

Clear Aligners in Orthodontic Expansion: A Systematic Review of Effectiveness and Limitations

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Introduction:

Clear aligner therapy (CAT) had revolved contemporary orthodontics by providing a tactful and patient friendly alternate for the conventional fixed appliances¹. Among the various applications of aligners, maxillary expansion has emerged as a major point of interest, particularly in the non-growing patient and the mild-to-moderate transverse deficiency (Lione et al., 2021). Conventional rapid maxillary expansion (RME) uses heavy forces to achieve skeletal changes. In contrast, aligners provide controlled low forces that mainly induce dentoalveolar expansion².

The clinical interest in aligners is related to the possibility to combine aesthetics with biomechanical efficiency, making them especially suitable for adolescents and adults seeking minimally invasive correction of transverse discrepancies. It remains controversial³ to what extent aligners can achieve significant expansion by tipping, bodily movement or skeletal adaptation. Although literature suggests that aligners may not replicate the skeletal effects of RME, aligners can be successful in the management of mild arch constriction (≤ 6 mm) with optimisation using attachments and staging protocols. However, concerns still exist about buccal tipping and long-term stability especially in cases requiring extensive expansion⁴. This systematic review aims to review the effectiveness, biomechanics and treatment outcomes and limitations of aligner-induced expansion by synthesizing evidence from clinical trials, finite element analyzes and

retrospective studies. The goal is to establish the role of aligner-induced expansion in maxillary expansion and modern orthodontic practice.

Aim

This systematic review will aim to:

- Assessment of the efficiency of clear aligners in maxillary and mandibular arch expansion.
- To determine the clinical and treatment factors that may affect the extent and predictability of arch expansion using clear aligner therapy.

PICO Objective:

The research question was formulated according to the PICO framework as:

Population (P): Patients in orthodontic treatment.

Intervention (I) Orthodontic treatment with clear aligners.

Comparison (C): Normal arch size.

Outcome (O) : Effectiveness and predictability of clear aligners in maximising maxillary and mandibular arch expansion.

Inclusion Criteria:

Studies published in English between 2000 and 2025 were eligible for inclusion. PubMed, Google Scholar, the Cochrane Library, and Embase were used to find pertinent articles. Only original human studies, including clinical studies and randomised controlled trials, that evaluated arch expansion in relation to clear aligner therapy were included.

Exclusion Criteria:

The study excluded review articles, case reports, animal studies, letters to the editor,

conference or meeting abstracts, replies from authors, non-English publications, studies for which the full text was not available and duplicate publications.

Search strategy :

(expansion) AND (clear aligners), (expansion) AND (clear aligners therapy), (palatal expansion) AND (clear aligners), (expanders) AND (clear aligners), The Boolean search string was constructed using the plain text and MeSH terms as follows:

Data collection procedure:

Two authors independently assessed the eligibility of selected articles for this review. The title and abstract were the main criteria for selection. Articles that fulfilled the inclusion criteria were selected for full text analysis. Articles relevant to the study protocol were included. If disagreement occurred, the third author re-assessed the articles for eligibility for review.

Results:

The primary search identified a total of 4050 articles using a Boolean search strategy, covering publications from 2000 to till date. Removing duplicates $n = 835$ with an automation tool yielded 3215 unique articles. In the initial screening phase, we excluded review articles, meta-analyses and case reports ($n = 1524$). Of the remaining 1691 articles, only 572 articles had full-text access, and those with only abstracts ($n = 1121$) were excluded. All 572 full-texts were reviewed in detail and 550 were excluded as irrelevant to the research question. Finally, 22 articles were deemed eligible to be included in this systematic review. The selected articles were analysed in detail and the data of interest extracted and tabulated.

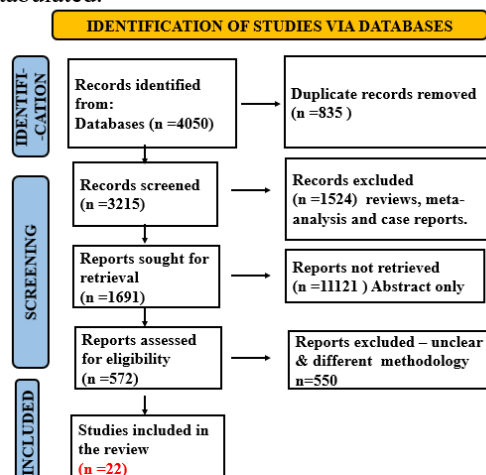


Figure 1: PRISMA flow chart

AUTHOR	TITLE	TYPE OF STUDY	Type of aligner studied	RESULT	CONCLUSION	SIGNIFICANCE
Ullrich et al 2021	Maxillary expansion or contraction and occlusal contact adjustment: effectiveness of current aligner treatment	Retrospective	SmartTrack®	The overall effectiveness of achieving planned transverse expansion or contraction was 45%. - No significant improvement was observed with SmartTrack® compared to the older Ex30® material. - Larger planned expansions (>2 mm) showed reduced clinical effectiveness.	SmartTrack® aligners did not significantly improve transverse movement precision compared to previous materials. Eliminating all red contacts in simulations is unnecessary, as most do not materialize intensely. Pretreatment maxillary expansion should be considered for large transverse	The clinicians should anticipate ~60% accuracy in achieving planned occlusal contacts and ~45% in transverse movements.

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					discrepancies	
Cristina Adelaar-Rossini-Garayzar 2022	Factors affecting expansion on predictability of clear aligner treatment	Retrospective	Invisalign	The mean absolute discrepancy between planned and achieved expansion was 0.92 mm (95% CI: 0.86–0.99). 72.2% of cases showed underexpansion , while 79.3% of overcorrections occurred in the mandible . Key Factors Affecting Predictability: - Expansion was less predictable in the maxilla (discrepancy: 1.24 mm) vs. the mandible (0.61 mm). Canines showed the highest predictability; molars and premolars were less accurate. Cases with crossbite	Mandibular expansion and anterior teeth (canines) are more predictable than maxillary expansion on or posterior teeth movements. Posterior crossbite and large planned expansions reduce predictability	The over-reliance on aligners for large maxillary expansions (>2 mm), especially in crossbite cases, is sometimes not useful in treatment.

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				(unilateral/bilateral) had significantly lower predictability . Larger planned expansions (>2 mm) correlated with greater discrepancies .		
Mehmet Akif Akkurt 2022	Accuracy of arch expansion with two thermo plastic materials in Invisalign® patients: EX30® and SmartTrack	Retrospective	Invisalign	The overall accuracy was higher in mandible than in maxilla for both the materials. No statistically significant difference in expansion accuracy between EX30® and SmartTrack® (*p > 0.05). SmartTrack® showed higher numerical accuracy , particularly in the mandible	No superiority of SmartTrack® over EX30® in transverse expansion accuracy was statistically proven, despite higher numerical values for SmartTrack®. Mandibular expansion was more predictable than maxilla	

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					ry expansion for both materials. Posterior teeth and gingival margins showed the lowest accuracy. Overcorrection and buccal crown torque are recommended to compensate for under-expansion	
Y	Effects of upper arch expansion using clear aligners on different stride and torque: a three-dimensional		Invisalign	Maxillary arch expansion caused buccal tipping of posterior teeth, lingual tipping of anterior teeth, and incisor extrusion. Torque compensation	Torque compensation is effective for reducing buccal tipping but must be carefully calibrated	The findings aid orthodontists in selecting stride lengths and torque angles tailored to patient needs,

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	onal finite element analysis			n reduced buccal tipping but also decreased expansion efficiency. Buccal tipping increased with larger stride lengths (e.g., 0.3 mm).	ed to avoid compromising expansion goals. Posterior teeth cause a degree of buccal tilt when maxillary arch expansion is ensured	enhancing predictability and outcomes in CAT
Sava	Predictability of expansion movements performed by clear aligners in mixed dentition in both arches: a retrospective study on digital casts		Clear aligners	Expansion Predictability : Upper arch : • After the first set of aligners (T1), predictability ranged from 23.9% to 46.4% , with the highest expansion observed at the first deciduous molars (46.4%). • By treatment completion (T2), predictability improved to 49.6–70.8% , peaking at	Clear aligners can induce significant dental alveolar expansion in mixed dentition, but predictability is limited during the first set of aligners (<50 %).	This study highlights the need for refinement aligners to achieve desired expansion, especially in the maxillary arch and for permanent molars

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				the second deciduous molars (70.8%). Permanent molars showed lower predictability (54.9% mesial width, 58.9% distal width). Lower Arch: - Predictability at T1 ranged from 36.3% to 48.7%, highest at the second deciduous molars (48.7%). - At T2, predictability increased to 50.5–75.3%, with the second deciduous molars achieving		

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				the highest expansion (75.3%).		
				Efficacy of Expansion: Maxillary Arch: Premolars showed the greatest expansion (1st PM: 2.19 ± 3.27 mm; 2nd PM: 2.53 ± 1.33 mm). Mandibular Arch: Similar trends, with premolars expanding most (1st PM: 2.40 ± 1.77 mm; 2nd PM: 2.47 ± 1.60 mm). All changes were statistically significant ($*p < 0.001$). Overexpansion: Lower first molars exceeded planned expansion by 0.54 ± 0.85 mm ($*p < 0.001$).	Invisalign® aligners effectively achieved dentoalveolar expansion , particularly in premolars. ClinCheck® software was reliable but showed overexpansion in molars and underexpansion in canines .	

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				Underexpansion: Maxillary canines fell short by 0.56 ± 0.64 mm (*p* < 0.001).		
Ning ZHOU 2022	Efficiency of upper arch expansion with the Invisalign system	Prospective clinical study	Invisalign	Crown Expansion Efficiency- Significant differences between designed and achieved expansion for all teeth ($P < 0.05$). Efficiency decreased posteriorly	1. The Invisalign system effectively increased arch width but primarily through tipping rather than bodily movement. 2.	

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	Maxillary arch development with Invisalign system: Analysis of expansion on dental movements on digital dental casts	Prospective Invisalign study		Linear Expansion: Greatest expansion at premolars: First premolars: +3.5 mm. Second premolars: +3.8 mm.	Premolars are most responsive to expansion, while second molars are least responsive.	While Invisalign® effectively expands the maxillary arch (especially premolars), digital overcorrection of canines

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						and monitor posterior teeth for minimal response
Holland et al 2022	Evaluation of maxillary dimensional changes in the mixed dentition: clear aligners vs acrylic expanders	Prospective aligners vs acrylic expanders study		For palatal expansion, RE group had significant increases in SA (+34.32 mm ²) and VAP (+119.15 mm ³) ($P < 0.05$); IF changes were nonsignificant	RE may be preferred for posterior expansion, while IF suits anterior expansion with better patient comfort.	
Gabriel et al 2023	Efficacy and Accuracy of Maxillary Arch Expansion with Clear Aligner Treatment	Prospective Invisalign study		Expansion Efficacy- Significant increases in all transverse measurements ($P < 0.05$). Highest expansion: First premolar cusp (+2.76 mm, 6.87%). Lowest expansion: Molar gingival (+0.98 mm, 2.92%). ClinCheck®	Invisalign® achieved 70% overall accuracy in maxillary expansion, primarily through crown tipping (evidenced by lower gingival accuracy)	ClinCheck® tends to overestimate expansion, especially for bodily movement

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				Predictability - Overestimated expansion by ~0.65 mm on average.	y).	
Maxillary alveolar bone evaluation following dental expansion with clear aligners in adults: A cone-beam computed tomography study	Retrospective analysis	Invisalign		Increases in transverse measurements were observed across all teeth (incisors, canines, premolars, and molars) after treatment (p < 0.001)		Invisalign® aligners can achieve mild maxillary expansion in adults without compromising alveolar bone integrity
Elementary Accuracy of Invisalign® treatments in the anterior tooth region	Retrospective analysis	Invisalign		Expansion: Achieved with high accuracy (deviations <0.5 mm for overjet/midline), but vertical corrections (overbite) showed larger discrepancies (0.9 mm)	ClinCheck® provides reliable virtual planning for sagittal movements but requires overcorrection or adjuncts (e.g.,	

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		study			attachments) for vertical corrections	
In Vitro Comparison of Direct Attachment Shape and Size on the Orthodontic Forces and Moments Generated by Thermo-plastic Aligners During Expansion	Retrospective analysis	0.76-mm-thick clear aligners (Great Lakes Dental Technologies) thermoformed using Bios tar.		1 mm rectangular attachments are optimal for premolars (UR4), while 1 mm hemi-ellipsoid works best for second premolars (UR5). Molars (UR6) benefit from 0.5 mm rectangular attachments .		Attachment shape/size significantly impacts expansion efficiency, requiring tooth-specific designs for optimal force delivery.
Effect of Low-Intensity Pulsed Ultrasound (LIPUS) on Alveolar Bone during Maxillary Expansion	Clinical analysis	Invisalign®		Average expansion was 1.93 mm for upper first premolars (1PM) and 1.67 mm for upper second premolars (2PM). Minimal changes in periodontal health and bone	Invisalign® for expansion did not significantly alter periodontal health or bone dimensions, with	

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218	Using Clear Aligners	h	measurements were observed	removable aligners favoring oral hygiene.		
	Maxillary expansion or contraction and occlusal contact adjustment: effectiveness of current aligner treatment	Retrospective	Invisalign® with older Ex30® SmartTrack® material	The effectiveness of achieving planned transverse expansion or contraction was 45%, with no significant improvement over the material. Larger planned movements (>2 mm) showed reduced accuracy. Occlusal contacts achieved ~60% of simulated goals.	SmartTrack® aligners for expansion/contraction had limited precision (45%), suggesting overcorrection may be needed	
	Effects of different tooth movements and aligner thicknesses on	Retrospective	Clear aligners with thicknesses of 0.5 mm	Expansion primarily caused buccal tipping, with efficiency decreasing from premolars to molars.	Alternating movement patterns improve expansion efficiency	

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	maxillary arch expansion with clear aligners: a three-dimensional finite element study	st and 0.75 mm.			cy, but anchorage must be reinforced.	
Mari - Lu - V - B - 2020	Efficacy and predictability of maxillary and mandibular expansion with the Invisalign® system	Retrospective	Invisalign	Expansion showed high predictability (98–100% coronal, 85–90% gingival), with moderate expansion (2–3.5 mm) being most predictable.	Invisalign® is effective for dental alveolar expansion, with moderate expansion offering the highest predictability.	
Chen - H - 2019	The predictability of arch expansion with the Invisalign	Retrospective	Invisalign - First	Predictability varied by tooth type—highest for mandibular primary canines (81.1%) and	Invisalign First® is effective for arch expansion	

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Ignatius et al. 2022	First permanent mixed dentition: a retrospective study	Review study		lowest for maxillary first permanent molars (53.4%)	on in mixed dentition, with mandibular teeth showing higher predictability	
Al-Saleh et al. 2022	Predictability of maxillary dental alveolar expansion with clear aligners in patients with mixed dentition	Prospective study	Invisalign First	Expansion accuracy was highest in anterior teeth (87.7% at canine cusp level) and decreased posteriorly (67.9% at molar gingival level), with crown tipping observed, especially in molars.	CAT is predictable for moderate maxillary expansion in mixed dentition.	overcorrection is recommended due to posterior accuracy limitations.
Mahmoud et al. 2023	Comparison of alveolar bone thickness and height after slow expansion using quad-helix clear aligners	Randomized controlled trial	quad-helix vs. clear aligners	Clear aligners showed no significant reduction in alveolar bone height/width, unlike quad-helix, which decreased bone thickness at molars/premolars. Inter-canine expansion was significant	Clear aligners better preserve alveolar bone integrity during SME compared to quad-helix, making them a prefera	

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Vincenzo et al. 2023	The Predictability of Transverse Changes in Patients Treated with Clear Aligners	Prospective study	Oral aligners (UAB OrthoLine, Vilnius, Lithuania).	Expansion accuracy was 71% at cusp level and 60% at gingival level for the upper arch, and 67% (cusp) and 59% (gingival) for the lower arch	Clear aligners achieve moderate expansion accuracy, primarily through crown tipping.	Overcorrection is recommended for predictable outcomes, especially in posterior regions.
Al-Saleh et al. 2024	Efficacy of clear aligners vs rapid palatal expanders on palatal volume and surface area in mixed dentition patients: A randomized controlled trial	Prospective study	Invisalign First Phase I (multilayer thermoplastic polyurethane/copolyester, 0.75 mm thick)	Both treatments increased palatal volume and transverse dimensions, but RME showed greater expansion (532.01 mm ³ vs. 243.95 mm ³ for aligners)	Clear aligners achieved expansion but were less effective than RME, primarily inducing dental alveolar changes (tipping) rather	Aligners are a viable option for mild expansion (≤6 mm discrepancy), but RME remains superior for significant skeletal expansion.

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			k).		than skeletal expansion.	

Discussion:

This systematic review of 22 studies on maxillary and mandibular expansion with clear aligners, most commonly Invisalign, provides several important findings about the predictability, efficacy and limitations of aligner treatment to achieve transverse dental expansion. The studies are retrospective, prospective, and clinical evaluations giving a complete picture of the current evidence.

The predictability of transverse expansion with clear aligners was highly variable among studies, with accuracy ranging between 45% and 98%. Interestingly, moderate expansion (2–3.5 mm) was the most predictable, especially in the anterior region (e.g., canines) with less predictability for larger expansions (>2 mm) and posterior teeth (molars and premolars). For example Ulrike Riede et al. (2021) studies and Cristina de-la-Rosa-Gay and associates (2025) discovered that the development of the maxillary area was less consistent compared to the enlargement of the mandibular area, with variances of 1.24 mm and 0.61 mm, respectively^{5, 6}. Considering this, it seems that aligners are more effectual for dento-alveolar expansion of the mandible and anterior maxilla, but posterior maxillary expansion often requires overcorrection or further interventions.

The results indicated that the premolars were most susceptible to growth. Research carried out by Roberta Lione (2021) and Ana Sofia Rocha (2023) states that the region expanded significantly between 2.19 and 3.8 millimeters 10, 12. The least predictable were the molars, which, as mentioned by Ning Zhou (2020) and Gabriella Galluccio (2023), were due to buccal tilting not muscle action. The tipping effect successfully induced coronal expansion; yet, it could have resulted in insufficient expansion at the gingival level, suggesting that torque correction has to be included into the aligner design.

Material and Technological Considerations:

Medeiros RB et al. (e.g., SmartTrack® vs. EX30®) conducted comparative studies of aligner materials and found no statistically significant differences in the accuracy of expansion, but SmartTrack® showed slightly better numerical results⁷. But attachments were a significant factor. Megann Lear et al showed that the design of tooth-specific attachments (e.g., rectangular for premolars, hemiellipsoid for molars) could optimize the force delivery and improve the efficiency of expansion¹⁷.

Overcorrection The authors D'Antò 2023, Bruni 2025 in their studies suggested the consideration of 10–20% overcorrection in treatment planning, due to the propensity for underexpansion, particularly in maxilla and posterior regions^{22, 23}.

Mixed Dentition: Invisalign First® presented moderate predictability for expansion in children (Chi Hoon Kim 2024) but refinement aligners were often needed to reach desired results^{9, 21} (Saveria Loberto 2024).

Skeletal Expansion compared to Dentoalveolar Expansion: Clear aligners proved less efficacious than rapid palatal expanders (RPE) for skeletal expansion, therefore rendering them suitable just for mild to moderate dentoalveolar discrepancies¹.

The effectiveness of clear aligners in achieving transverse expansion depends on several factors including the attachment design, patient compliance, and staging protocols.

Enhanced attachments, including horizontal beveled designs, significantly improve the control of the tooth movement, increasing the force application and decreasing the undesired tipping²⁴. The second most important factor is patient compliance, as studies show that less than 20 hours per day of wear time may significantly reduce the effect of treatment²⁵. Adequate staging of tooth movement, typically 0.25 mm to 0.5 mm per aligner, usually guarantees predictable expansion with a lower risk of root resorption and loss of anchorage²⁶.

Limitations:

Bone Response The aligners preserved the integrity of the alveolar bone. Skeletal stability in the long term is poorly studied.

Technological Advances: Future research should evaluate the role of AI-assisted planning, optimized attachment protocols and hybrid systems (e.g., aligners with mini-screws) to improve the accuracy of posterior expansion.

Conclusion:

The use of clear aligners is a viable option for small dentoalveolar expansion, especially in the anterior and mandibular regions of the oral cavity. With less predictability as development increases and in posterior teeth meticulous

planning, overcorrection and use of adjunctive therapies in some situations are of paramount importance. More carefully designed randomized controlled trials are needed to standardize expansion protocols and to evaluate new aligner technologies.

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