, which studies by Huynh and studies by Kitagaito, reporting no statistically significant differences in these specific parameters between OSA and non-OSA groups or between severity strata [14, 4].

DISCUSSION

Evidence Summary

This systematic review pooled data from seven studies confirmed by polysomnography (PSG) that included 4,717 children and adolescents in the mixed dentition phase to determine which types of malocclusions are most consistently associated with pediatric obstructive sleep apnea (OSA). The synthesized evidence converges on two main phenotypes: (1) Class II sagittal skeletal discrepancy, characterized by increased ANB angle and mandibular retrognathia/retrusion, reported in six of the seven included studies [10,12,14,13,11,3], and (2) a hyperdivergent vertical growth pattern of the long face with increased mandibular plane angles, especially seen in children with more severe OSA [10,13,3]. In contrast, the association between OSA and transverse discrepancies (posterior crossbite, maxillary narrowing) or isolated clinical occlusal parameters (overjet, overbite, open bite, crowding) was less consistent, with two of seven studies ([14,4]) reporting no statistically significant differences in these specific parameters between OSA and non-OSA groups.

Biological Plausibility of Sagittal and Vertical Findings

The predominance of a Class II skeletal pattern and hyperdivergent facial morphology in children with more severe OSA is consistent with a pathophysiology

model linking craniofacial skeletal position to pharyngeal airway volume. Mandibular retrognathia shifts the base of the tongue posteriorly, narrowing the retroglossal airway, while rotation of mandibular growth downward and backward (clockwise) elongates the lower face and reduces the oropharyngeal space available during neuromuscular relaxation during sleep. These mechanisms are broadly consistent with descriptions in the broader OSA literature: a narrative review of OSA pathophysiology and risk factors also lists mandibular deficiency, bimaxillary retrusion, increased lower anterior facial height, dolichofacial patterns, and steep mandibular plane angles among the craniofacial morphologies that predispose to airway obstruction, and separately notes that Class II malocclusion has been reported as a dental feature associated with OSA [1]. Although the review was intended for a broader population, particularly in the adult population, its craniofacial risk factor profile closely matches the sagittal and vertical phenotypes identified in PSG-confirmed pediatric research syntheses, suggesting the presence of shared skeletal mechanisms across the lifespan and not a phenomenon unique to the mixed dentition that population-specific anatomical variations contribute to this heterogeneity; for example, normative studies of facial proportions have shown that the distribution of angular malocclusion classes and the ratio of upper to lower facial height differ significantly between ethnic populations, with Class I malocclusions predominating in some groups and lower facial height consistently exceeding upper facial height in all malocclusion classes [6]. Because the seven studies were conducted in six countries with different population backgrounds (Australia, China, Canada, the United States, Turkey, and Armenia), population-level differences in baseline craniofacial proportions may attenuate or obscure transverse relationships that may be more pronounced in a more homogeneous population.

Although cross-sectional associations are inconsistent, intervention evidence provides indirect support for the biological relevance of the transverse dimension in pediatric OSA. In a cohort of children aged 7–11 years with OSA-related symptoms, rapid maxillary expansion (RME) resulted in a statistically significant reduction in apnea-hypopnea index and improvement in quality of life scores in the majority of patients after treatment [7]. The fact that correction of maxillary narrowing improves respiratory outcomes, even though transverse differences do not consistently differentiate OSA from non-OSA groups in cross-sectional comparisons, illustrates a broader point relevant to this review: cross-sectional malocclusion-OSA associations may underestimate the causal contribution of a particular phenotype, especially when the comparison group is heterogeneous or when differences are present but subclinical at the time of assessment.

Methodological and Developmental Considerations for the Age Window Examined

The decision to focus this review on children in the mixed dentition phase is supported by evidence that

dental maturation is closely and predictably related to chronological age during this period; Tooth eruption status has been shown to correlate strongly with chronological age in children aged six to thirteen years ($r = 0.72$, $R^2 = 0.62$), making this developmental window relatively homogeneous and well-suited to cross-study comparison [15]. This supports the review's rationale that limiting inclusion to the mixed dentition period will reduce the confounding variable of very different dental and skeletal maturity that would occur across a wider age range from toddlers to older adolescents.

At the same time, the AHI threshold used to diagnose OSA varied across the included studies (from >1 event/hour to >2 events/hour, with different severity stratification), which is a recognized source of heterogeneity in the broader OSA literature. Diagnostic criteria for OSA are not completely standardized even outside the field of pediatrics, and differences between the apnea-hypopnea index and related indices such as the respiratory distress index can result in unequal severity classifications, depending on the metrics and thresholds applied in the study [1]. This variability likely contributes to some of the inconsistencies observed in the less robust findings in this review (e.g., transverse and isolated occlusal parameters) and should be considered when explaining effect size comparisons between studies.

Strengths and Limitations

• Strengths

The main strength of this review lies in the strict inclusion criteria of OSA diagnoses confirmed by PSG, which excludes diagnostic imprecision associated with questionnaire-based or screening case ascertainment and thereby increases confidence in the identified malocclusion-OSA association. Limiting the population to non-syndromic children under 16 years old would reduce confounding from craniofacial anomalies and wide variability in skeletal maturity seen across a broader range of child ages. In addition, the methodological quality of every included study was independently appraised using the Joanna Briggs Institute (JBI) critical appraisal tool, allowing the strength of the synthesized evidence to be weighed against each study's risk of bias (Table 2).

• Limitations

The limitation of this systematic review is only seven studies met full eligibility criteria, and most used cross-sectional designs, precluding causal conclusions about whether OSA predisposes to or develops as a secondary consequence of chronic mouth breathing. Second, the sample sizes varied widely between studies (from 39 to 3,671 participants), and smaller studies may have been less able to detect associations with less common malocclusion subtypes. Third, methodological quality was assessed using the Joanna Briggs Institute (JBI) critical appraisal tool; other validated instruments for observational studies, such as the Newcastle–Ottawa Scale, which is also recommended by the Cochrane Collaboration for assessing study quality and risk of bias in non-randomized studies,

may result in different quality assessments, and the two tools have not been shown to be completely interchangeable [9]. Fourth, confounding variables known to influence craniofacial morphology and severity of OSA, such as body mass index and degree of tonsillar/adenoid hypertrophy, were not uniformly reported or statistically controlled in the studies used, which may partially explain the heterogeneity observed in transverse and isolated occlusal findings.

Implications for Clinical Practice and Future Research

Overall, these findings suggest that pediatric dentists and orthodontists evaluating children in the mixed dentition phase should consider Class II sagittal skeletal discrepancy and a hyperdivergent vertical facial pattern as clinically meaningful indicators that warrant referral for polysomnography evaluation when signs or symptoms of sleep-disordered breathing are present. Given the interventional evidence that correction of maxillary transverse deficiency can improve respiratory outcomes even when cross-sectional relationships are inconsistent, transverse assessment should not be considered clinically irrelevant based on the current synthesis alone. Future primary studies would benefit from prospective, longitudinal designs that can clarify the temporal and bidirectional relationship between malocclusion and OSA, from the use of standardized AHI thresholds and PSG-based severity classifications across study populations, and from consistent reporting and adjustment for BMI and degree of adenotonsillar hypertrophy, so that the independent contribution of dentofacial morphology to pediatric OSA risk can be measured more precisely.

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