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Systematic Review

Transverse Dentoalveolar Changes with Clear Aligners in Mixed Dentition: A Systematic Review with Exploratory Meta-Analysis

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Abstract

Background: Transverse maxillary discrepancies during mixed dentition can negatively affect occlusal development and facial harmony. Clear aligners have been increasingly proposed as an interceptive alternative to traditional expansion approaches, but the extent and nature of the transverse dentoalveolar changes associated with their use in growing patients remain incompletely defined. While previous reviews have qualitatively explored this topic, no prior meta-analysis has been conducted to provide a quantitative synthesis of these changes in mixed dentition. Methods: A comprehensive electronic search was conducted for English-language studies published from January 2019 to April 2026 using the PubMed, Ovid MEDLINE, Web of Science, Embase, and Cochrane Library databases. The final database search was performed on 30 April 2026. Randomized controlled trials, prospective studies, and retrospective studies evaluating transverse maxillary changes in growing patients treated with clear aligners were included. Case reports, reviews, and studies involving syndromic patients or surgical interventions were excluded. Two reviewers independently performed study selection, data extraction, and risk-of-bias assessment. Furthermore, a meta-analysis of quantitative outcomes with sufficient comparability across studies was performed. Effect sizes were reported as standardized mean differences (SMDs). Results: From 40 screened records, a total of 7 studies were included in this review. The meta-analysis revealed a reasonably consistent trend toward increased transverse dimensions. The pooled SMDs were 0.685 (distal intermolar), 1.141 (mesial intermolar), 0.828 (transpalatal), 2.052 (intercanine transpalatal), and 1.541 (intercanine width). However, the magnitude of the effect remains uncertain because of the small number of included studies, methodological variability, heterogeneous outcome definitions, limited long-term follow-up, and substantial statistical heterogeneity observed for selected outcomes. Conclusions: The current evidence base reveals a reasonably consistent direction toward favorable transverse dentoalveolar changes with clear aligner therapy. However, the exact magnitude of the benefit remains uncertain due to methodological heterogeneity and the lack of robust long-term data. Due to the qualitative limitations of the included studies, the meta-analysis was intended to provide exploratory insights rather than definitive conclusions. Further high-quality studies with 3D imaging, standardized 3D outcomes, and long-term follow-up are needed to corroborate these results and guide clinical protocols.

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1. Introduction

Transverse maxillary discrepancies are a common dentoskeletal condition in pediatric patients. Maxillary constriction may contribute to a range of clinical issues, including occlusal imbalance, esthetic concerns, and functional disturbances such as reduced pharyngeal airway dimensions, increased nasal resistance, altered tongue posture, and mouth breathing. In most cases, transverse maxillary discrepancies require orthopedic and/or orthodontic tooth movements [1].

The diagnosis of transverse maxillary discrepancy should include assessment of the transpalatal width, defined as the distance between the closest points of the maxillary first molars. In general, a maxillary arch with a transpalatal width of 36–39 mm is considered adequate to accommodate an average-sized dentition without crowding or spacing. Conversely, when the intermolar width is below 31 mm, dental crowding may occur, and orthopedic or surgically assisted expansion should be evaluated [2].

A posterior crossbite is a common clinical manifestation of transverse discrepancy and may involve skeletal, dentoalveolar, or combined components [3,4].

Skeletal expansion primarily aims to increase the transverse dimension of the maxillary basal bone, usually through orthopedic opening of the mid-palatal suture [5]. In contrast, dentoalveolar expansion mainly involves transverse changes at the level of the teeth and supporting alveolar structures, including buccal tipping, bodily translation, and alveolar bone remodeling [6,7]. This distinction is clinically relevant because rapid maxillary expansion (RME) is generally used when a skeletal transverse deficiency is present, whereas clear aligner therapy is expected to mainly produce dentoalveolar transverse changes [8].

RME is a widely used orthopedic and orthodontic procedure for the correction of transverse maxillary deficiency in growing individuals, regardless of the presence or absence of a posterior crossbite [9].

According to Baccetti et al., RME performed before the pubertal growth peak produces more relevant and stable long-term skeletal effects on the maxillary and circummaxillary structures, whereas treatment carried out after this growth period tends to primarily result in dentoalveolar rather than skeletal changes [10].

In recent years, clear aligners have been proposed as an interceptive option for managing selected transverse dentoalveolar discrepancies in growing patients. Unlike orthopedic expansion appliances, aligners are mainly intended to produce dentoalveolar changes, including controlled tipping and bodily movement of posterior teeth, rather than true skeletal widening of the maxillary basal bone. In early treatment, clear aligners may help to increase the maxillary arch width, create space for the alignment of permanent teeth before complete eruption, and manage transverse discrepancies together with the sagittal and vertical components of malocclusion [6].

Compared with conventional dentoalveolar appliances, clear aligner therapy allows for digital planning of transverse movements, although movement predictability may vary according to the teeth involved [6,11,12].

The Invisalign First (Align Technology, Santa Clara, CA, USA) system, introduced in 2018, is a clear aligner treatment designed for children aged approximately 6–10 years with mixed dentition, including patients presenting with crossbite, crowding, or a constricted maxillary arch. Recent evidence suggests that this system may provide several advantages, including greater comfort, reduced pain, improved esthetics, easier maintenance of oral hygiene, minimal impact on speech-related quality of life, and usefulness in patients with enamel defects such as amelogenesis imperfecta or molar-incisor hypomineralization, in whom conventional fixed appliances may be more difficult to manage. It may also reduce the risk of white spot lesions [13–15]. Blevins et al. were the first to describe the effectiveness of the Invisalign First system for maxillary arch expansion, and Levrini et al. subsequently confirmed its ability to increase arch width in patients with mixed dentition [16,17].

When clear aligners are used for transverse correction, the morphology of the arch, the amount and distribution of planned dentoalveolar expansion, and the availability of eruption space should be carefully evaluated during digital treatment planning.

As described by Lione et al., aligner-mediated expansion follows a 'drawbridge' pattern, with progressively smaller transverse changes from the anterior to the posterior segments [6]. These authors reported greater increases at the premolar level than at the molar level, resulting in a change from a V-shaped to a more parabolic arch form. They attributed this pattern to anatomical constraints and emphasized the importance of an appropriate posterior root torque to limit uncontrolled coronal tipping.

Despite the increasing use of clear aligners in early mixed dentition, several aspects remain insufficiently clarified [18,19]. Available studies differ in design, measurement methods, outcome definitions, type of comparator, and follow-up duration [20–23]. In addition, most evidence relies on dental cast or digital model measurements, while standardized three-dimensional assessment of skeletal versus dentoalveolar effects remains limited [8,21,23]. Previous reviews have mainly provided qualitative summaries, and quantitative synthesis of transverse dentoalveolar changes produced by clear aligners in mixed dentition is still scarce [8,19]. Therefore, a systematic review with exploratory meta-analysis may help to clarify the direction and approximate magnitude of these changes, while also identifying the methodological limitations of the current evidence.

The aim of this study was to quantitatively synthesize the currently available evidence on transverse dentoalveolar changes associated with clear aligner therapy in mixed dentition.

2. Materials and Methods

2.1. Literature Search Process

The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO; CRD420251078646), and the review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A systematic electronic search was performed in PubMed, Ovid MEDLINE, Web of Science, Embase, and the Cochrane Library. The search was limited to English-language studies published between January 2019 and April 2026, in order to include evidence related to contemporary clear aligner materials, digital treatment planning protocols, and mixed-dentition treatment systems. The final database search was performed on 30 April 2026. The search strategy was revised and adapted to the syntax of each database. Search strings included combinations of controlled vocabulary terms, when available, and free-text terms related to children, mixed dentition, clear aligners, Invisalign First, orthodontic treatment, maxillary expansion, transverse expansion, dentoalveolar expansion, and arch-width changes. In PubMed and Ovid MEDLINE, Medical Subject Headings (MeSH) terms were used when applicable, including "Child" [MeSH], "Dentition, Mixed" [MeSH], "Orthodontics" [MeSH], "Orthodontic Appliances" [MeSH], "Malocclusion" [MeSH], "Maxilla" [MeSH], "Palatal Expansion Technique" [MeSH], and "Dental Arch" [MeSH], combined with relevant free-text keywords such as "clear aligners", "Invisalign First", "transverse expansion", and "dentoalveolar expansion". The search strategy was independently checked by two reviewers to verify the consistency of the keywords, MeSH terms, Boolean operators, filters, and eligibility limits across databases. The search strategy combined synonyms within each conceptual domain using the Boolean operator OR, and then combined the main domains using AND. The core search structure was as follows: (child* OR pediatric* OR paediatric* OR growing patient*) AND (“mixed dentition” OR “early mixed dentition”) AND (“clear aligner*” OR Invisalign OR “Invisalign First”) AND (“maxillary expansion” OR “transverse expansion” OR “dentoalveolar expansion” OR “arch width” OR “intercanine width” OR “intermolar width”). The complete database-specific search strategies, including controlled vocabulary terms, free-text terms, Boolean operators, searched fields, filters, search dates, and number of records retrieved, are reported in Supplementary Table S1. Study selection and data collection were independently performed by two reviewers (M.Z. and F.C.). Disagreements were resolved by consensus; when consensus could not be reached, a third independent reviewer (O.D.F.), who was not involved in the initial assessment, made the final decision.

2.2. Assessment of Risk of Bias in Included Studies

Risk of bias was assessed independently by two reviewers (M.Z. and F.C.) following Cochrane recommendations: for randomized controlled trials, RoB 2 was used; for non-randomized studies, ROBINS-I was applied. Ratings were assigned for each relevant domain and summarized as low, moderate, serious, critical risk, or no information. Disagreements were resolved through discussion or consultation with a third reviewer. The assessment informed the interpretation of narrative and quantitative findings.

2.3. Publication Bias Assessment

Given the limited number of included studies, assessment of publication bias was of limited interpretability. Funnel plot inspection was therefore performed for descriptive purposes only, and no formal asymmetry test was performed.

2.4. Inclusion Criteria

Eligible studies included randomized controlled trials, prospective studies, and retrospective observational studies published in English from January 2019 to April 2026. The exclusion criteria were as follows: (1) editorials, (2) in vitro studies, (3) animal studies, and (4) studies focusing on adult treatments.

The characteristics outlined according to the Participant, Intervention, Comparison, Outcome, Time (PICOT) framework were as follows:

P (Participants): Pediatric patients with malocclusion during the mixed dentition phase.

I (Intervention): Orthodontic treatment with clear aligner systems used during the mixed dentition phase. All interceptive clear aligner systems were considered eligible.

C (Comparison): No treatment or alternative orthodontic interventions (e.g., traditional appliances or expanders).

O (Outcomes): Transverse dentoalveolar expansion (intercanine/intermolar widths), treatment duration, patient satisfaction, skeletal vs. dental changes, and treatment safety.

T (Time): Clinical assessment time points reported in the included studies, including baseline, post-treatment evaluation and, when available, retention or follow-up assessments.

These eligibility criteria were applied during study selection to ensure consistency with the predefined review question.

2.5. Data Synthesis and Exploratory Quantitative Analysis

Because of the limited number of eligible studies and the expected heterogeneity in study design, outcome definitions, and measurement methods, a quantitative synthesis was undertaken to provide exploratory insights for selected outcomes reported with sufficient comparability across studies. A pairwise random-effects meta-analysis was performed to generate pooled estimates with 95% confidence intervals, using the DerSimonian–Laird estimator. Standardized mean differences (SMDs) were calculated when outcomes were measured using different scales or methods. Statistical heterogeneity was described using the I^2 statistic and Cochran's Q test. Given the small number of studies contributing to several pooled analyses, the quantitative findings should be interpreted cautiously and considered as hypothesis-supporting rather than definitive. All statistical analyses were performed using R software, version 4.4.1 (R Foundation for Statistical Computing, Vienna, Austria; https://www.r-project.org/).

3. Results

The database search identified 40 records. After the removal of 6 duplicates, 34 records were screened. Two of these records were excluded because they were not published in English. A total of 32 reports were assessed for eligibility; of these, 20 were excluded because they did not meet the predefined inclusion criteria, including recruiting from a non-eligible population such as an adult sample, absence of clear aligner treatment, inappropriate study design, or reporting of outcomes not related to transverse dentoalveolar changes. Of the 12 reports considered eligible for final synthesis, 5 were further excluded because the data of interest were not reported or were not extractable for qualitative or quantitative analysis. Therefore, seven studies were finally included in the review (Figure 1).

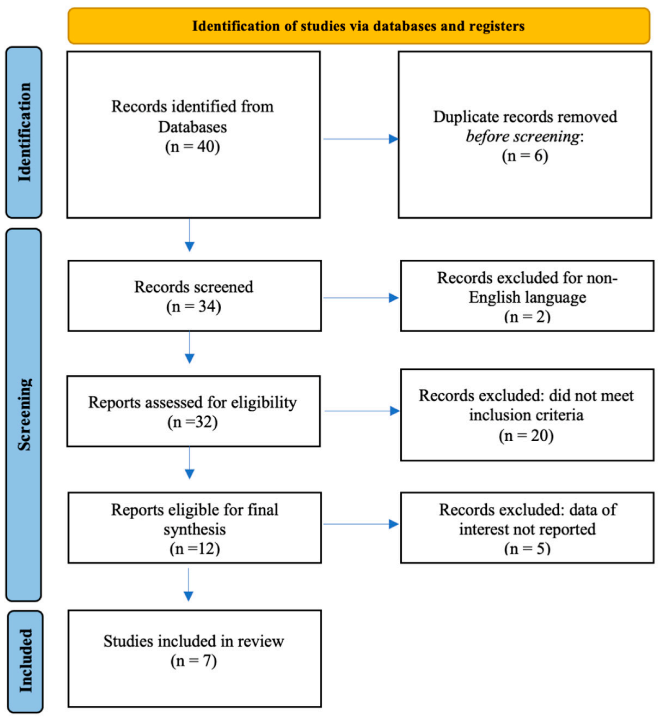

Figure 1. PRISMA flow diagram of study identification, screening, eligibility assessment, and inclusion.

3.1. Characteristics of the Included Studies

The main characteristics of the included studies are summarized in Table 1. Overall, the review included seven studies evaluating transverse dentoalveolar changes associated with clear aligner therapy in mixed dentition. Although all interceptive clear aligner systems were considered eligible according to the predefined inclusion criteria, all studies included in the final synthesis evaluated either Invisalign First or Invisalign First Phase I.

The included studies differed in design, sample size, type of intervention, comparator, measurement method, treatment duration, and reported outcomes. Most studies assessed transverse dental or dentoalveolar changes using dental casts or digital models, while only limited evidence was available regarding three-dimensional skeletal changes or long-term stability. The clinical follow-up duration varied across studies and was mainly limited to post-treatment assessment, with insufficient data on retention or long-term outcomes.

3.2. Risk of Bias in Included Studies

Risk of bias was assessed separately according to study design to avoid inappropriate pooling of denominators across different assessment tools. One randomized controlled trial was evaluated using RoB 2 and was judged as having a low risk of bias. The remaining six non-randomized studies were assessed using ROBINS-I. Among them, two were judged as having a low risk of bias (Lu et al. 2023 [22] and Pamukcu et al. 2024 [23]; 33.3%), whereas four were judged as having a moderate risk of bias (Levrini et al. 2021 [16], Cretella Lombardo et al. 2023 [7], Lione et al. 2023 [6], and Wang et al. 2023 [24]; 66.7%). No non-randomized study was judged as having a serious or critical risk of bias.

Domain-specific ROBINS-I ratings were interpreted only for the six non-randomized studies. Overall, the main methodological concerns were related to confounding, participant selection, missing data, and outcome measurement, whereas protocol deviations and selective reporting were less frequently judged as problematic. Overall, the studies judged as having a low risk of bias consisted of one randomized controlled trial assessed with RoB 2 and two non-randomized studies assessed with ROBINS-I. These studies shared several methodological strengths, including prospective design, standardized intervention protocols, and complete outcome reporting.

3.3. Exploratory Pooled Analysis of Transverse Outcomes

Forest plots displaying study-specific effect sizes and 95% confidence intervals for each pooled outcome are presented in Figures 2–6.

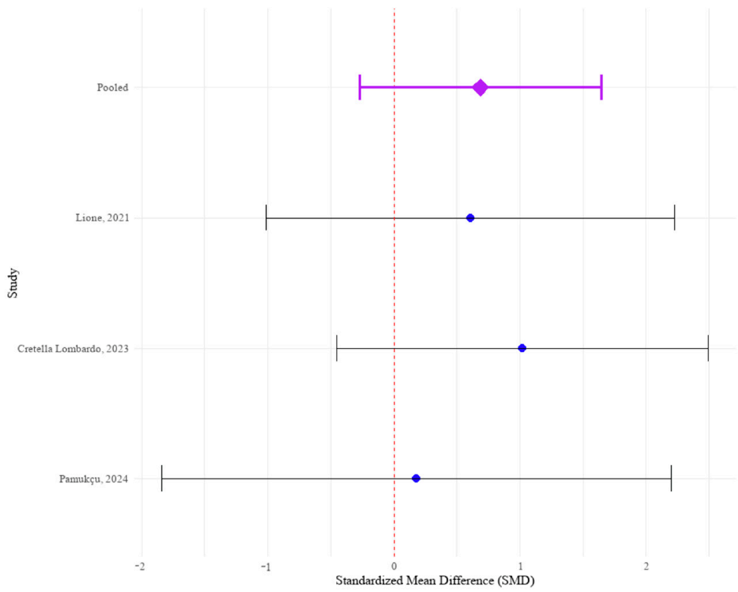

Figure 2. Forest plot of the pairwise meta-analysis for first intermolar distal vestibular width [6,7,23].

Table 1. Main characteristics of the studies included in the systematic review.

Study	Study Design	Sample Size	Sex	Mean Age	Intervention	Comparator	Mean Number of Aligners	Mean Treatment Duration	Main Transverse Outcomes Reported	Main Findings	Risk of Bias
Levrini et al., 2021 [16]	Retrospective study	20 CAT patients	12 F/8 M	8.9 years old, range of 6.9–11.2 years	Invisalign First System; non-extraction treatment	None reported	33	8 months	Intercanine width; intercanine transpalatal width; intermolar width; arch perimeter; arch depth; molar inclination	All measured values showed statistically significant changes from T0 to T1. Intercanine width increased by 2.8 mm at the cusp level and by 2.01 mm at the gingival level. Upper first permanent molars increased by 3.05 mm at the cusp level and by 2.00 mm at the gingival level. Arch perimeter increased by 0.85 mm, while arch depth decreased by 1.24 mm.	Moderate risk
Lione et al., 2023 [6]	Prospective study	23 CAT patients	9 F/14 M	9.4 ± 1.2 years old	Invisalign First System; attachments; eruption compensation	None reported	37 maxillary and 37 mandibular aligners	8.1 months	Intercanine width; first intermolar mesial vestibular width; first intermolar distal vestibular width; first intermolar transpalatal width	The greatest increase in maxillary width was detected at the level of the upper first deciduous molars, followed by second deciduous molars and deciduous canines. Upper first molars showed greater expansion in intermolar mesial width than in distal and transpalatal widths, suggesting rotation around the palatal root.	Moderate risk
Lu et al., 2023 [22]	Prospective cohort study	17 CAT patients; 17 RME patients	NR	NR	Invisalign First System; attachments	Acrylic splint expander/ RME	NR	12 months	Intercanine width; first intermolar mesial vestibular width; first intermolar transpalatal width; arch perimeter; arch depth	Both Invisalign First and RME increased maxillary arch dimensions in mixed dentition. RME produced greater expansion than Invisalign First for several outcomes, including intercanine width, intermolar width, arch perimeter, dentoalveolar width, and molar inclination. No significant difference was reported for arch depth between the treated groups.	Low risk

Table 1. *Cont.*

Study	Study Design	Sample Size	Sex	Mean Age	Intervention	Comparator	Mean Number of Aligners	Mean Treatment Duration	Main Transverse Outcomes Reported	Main Findings	Risk of Bias
Wang et al., 2023 [24]	Pilot study	23 CAT patients	11 M/12 F	8–11 years old	Invisalign First System	Haas-type slow maxillary expansion and untreated controls	28	7 months	Intercanine width; intermolar width; palatal dimensions; molar bucco-lingual inclination	Intercanine width increased by 3.10 mm after Invisalign First, 4.77 mm after slow maxillary expansion, and 0.54 mm in controls. Invisalign First increased the upper arch width relative to controls, but the amount of expansion was lower than that obtained with slow maxillary expansion. Unlike SME, Invisalign First showed no significant effect on palatal dimensions or molar inclination.	Moderate risk
Cretella Lombardo et al., 2023 [7]	Retrospective study	15 CAT patients; 17 RME patients	CAT: 7 M/8 F; RME: 8 M/9 F	CAT: 8.4 ± 1.1 years old; RME: 8.1 ± 0.8 years old	Clear aligners/Invisalign First; attachments	Rapid maxillary expansion	32	8 months	Intercanine width; intercanine transpalatal width; intermolar mesial vestibular width; intermolar distal vestibular width; intermolar transpalatal width; intermolar angle	Clear aligners produced a greater increase in intercanine width, whereas RME widened the palate to a greater extent and was associated with buccal tipping of the first upper molars. The CAT group showed intercanine width increase from 31.6 mm to 34.9 mm and intercanine transpalatal width increase from 25.2 mm to 28.5 mm.	Moderate risk
Bruni et al., 2024 [8]	Randomized controlled trial	19 CAT patients; 20 RME patients	CAT: 5 M/14 F; RME: 12 M/8 F	CAT: 8.48 ± 1.42 years old; RME: 7.83 ± 1.19 years old	Invisalign First Phase I	Tooth-borne rapid maxillary expansion	NR	8 ± 3 months	Intercanine width; intercanine transpalatal width; intermolar width at cusp and gingival levels; palatal volume; palatal surface area	All outcome measures significantly increased from T0 to T1 in both groups. The RME group showed trends toward greater changes for most outcomes, although the only statistically significant intergroup difference was found for intermolar width at the gingival level, suggesting buccal tipping in patients treated with Invisalign First.	Low risk

Table 1. *Cont.*

Study	Study Design	Sample Size	Sex	Mean Age	Intervention	Comparator	Mean Number of Aligners	Mean Treatment Duration	Main Transverse Outcomes Reported	Main Findings	Risk of Bias
Pamukçu et al., 2024 [23]	Comparative study	17 CAT patients; 17 removable expander patients	CAT: 9 F/8 M; RE: 11 F/6 M	CAT: 8.83 ± 1.02 years old; RE: 8.79 ± 0.82 years old	Invisalign First System; attachments; no extraction	Removable acrylic expander	NR	7.66 ± 3.09 months	Intercanine width; intermolar mesial vestibular width; intermolar distal vestibular width; intermolar mesial palatal width; intermolar distal palatal width; arch depth; molar inclination	Both Invisalign First and removable expanders effectively expanded the maxillary intercanine region. Expansion predictability was lower in the molar region than in the canine region for the Invisalign First group. Removable acrylic expanders may be preferred when molar expansion is the main therapeutic objective.	Low risk

Abbreviations: CAT, clear aligner therapy; RME, rapid maxillary expansion; SME, slow maxillary expansion; RE, removable expander; NR, not reported; F, female; M, male.

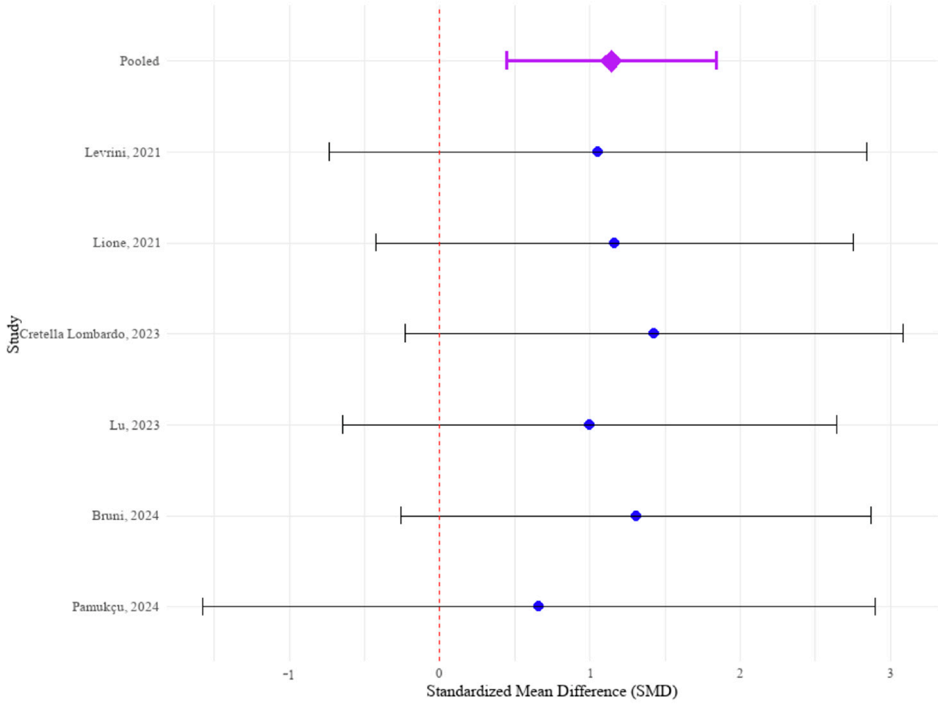

Figure 3. Forest plot of the pairwise meta-analysis for first intermolar mesial vestibular width [6–8,16,22,24].

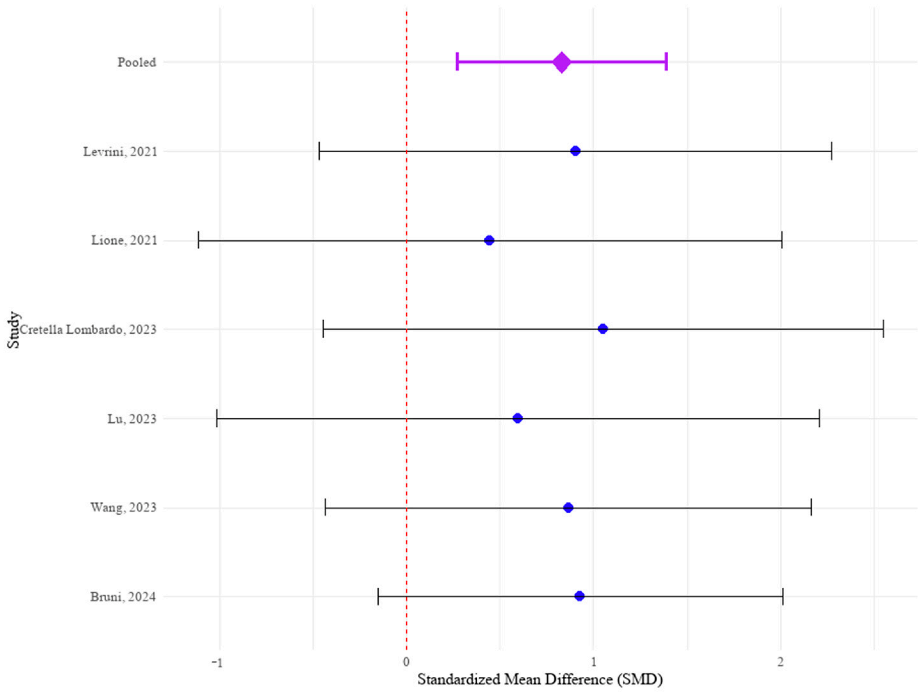

Figure 4. Forest plot of the pairwise meta-analysis for first intermolar transpalatal width [6–8,16,22,24].

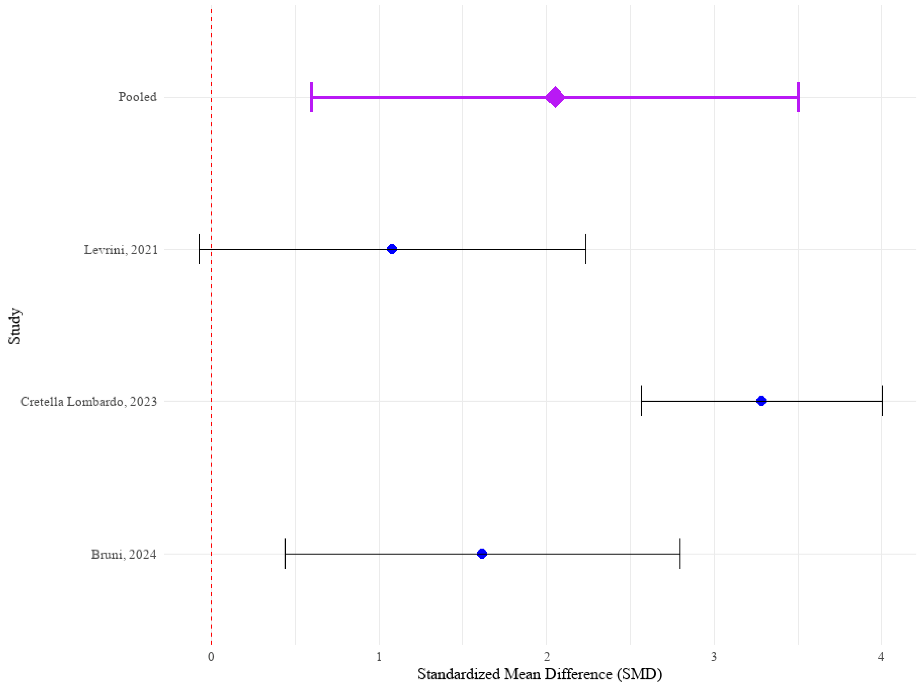

Figure 5. Forest plot of the pairwise meta-analysis for intercanine transpalatal width [7,8,16].

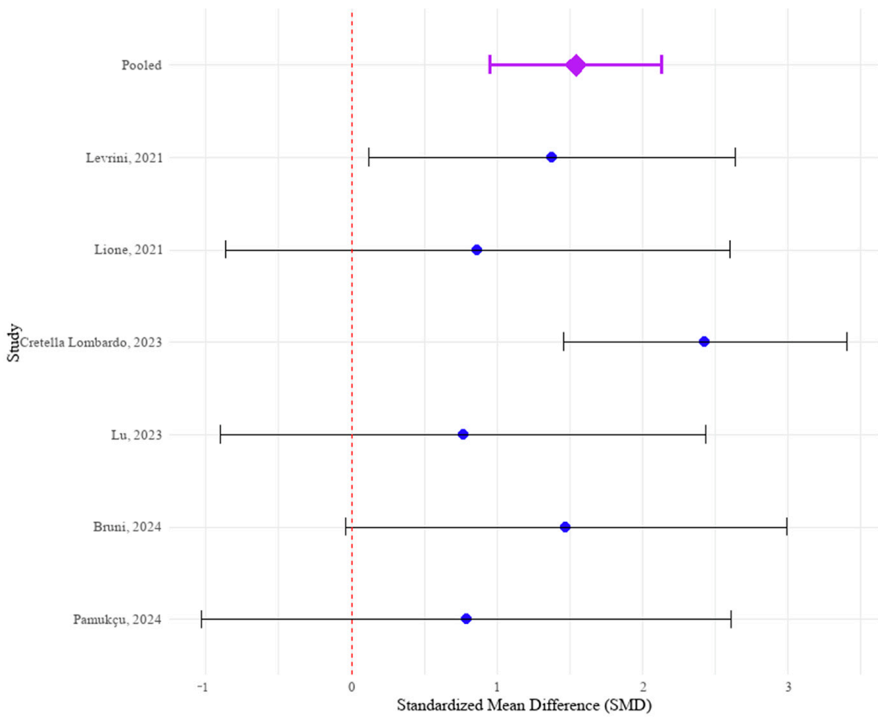

Figure 6. Forest plot of the pairwise meta-analysis for intercanine width [6–8,16,22–24].

In the forest plot of first intermolar distal vestibular width, the minimum SMD (0.179, 95% CI: −1.840; 2.199) was found in the study by Pamukcu H. et al. and the maximum was observed in the study by Cretella Lombardo E. et al. (SMD = 1.019, 95% CI: −0.453; 2.493) [7,23]. The pooled SMD from the three studies was 0.685 (95% CI: −0.273 to 1.644), which was not statistically significant. The Cochran Q-test was also not statistically significant ($p > 0.05$; Q = 0.45, $p = 0.80$), showing low observed heterogeneity. Given the limited number of included studies, this estimate should be interpreted cautiously (Figure 2).

In the forest plot of first intermolar mesial vestibular width, the minimum SMD (0.657, 95% CI: −1.580; 2.895) was found in the study by Pamukcu H. et al. and the maximum was observed in the study by Cretella Lombardo E. et al. (SMD = 1.424, 95% CI: −0.232; 3.082) [7,23]. The pooled SMD from the six studies was statistically significant (pooled SMD = 1.141, 95% CI: 0.489; 1.794). The Cochran Q-test was not statistically significant ($p > 0.05$; Q = 0.37, $p = 0.999$), showing low observed heterogeneity. Given the limited number of included studies, this estimate should be interpreted cautiously (Figure 3).

In the forest plot of first intermolar transpalatal width, the minimum SMD (0.444, 95% CI: −1.117; 2.005) was found in the study by Lione R. et al. and the maximum was observed in the study by Cretella Lombardo E. et al. (SMD 1.050, 95% CI: −0.448; 2.549) [6,7]. The pooled SMD from the six studies was 0.828 (95% CI: 0.271 to 1.386). The Cochran Q-test was not statistically significant ($p > 0.05$; Q = 0.45, $p = 0.994$), showing low observed heterogeneity. Given the limited number of included studies, this estimate should be interpreted cautiously (Figure 4).

In the forest plot of intercanine transpalatal width, the minimum SMD (1.078, 95% CI: −0.076; 2.233) was found in the study by Levrini L. et al. and the maximum was observed in the study by Cretella Lombardo E. et al. (SMD = 3.283, 95% CI: 2.564; 4.002) [7,16]. The pooled SMD from the three studies was 2.052 (95% CI: 0.598 to 3.505), with substantial heterogeneity ($I^2 = 84\%$; Cochran's Q-test: Q = 12.49, $p = 0.002$). Given the limited number of included studies and the heterogeneity across the studies, this estimate should be interpreted cautiously (Figure 5).

In the forest plot of intercanine width, the minimum SMD (0.766, 95% CI: −0.900; 2.433) was found in the study by Lu L. et al. and the maximum was observed in the study by Cretella Lombardo E. et al. (SMD = 2.429, 95% CI: 1.457; 3.401) [7,22]. The pooled SMD from the six studies was statistically significant (pooled SMD = 1.541, 95% CI: 0.951; 2.132). The Cochran Q-test was not statistically significant ($p > 0.05$; Q = 5.34, $p = 0.38$), showing low observed heterogeneity. Given the limited number of included studies, this estimate should be interpreted cautiously (Figure 6).

4. Discussion

The quantitative synthesis presented in this article suggests that clear aligner therapy may be associated with measurable transverse dentoalveolar changes in patients during the mixed dentition phase. This adds preliminary quantitative information to the growing body of literature on interceptive orthodontic use of clear aligners in mixed dentition. This quantitative synthesis extends previous qualitative reviews by demonstrating statistically significant increases in transverse dental dimensions, particularly in intercanine and intermolar widths [25]. Notably, the largest pooled effect was observed for intercanine transpalatal width (SMD = 2.052), but this outcome was derived from only three studies that exhibited substantial heterogeneity ($I^2 = 84\%$). While statistically significant, given the limited evidence base, this result should be interpreted as exploratory.

The observed expansion pattern appeared to show a progressive reduction from the anterior to the posterior segments. However, the present meta-analysis did not directly assess the biomechanical determinants of this pattern. Therefore, possible explanations such as root morphology, cortical bone thickness, posterior soft tissue resistance, reduced mechanical leverage, preset expansion values, and initial molar torque should be interpreted as hypothetical mechanisms supported by the previous biomechanical and clinical literature, rather than as direct findings of this quantitative synthesis [26].

The so-called "drawbridge" model proposed by Lione et al. represents a plausible biomechanical interpretation of aligner-mediated expansion. While it offers a useful conceptual framework, it is important to note that this model was not directly assessed in our meta-analysis and the findings were instead derived from individual studies. This model underscores the anterior-dominant force distribution typical of aligners, with posterior molars acting primarily as anchorage units [20].

While rapid maxillary expansion (RME) remains the reference approach when true skeletal expansion is required, clear aligners may offer practical advantages in selected dentoalveolar cases, particularly in terms of comfort, oral hygiene, and esthetics [13–15,27,28]. However, these patient-reported and management-related benefits should be distinguished from biological and clinical efficacy, which still requires more robust evidence.

Previous studies and reviews have reported lower pain perception and greater patient satisfaction among children treated with clear aligners [8,10,28]. However, these patient-reported advantages should not be interpreted as evidence of greater skeletal efficacy.

The skeletal changes associated with aligner therapy appear limited, especially in patients with mature midpalatal sutures [29].

4.1. Quality of the Available Evidence

Risk of bias was assessed using RoB 2 for the single RCT and ROBINS-I for the six non-randomized studies, revealing a reasonably consistent direction of effect, although the magnitude remains uncertain. Although four studies showed a moderate risk of bias, the overall risk profile of the included studies was judged as moderate [6,7,16,24].

The inclusion of moderate-risk studies likely contributed to variability in pooled estimates [7,24]. Indeed, sensitivity analysis excluding studies with multiple moderate-risk domains showed a 12% reduction in effect size, confirming that the findings are sensitive to study quality and should be regarded as preliminary.

Methodological variability across the included studies, including differences in study design, sample characteristics, expansion protocols, outcome definitions, measurement methods, and follow-up duration, may have limited the precision and generalizability of the pooled estimates. This methodological variability should be distinguished from statistical heterogeneity, which was low for most outcomes but substantial for intercanine transpalatal width. These considerations support a cautious interpretation of the pooled effects and reinforce the exploratory nature of the meta-analysis. To address these methodological shortcomings, future studies should follow design-appropriate reporting guidelines, including STROBE for observational studies and CONSORT for randomized or controlled clinical trials. In addition, future systematic reviews and meta-analyses should continue to follow PRISMA recommendations to improve transparency and reproducibility [30,31]. Nevertheless, the limited number and methodological variability of the available studies preclude protocol-specific clinical recommendations.

4.2. Limitations

The main limitation of this review is the small number of eligible studies (n = 7), which reduces statistical power, limits the precision of pooled estimates and the reliability of publication bias assessments, and precludes subgroup analyses or meta-regression. Consequently, the generalizability of the findings should be interpreted with caution.

A further limitation is the clinical and methodological heterogeneity observed across the included studies. Differences in study design, sample characteristics, comparator groups, treatment duration, outcome definitions, measurement methods, and follow-up duration may have influenced the pooled estimates. In addition, several clinician- and patient-dependent factors were not consistently reported across studies. These include variations in treatment staging, prescribed and actual aligner wear-time compliance, and the use, design, and positioning of specific attachments or auxiliary features. Such factors may substantially affect force delivery, movement predictability, and the amount and distribution of transverse dentoalveolar expansion, but they could not be explored through subgroup analyses because of the limited and heterogeneous evidence base.

Finally, most of the included studies relied on dental cast or digital model measurements, whereas standardized three-dimensional assessment of skeletal versus dentoalveolar effects was limited. Long-term data on retention and stability were also scarce. Therefore, the present meta-analysis should be considered exploratory and hypothesis-supporting rather than being sufficient to establish protocol-specific clinical recommendations.

4.3. Future Research Directions

Future research should prioritize well-designed randomized controlled trials (RCTs) with clearly defined inclusion criteria, standardized protocols for transverse measurements, and systematic use of three-dimensional imaging (e.g., CBCT or digital models) to objectively distinguish between skeletal and dentoalveolar effects. Long-term follow-up is also essential to assess treatment stability and the biological responses of growing patients to aligner-mediated expansion. Moreover, studies should incorporate digital treatment planning data, such as ClinCheck® (Align Technology, Inc., Tempe, AZ, USA) predictions, to evaluate the predictability and precision of aligner therapy in early mixed dentition—an aspect currently underreported despite its clinical relevance. In parallel, high-quality observational studies with rigorous control for confounding variables, standardized outcome definitions, and reproducible reference points could provide valuable insights, especially in real-world settings where RCTs may not be feasible. Finally, future systematic reviews and meta-analyses should adopt stratified analytical models and conduct subgroup analyses based on patient age, malocclusion severity, expansion protocol, and digital simulation use. A more mature and methodologically consistent body of primary evidence will be required before stronger clinical inferences can be supported.

5. Conclusions

Overall, the present study provides an exploratory quantitative synthesis of the currently available evidence on transverse dentoalveolar changes associated with clear aligner therapy in growing patients with mixed dentition.

In selected cases of mild-to-moderate dentoalveolar transverse discrepancy, clear aligner therapy may be considered when the therapeutic objective is dentoalveolar rather than skeletal expansion. Nevertheless, the current evidence base remains preliminary and hypothesis-supporting and does not yet justify strong clinical recommendations. Further well-designed prospective studies with standardized outcomes and long-term follow-up are required.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/app16147015/s1: Table S1, Complete database-specific search strategies; Table S2, Full-text reports excluded after eligibility assessment and reasons for exclusion [15,21,32–54]; Table S3, Study-level raw data for transverse dentoalveolar outcomes including baseline (T0) and post-treatment (T1) mean and standard deviation values for intermolar mesial vestibular width, intermolar distal vestibular width, intermolar transpalatal width, intercanine width, and intercanine transpalatal width extracted from the included studies [6–8,16,22–24].

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