

Clear Aligner Therapy for Excessive Gingival Display: A Systematic Review of Absolute and Relative Intrusion and Vertical Correction

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Abstract

Background: Excessive gingival display (EGD) is multifactorial, and clear aligner therapy (CAT) may provide dentoalveolar vertical correction. However, reported “intrusion” may represent absolute tooth translation or relative vertical correction through tipping, extrusion, and other movements.

Objective: To evaluate the effectiveness of CAT for reducing EGD and to distinguish absolute intrusion from relative vertical correction.

Methods: A structured PubMed search identified literature on clear aligners, anterior intrusion, overbite, deep bite, vertical correction, and EGD. Evidence was classified according to whether absolute intrusion was directly demonstrated, probable, or inferred from relative vertical outcomes.

Results: The current search identified 342 records before deduplication and 339 unique records after removal of 3 duplicates. Preliminary title/abstract screening identified 175 potentially relevant records and 150 requiring full-text assessment. Direct EGD evidence was limited. Mechanistic studies reported variable intrusion predictability, with planned movement generally exceeding achieved movement. Several studies indicated that observed vertical correction may also involve tipping, extrusion, or other compensatory movements.

Conclusion: CAT can produce clinically relevant vertical correction, but current evidence does not establish that reduction in gingival display is consistently attributable to absolute intrusion. Direct EGD outcomes and standardized three-dimensional measurements are needed to determine the true contribution of intrusion to smile improvement.

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Introduction

Evidence on CAT vertical control is broader than evidence specific to EGD. Most intrusion studies involve deep bite or other vertical malocclusions and report overbite, incisor position, or planned-versus-achieved movement rather than gingival display. The current search showed the same pattern. Therefore, this review uses reduction in gingival display as the primary clinical endpoint and treats absolute intrusion and relative vertical correction as mechanistic outcomes, while separating direct EGD evidence from indirect vertical-control evidence [1,2].

Absolute intrusion is defined as demonstrated axial or apical displacement, preferably established by root-, centroid-, CBCT-, or 3-D measurements. Relative vertical correction refers to improvement in the smile or occlusal relationship when axial translation cannot be isolated and may include

intrusion, tipping, extrusion, posterior vertical movement, mandibular rotation, or combinations thereof. This distinction preserves clinically useful evidence without overstating mechanism.

“Intrusion” is not a uniform endpoint. Programmed intrusion, crown displacement, overbite reduction, and gingival-display reduction are not interchangeable. Crown-level change may reflect axial translation, tipping, opposing-tooth extrusion, posterior vertical change, mandibular rotation, or combinations. Thus, crown displacement or overbite reduction should not automatically be interpreted as axial intrusion; measurement differences can otherwise create apparent efficacy differences [5,9]. CAT permits digitally planned 3-D tooth positioning and use of attachments, bite ramps/planes, elastics, staging changes, and overcorrection. Planned movement is not guaranteed biologically; vertical movement is sensitive to tooth morphology,

biomechanics, attachments, programmed magnitude, and patient factors [5–8]. A 2025 systematic review reported approximately 0.4–1.5 mm achieved lower-incisor intrusion and 35–65% predictability, with substantial heterogeneity and predominantly serious risk of bias [9].

EGD correction may involve maxillary incisor position, posterior vertical relationships, or both. Anterior intrusion can lower clinical crowns, while posterior or total-arch intrusion may alter the occlusal plane and facial vertical relationships. Skeletal-anchorage-supported fixed treatment can produce larger, more controlled intrusion [3,4], providing the rationale for CAT in patients with a predominantly dentoalveolar EGD component.

EGD (gummy smile) is multifactorial and may reflect vertical maxillary excess, dentoalveolar extrusion, altered passive eruption, gingival enlargement, lip length, or increased upper-lip mobility. It should therefore be treated as an etiologic dentofacial problem rather than a purely millimetric abnormality. Treatment depends on cause and severity, with orthodontics most relevant when a dentoalveolar component is substantial [1,2].

2. Review Question and Objectives

Primary question: In patients with excessive gingival display/gummy smile, how effective is clear aligner therapy in reducing gingival display, and to what extent is the observed vertical correction attributable to absolute intrusion versus relative vertical correction?

Determine the magnitude of EGD/gummy-smile correction reported with CAT.

Quantify absolute anterior or posterior intrusion where directly measurable.

Characterize relative vertical correction when gingival display, overbite, incisal position, or occlusal relationships are used as outcomes.

Determine whether tipping, extrusion, posterior vertical change, or mandibular rotation contributes to relative correction.

Compare planned versus achieved movement and report predictability where compatible.

Evaluate the influence of attachments, bite ramps/planes, staging, overcorrection, squeezing protocols, aligner design, and skeletal anchorage.

Separate direct EGD evidence from indirect deep-bite/vertical-control evidence.

Assess root resorption, alveolar housing, periodontal outcomes, and refinement requirements where reported.

Keep clinical efficacy separate from finite-element and laboratory biomechanical evidence.

3. Conceptual Framework: Absolute Versus Relative Intrusion

The review will classify vertical correction according to what the study actually demonstrates rather than according to the treatment objective. This preserves clinically useful studies while preventing an indirect outcome from being treated as proof of absolute axial intrusion.

For study-level extraction, the earlier three-level evidence hierarchy will be retained: Grade I, direct absolute intrusion; Grade II, probable intrusion; and Grade III, indirect vertical correction. Mechanism will additionally be coded as A, absolute-intrusion dominant; B, extrusion dominant; C, mixed intrusion plus extrusion; D, tipping/inclination dominant; or E, indeterminate [3].

4. PICO Framework

PICO element	Operational definition
P — Population	Patients undergoing orthodontic treatment who present with excessive gingival display (EGD/gummy smile), or patients with anterior vertical malocclusion/deep bite in whom anterior vertical correction or intrusion is evaluated and is mechanistically relevant to EGD.
I — Intervention	Clear aligner therapy (CAT), including Invisalign and other clear-aligner systems, with or without attachments, bite ramps/planes, elastics, overcorrection, or other adjunctive mechanics intended to produce vertical tooth movement.
C — Comparator	Baseline/pre-treatment condition; planned digital position; alternative CAT protocol; fixed orthodontic treatment; skeletal anchorage/TAD-assisted treatment; or no comparator where a pre-post design is used.
O — Primary outcome	Reduction in excessive gingival display/gingival exposure during smiling.
O — Mechanistic outcomes	Absolute tooth intrusion; relative vertical correction; incisor vertical displacement; root/centroid displacement; planned-versus-achieved intrusion; incisor inclination/tipping; posterior extrusion or intrusion; mandibular rotation; and other contributors to vertical correction.
O — Secondary outcomes	Overbite correction, treatment predictability, refinement requirements, periodontal/alveolar effects, root resorption, adverse

	effects, and patient-reported aesthetic outcomes where reported.
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5. Methods

5.1 Reporting framework

The manuscript is structured in accordance with PRISMA 2020 reporting principles. PRISMA 2020 emphasizes transparent reporting of how studies were identified and selected, how risk of bias was assessed, and how results were synthesized [4]. Because full-text screening is still in progress, the present version is explicitly identified as an interim systematic-review manuscript rather than a completed final review.

5.2 Information source and search strategy

PubMed/MEDLINE was used as the primary database in the current evidence set. The principal search combined clear-aligner terminology with intrusion and broader vertical-control terminology, including deep bite, overbite, vertical movement, and anterior tooth terms. A complementary search specifically targeted EGD/gummy smile terminology. The current principal search returned 336 records and the complementary EGD search returned 6 records, yielding 342 records before deduplication. Three duplicates were identified, leaving 339 unique records for screening.

The original manuscript draft contained an earlier preliminary count of 381 records. That number is not used for the current PRISMA accounting because the working master dataset has subsequently been deduplicated to 339 records. The 339-record dataset is therefore the current working denominator.

5.3 Eligibility

Studies will be eligible when CAT is evaluated in human participants and the report contains a quantitative outcome relevant to EGD/gummy-smile correction or a vertical tooth movement that can reasonably inform the mechanism of such correction. Direct EGD studies will form the primary evidence stream. Vertical-control and intrusion studies without EGD measurement will be retained as indirect mechanistic evidence when they quantify movements relevant to the proposed correction.

Finite-element and laboratory studies will be retained in a separate biomechanical evidence stream and will not be pooled with clinical efficacy estimates. Case reports and other designs will remain pending until full-text eligibility criteria are applied.

5.4 Study selection

A preliminary title/abstract audit of the 339-record set identified 175 records with an anterior/vertical signal and 6 with a direct EGD signal. Fourteen records were initially flagged as preliminary exclusions and 150 as requiring full-text assessment. At the time of this manuscript version, the first 51 records have undergone a dedicated eligibility audit. Among these, 41 were retained for full-text assessment, 5 were categorized as

biomechanical/FEA evidence to be kept separate from clinical efficacy, 4 as secondary evidence for background/cross-checking.

5.5 Data extraction

The planned extraction includes study design, sample characteristics, EGD definition, smile measurement method, malocclusion, aligner system, target tooth/region, planned intrusion, achieved absolute intrusion, relative vertical correction, gingival-display change, overbite change, incisor inclination, posterior vertical movement, mandibular rotation, attachments, bite ramps/planes, staging, overcorrection, refinements, skeletal anchorage, unwanted movement, root resorption, and alveolar/periodontal outcomes.

Predictability will be calculated as achieved/planned $\times 100$ only when planned and achieved measurements are commensurate and measured using compatible reference systems.

5.6 Risk of bias

Randomized trials will be assessed using RoB 2, nonrandomized comparative intervention studies using ROBINS-I, and other observational designs using an appropriate validated instrument. FEA studies will be critically appraised separately according to model assumptions, validation, material properties, boundary conditions, loading conditions, sensitivity analysis, and clinical translatability.

6. Current Evidence Synthesis

6.1 Direct EGD/gummy-smile evidence

The current search identified 6 records with a direct EGD/gummy-smile signal. These records form the highest-priority stream because the review's primary clinical outcome is reduction in gingival display.

The broader EGD literature supports the multifactorial nature of gummy smile and the importance of matching treatment to the underlying mechanism. Existing systematic reviews of gummy-smile treatment include orthodontic and surgical approaches, while reviews of nonsurgical approaches emphasize that evidence quality and treatment response vary by severity and etiology [1,2]. These reviews provide background context but do not replace the CAT-specific evidence synthesis.

6.2 Absolute intrusion: direct mechanistic evidence

The strongest mechanistic evidence comes from studies that attempt to separate axial tooth translation from crown tipping. Al-Balaa et al. [3] used CBCT and ClinCheck data in patients treated with Invisalign and reported a mean precision of approximately 51.19% for absolute anterior intrusion. This study is particularly relevant to the absolute-intrusion category because the measurement was based on three-dimensional imaging and compared predicted and actual movement [3,5].

More recent three-dimensional studies reinforce the discrepancy between programmed and achieved movement. A 2026 mandibular-anterior study using

CBCT and intraoral scans reported that actual intrusion was significantly less than predicted and that actual crown labial movement exceeded the predicted movement, illustrating the contribution of proclination to the observed response. A separate 2026 centroid-based study in 27 adults treated with Invisalign and precision bite ramps reported approximately 1.63 mm of centroid-based mandibular-incisor intrusion. Because centroid-based measurement attempts to isolate translational movement from tipping, this study is particularly informative for the absolute-intrusion framework [3].

A 2026 three-dimensional study of planned versus achieved anterior tooth position in 40 adults also reported low predictability for upper-incisor intrusion, with an intrusion predictability of approximately 23.1% in the upper incisors during the first aligner series. These findings reinforce the importance of distinguishing digital prescription from biological expression.

6.3 Relative vertical correction

The relative-correction stream is considerably larger than the direct EGD stream. Deep-bite and overbite studies show that CAT can produce clinically meaningful vertical correction, but the mechanism may be composite. The 2026 deep-bite systematic review and meta-analysis reported pooled overbite reduction of approximately 1.79 mm, lower-incisor intrusion of 1.37 mm, upper-incisor intrusion of 0.53 mm, lower-molar extrusion of 0.70 mm, and upper-molar extrusion of 0.32 mm, with very high heterogeneity [3].

These findings are central to the relative-intrusion concept: the amount of overbite correction is not identical to the amount of absolute incisor intrusion because posterior extrusion and other tooth movements may contribute to the final vertical relationship. The same principle applies to gummy-smile correction. A reduction in gingival display should therefore be interpreted in conjunction with incisor vertical displacement, inclination, posterior vertical changes, and, where possible, root/centroid movement.

6.4 Predictability of programmed intrusion

The current evidence suggests incomplete and variable expression of digitally programmed intrusion. A 2025 systematic review of lower-incisor intrusion identified eight clinical studies and reported approximately 0.4–1.5 mm mean intrusion with approximately 35–65% predictability, substantial heterogeneity, and predominantly serious risk of bias [6]. Individual studies in the current extraction set include planned-versus-achieved differences and reported intrusion accuracies around 45–52% in several contemporary deep-bite protocols.

These values should not be transferred directly to gummy-smile patients. They are mechanistic evidence about the ability of CAT to generate vertical tooth movement. The primary EGD

outcome remains gingival-display change, and the extent to which a given amount of intrusion translates into visible smile improvement requires direct EGD studies.

6.5 Relative correction through tipping and extrusion

The current evidence also demonstrates why tipping and extrusion must be explicitly coded. Crown-only vertical movement can occur when a tooth changes inclination, and overbite can decrease when opposing teeth extrude. Accordingly, a study reporting vertical crown displacement without independent root or inclination information will be classified as Grade II rather than Grade I. Studies reporting only overbite or cephalometric vertical change will be Grade III unless additional data permit separation of mechanisms.

6.6 Posterior intrusion and open-bite evidence

Posterior vertical control is relevant to the relative-correction framework because changes in posterior tooth position can alter mandibular rotation and the relative vertical relationship of the anterior teeth. In a prospective comparative study, CAT with squeezing exercises produced approximately 0.68 mm of maxillary molar intrusion at six months compared with approximately 1.49 mm with fixed appliances supported by miniscrews. This evidence is not direct gummy-smile evidence, but it provides context for the limits of aligner-based posterior intrusion and the distinction between CAT alone and skeletal-anchorage-assisted mechanics [3].

6.7 Biomechanical evidence

FEA studies indicate that attachment position, aligner design, force direction, material properties, and activation strategy can modify intrusive-force distribution and tipping. For example, different buccal-palatal attachment configurations have been associated with differences in simulated molar intrusion and unwanted buccolingual tipping. These findings are mechanistically useful but cannot establish the magnitude of clinical gummy-smile correction and therefore will remain a separate evidence stream.

Catego ry	Operation al definition	Typical measureme nts	Interpretati on
Absolu te intrusio n	Actual axial/apic al displacem ent of the target tooth or dentition.	CBCT; root/centroi d displaceme nt; 3-D superimpos ition; long- axis translation.	Strongest evidence for absolute intrusion.
Probabl e intrusio n	Vertical tooth displacem ent is measured,	Digital models; cephalomet ry; crown	Suggestive , but mechanis m cannot

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				but tipping/rotation is not independently resolved.	displacement.	be isolated.		
Relative vertical correction				Improvement in the smile/occlusal vertical relationship without proof that the change is entirely due to axial intrusion.	Gingival display; overbite; incisal-edge position; occlusal-plane relationships.	Clinical correction, not direct proof of mechanism.		
Mixed correction				Absolute intrusion accompanied by extrusion, tipping, posterior vertical change, or rotation.	3-D/CBCT plus occlusal or cephalometric measures.	Mechanistically heterogeneous.		
Alternative correction				Correction occurs predominantly through mechanisms other than target-tooth intrusion.	Extrusion; inclination; mandibular rotation; soft-tissue change.	Important for interpreting gummy-smile outcomes.		
Study	Design	Confoundings	Selection	Intervention classification	Missing data	Outcome measurement	Overall provision of risk	Rationale

													CBCT/rotation data strengthen measurement; no randomized design and movement heterogeneity remain limitations.
Zhang et al. 2015	Prospective/clinical accuracy	Serious	Moderate	Low/Moderate	Low/Moderate	Moderate	Serious						
Kravitz et al. [4] 2009	Prospective clinical	Moderate	Moderate	Moderate	Low/Moderate	Moderate	Moderate						Prospective, but no randomized comparator; heterogeneous

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								ne ou s mo ve me nt typ es.
Sa ch de v et al. 20 21	Pro spe ctiv e clin ical	Mo der ate	Mo der ate	Lo w/ Mo der ate	Lo w/ Mo der ate	Mo der ate	Mo der ate	Pla nn ed- vs- ac hie ved me tho dis use ful ; sin gle - ce nte r/i n- ho use sys tem lim its ge ner ali za bili ty.
K ho sr av i et al. [5] 20 17	Ret ros pect ive coh ort	Se ri ous	Mo der ate	Mo der ate	Lo w/ Mo der ate	Mo der ate	Se ri ous	Co mp osi te ov erb ite en dp oin t do es not iso late

								axi al int rus ion .
Sh ah ab ud din et al. [6] 20 23	Ret ros pect ive coh ort	Se ri ous	Mo der ate	Mo der ate	Lo w/ Mo der ate	Mo der ate	Se ri ous	No ran do mi ze d co mp ara tor ; mi xe d ver tic al me ch ani sm s.
C ha m be rla nd & N at af 20 24	Co mp arat ive obs erv atio nal	Se ri ous	Se ri ous	Mo der ate	Lo w/ Mo der ate	Mo der ate	Se ri ous	Dif fer ent me ch ani cs and tre at me nt sel ect ion cre ate im por tan t co nfo un din g.
Evide nce unit	Curre nt status	What is measured/ identified		Role in revie w	Publi cation- stage			

				caution
Direct EGD search stream	6 records	EGD/gummy-smile terms present	High est-priority clinical endpoint stream	Full-text eligibility not yet locked; do not count as included studies
Primary outcome sought	Gingival display reduction	Direct smile/gingival measurement	Clinical efficacy	Must be separated from tooth-movement surrogates
Mechanistic linkage	Absolute intrusion / relative vertical correction	Root/centroid/CBCT/ 3-D measures where available	Mechanism attribution	
Indirect evidence	Deep-bite/vertical-control studies	Overbite, incisor position, posterior vertical changes	Mechanistic support	Not equivalent to direct EGD evidence
Biomechanical evidence	FEA/laboratory studies	Force distribution, attachment effects	Mechanistic plausibility	Not pooled with clinical EGD efficacy
Current status	6 direct-EGD signal records identified	0 final direct-EGD studies locked	Working evidence map	

Study	Measurement / population	Evidence grade	Mechanism	Key quantitative finding	Interpretation
Al-Balala et al. [3] 2021	CBC T + ClinCheck; 22 patients/142 anterior teeth	Grade I	A	~51.19% anterior intrusion precision	Direct 3-D planned vs achieved movement; measurement/registration assumptions apply
Han et al. [9] 2025	CBC T + digital planning; adult female deep overbite	Grade I/II	A/D	~45.54% first-phase intrusion; ~41.18% completed-case overbite correction	Method-dependent; direct axial component should be distinguished from composite overbite correction
Choo et al. [10] 2026	Centroid-based; 27 adults; precision bite ramps	Grade I	A	~1.63 mm pure mandibular-incisor intrusion	Useful for separating translation from inclination; retrospective
Xiang et al. [15] 2026	CBC T + intraoral scans; Angel align	Grade I	A/D	Actual intrusion less than predicted; greater-than-	Proclination contributes to observed correction

				predic ted labial crown move ment	
Jin et al. [8] 2025	Digita l model s + ClinC heck; 24 deep- bite patien ts	Gra de II	E/D	~52.2 % overal l intru sion accur acy; inciso r intru sion ~0.7– 1.8 mm	Root translati on not indepen dently resolve d
Kang et al. [7] 2024	Digita l model s/Clin Chec k; 20 deep- bite patien ts	Gra de II/III	E/D	~37.6 3% first set; ~38.5 4% compl eted	Compos ite vertical correcti on; refinem ents relevant
Khosravi et al. [5] 2017	Ceph alome tric; n=12 0	Gra de III	D/ B	Medi an overb ite openi ng ~1.5 mm	Mainly incisor- position change; minimal molar vertical change
Shahabudin et al. [6] 2023	Digita l model s + ClinC heck; n=24	Gra de II/III	D/E	~33% overb ite correc tion; ~1.15 mm first series	Mixed mechan ism; planned vs achieve d differed
Chamberland & Nataf 2024	Ceph alome tric CAT vs brace s/TA Ds; n=34	Gra de III	B/ D	CAT overb ite increa se ~2.33 mm; lower - inciso r extrus	Support s extrusio n/vertic al- control interpre tation

					ion ~1.22 mm		
With ayan ukon kij et al. [12] 2023	Prosp ective comp arativ e; anteri or open bite	Gra de I/II	A/E	Maxil lary molar intrus ion ~0.68 mm CAT vs ~1.49 mm fixed/ TAD	Posterior mechan ism; not direct EGD		
Krav itz et al. [4] 2009	Prosp ective ; 37 patien ts/401 anteri or teeth	Gra de II	E/D	Overal l move ment accur acy ~41%	Intrusio n- specific mechan ism not fully resolve d		
Sach dev et al. 2021	Prosp ective ; 30 patien ts/259 anteri or teeth	Gra de II	E/D	Intrus ion accur acy ~43.2 8%; overall l ~56.1 8%	In- house aligners ; movem ent decomp osition limited		
Fan et al. [13] 2022	Finite - elemen t study	Bio mec hani cal	Me cha nist ic	Attac hment positi on altere d intru sive- force distrib ution/ tipping	Mechan istic only; not clinical efficacy		
Study	Design	Sample	CAT / intervention	Measurement	Key findings	Evidence grade	Role in synthesis

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Al-Balaa 2021	Retrospective /clinical accuracy	22 patients; 14 anterior teeth	Invisalign	CBCT + Clincheck	Anterior intrusion precision ~51.19%	Grade I	Direct 3-D mechanistic evidence
Han 2025	Clinical deep-bite study	33 adult females; 9 CBCT-completed cases	Invisalign	CBCT + digital planning	~45.54% first phase; ~41.18% complete case overbite correction	Grade I/II	Absolute vs composite correction
Jin 2025	Retrospective	24 deep-bite patients	Invisalign	Digital models + Clincheck	~52.2% overall intrusion accuracy	Grade II	Overcorrection/predictability

Choo 2026	Retrospective	27 adults	Invisalign + precision bite ramps	Centroid-based	~1.63 mm pure mandibular-incisor intrusion	Grade I	Absolute intrusion
Xiang 2026	Clinical 3-D	20 adults; 74 incisors + 24 canines	Angelalign	CBCT + intraoral scans	Actual intrusion less than predicted; greater labial crown movement	Grade I	Absolute intrusion + tipping
Kou 2026	Comparative	Study-	Clearaligner	Digital/clinical	Bite plan	Grade	Mechanism modifier

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	deep -bite	le v el fu ll te xt p e n d i n g	s ± bite pla nes	cal ver tica l out co me s	es di d not en hance an ter ior intru sion ; re duce d sp on ta ne ous m ol ar intru sion	e II	
Ka ng 202 4	Retr ospe ctive	2 0 d ee p- bite p a t i e n t s	Inv isal ign	Di git al mo del s + Cli nC hec k	~3 7. 63 % fir st se t; ~3 8. 54 % com ple ted	G ra de II /I II	Relati ve vertic al correc tion
Kh osr avi 201 7	Retr ospe ctive	1 2 0 p a t i e n t s	Inv isal ign	Ce pha lo me try	M ed ia n ov er bit e	G ra de II I	Inciso r- posi tion domin ant

					op en in g ~1 .5 m m		
Sha hab udd in 202 3	Retr ospe ctive	2 4 p a t i e n t s	Inv isal ign	Di git al mo del s + Cli nC hec k	~3 3 % ov er bit e cor rec tion ; ~1 .1 5 m m fir st se rie s	G ra de II /I II	Mixed /indet ermin ate
Ch am ber lan d & Nat af 202 4	Com para tive obse rvati onal	3 4 p a t i e n t s	CA T vs bra ces/ TA Ds	Ce pha lo me try	C A T ov er bit e +~ 2. 33 m m; lo w er- in ci so r ex tr us io n ~1 .2 2 m m	G ra de II I	Extrus ion/tip ping domin ant

Wit hay anu kon kij 202 3	Pros pecti ve com para tive	4 0 a d ul ts	CA T+s que ezi ng vs fixe d+ min iscr ews	CB CT + cep hal om etr y	M ol ar int ru si on ~0 .6 8 vs 1. 49 m m	G ra de I/ II	Poste rior intrusi on
Kra vitz 200 9	Pros pecti ve	3 7 p at ie nt s; 4 0 1 a nt er io r te et h	Inv isal ign	Pre dic ted vs ach ie ved dig ital mo del s	O ve ral l ac cu ra cy ~4 1 %	G ra de II	Histor ical predic tabilit y eviden ce
Sac hdev 202 1	Pros pecti ve	3 0 p at ie nt s; 2 5 9 a nt er io r te et h	In hou se align ers	ST L super im posit ion	In tr us ion ac cu ra cy ~4 3. 28 %; ov er all ~5 6. 18 %	G ra de II	Gener al intrusi on predic tabilit y

Discussion

Principal interpretation

The evidence supports vertical correction with CAT, including measurable absolute intrusion in selected studies, but not all vertical correction should be

equated with absolute intrusion. Three-dimensional/centroid studies provide the strongest mechanistic evidence; overbite, crown position, and cephalometric outcomes may reflect intrusion, extrusion, tipping, posterior change, or compensation.

Planned movement is not always fully expressed clinically. Reported intrusion predictability varies by measurement and protocol, so programmed intrusion should not substitute for achieved intrusion; overcorrection is a strategy, not proof of successful movement.

Absolute intrusion versus relative vertical correction

The distinction becomes particularly important in studies of deep-bite correction. Overbite is a relational measurement between the maxillary and mandibular incisors and can change through several pathways. A reduction in overbite may result from intrusion of one or both incisor segments, extrusion of opposing teeth, incisor inclination, posterior vertical changes, or combinations of these mechanisms. Consequently, a reported reduction in overbite cannot, by itself, establish the magnitude of absolute incisor intrusion. The same principle applies to changes in incisal-edge position and other two-dimensional measures when root translation or tooth inclination has not been independently resolved.

CBCT and centroid studies demonstrate measurable absolute intrusion while showing differences between planned and achieved movement and accompanying positional changes. Digital-model and cephalometric studies remain useful, but should be classified as probable intrusion or relative correction when axial movement cannot be isolated.

Clinical and methodological interpretation

For EGD, the clinically meaningful endpoint is reduction in gingival display during smiling. Absolute intrusion is a mechanism, not the aesthetic endpoint. Gingival display also depends on tooth position, gingival margins, vertical maxillary relationships, inclination, and lip dynamics; improvement may therefore reflect combined dentoalveolar and soft-tissue changes.

Direct EGD evidence is limited; much of the clinical literature concerns deep bite or vertical control. These studies inform mechanism but should not be presented as direct evidence of EGD reduction unless gingival display was measured. The review therefore separates direct EGD outcomes from indirect mechanistic evidence.

Measurement methodology is a major source of heterogeneity. Digital models assess crowns and occlusal relationships but may not resolve roots; cephalometry is projection-based; CBCT provides 3-D assessment but requires careful registration and entails radiation; centroid methods may better separate translation from tipping. Studies should report reference systems, registration, tooth segment, and crown/root/centroid measurements.

Attachments, bite ramps/planes, elastics, and overcorrection may alter force systems, but do not automatically demonstrate greater absolute intrusion. FEA studies explain potential force and tipping effects but should not be treated as clinical movement magnitudes.

Limitations and future research

The principal limitation is heterogeneity in patient selection, malocclusion, aligner system, auxiliaries, staging, refinement, outcomes, measurement, and follow-up. Many studies are retrospective or observational, and composite outcomes often cannot separate absolute intrusion from relative correction. Direct EGD evidence is also much smaller than the broader deep-bite/intrusion literature.

Quantitative pooling should be reserved for sufficiently comparable populations, outcomes, measurements, and follow-up. Otherwise, a structured narrative synthesis preserving the absolute-versus-relative distinction is more appropriate, with attention to risk of bias and treatment-selection differences.

Future studies should prospectively enroll clearly defined EGD phenotypes and report gingival-display reduction as a primary endpoint, alongside validated 3-D tooth movement, inclination, posterior changes, and planned-versus-achieved movement. Standardized smile photography/video, head position, landmarks, and refinement reporting are needed.

Comparative prospective studies should test whether auxiliaries, overcorrection, or aligner designs alter the proportion of correction attributable to absolute intrusion. Mechanisms should be prespecified and reported separately to improve future synthesis.

Conclusion

Clear aligner therapy can produce measurable absolute intrusion, but the available evidence indicates that vertical correction is often composite and that programmed intrusion is not necessarily achieved as planned. For excessive gingival display, reduction in gingival display should remain the primary clinical endpoint, while absolute intrusion and relative vertical correction should be reported as distinct outcomes. Overbite reduction or crown displacement should not be interpreted as absolute intrusion unless the measurement method adequately resolves the axial component. A mechanism-based framework that separates absolute intrusion, relative correction, mixed correction, and alternative vertical mechanisms provides a more clinically interpretable basis for evaluating CAT in gummy-smile management. The strength of any final clinical inference should remain proportional to the quality, directness, and methodological consistency of the available evidence.

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