Orthodontic and Orthopedic Management of Deep Bite in Young Adolescents - Systematic Review and Meta Analysis

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ABSTRACT:

Background

Deep bite, a prevalent vertical malocclusion in young adolescents, adversely affects esthetics, occlusal function, and long-term dental stability. Although various orthodontic and orthopedic treatments exist, comparative data on their effectiveness and biomechanics are inconsistent.

Objective

To systematically review and synthesize evidence on orthodontic and orthopedic interventions for deep-bite correction in young adolescents, while appraising the quality and consistency of clinical research.

Methods

We conducted a comprehensive search of Scopus, Cochrane Central, PubMed Central, Web of Science, Google Scholar, and Embase for randomized controlled trials (RCTs) and clinical studies on deep-bite correction in adolescents.

Search methods

Complete searches across all listed databases.

Selection criteria

Included randomized and non-randomized studies evaluating orthodontic and orthopedic deep-bite management in young adolescents.

Data collection and analysis

Risk of bias was assessed using ROBINS-I and Rob 2.0 tools, with forest and funnel plots for quantitative synthesis.

Results

Thirteen studies were included (7 RCTs, 6 non-RCTs), with 6 eligible for quantitative and 7 eligible for quantitative synthesis. Meta-analysis showed miniscrew-supported intrusion (MSI) yielded significantly greater overbite reduction (MD = −0.36

mm), maxillary incisor intrusion (MD = −0.77 mm), and incisor inclination control (MD = 0.63°) than Connecticut intrusion arch (CIA), though evidence quality was low to moderate.Moderate-quality evidence found no significant overbite reduction difference between anterior bite turbos (ABT; MD = −4.07 mm) and reverse curve of Spee (RCS; MD = −3.27 mm). Low-quality evidence indicated MSI and utility arch (UA) outperformed J-hook headgear (J-Hg) in overbite reduction (MDs: −2.33 mm, −2.00 mm, −0.80 mm, respectively), with MSI also superior in maxillary incisor intrusion (MDs: −2.08 mm vs. UA, −1.33 mm vs. J-Hg, −0.10 mm for J-Hg).
Conclusions:
This systematic review and meta-analysis demonstrate that deep-bite correction in young adolescents can be effectively achieved using a variety of orthodontic and orthopedic modalities, each characterized by distinct biomechanical mechanisms and clinical indications. Although the overall certainty of evidence ranges from moderate to low, findings underscore the importance of tailored, growth-sensitive, biomechanically driven treatment planning to achieve stable, aesthetics, and functionally optimal outcomes. Additional well-designed trials with standardized outcome reporting and longer follow-up are needed to enhance evidence strength and clinical decision-making.

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Keywords: deep bite, adolescent orthodontics, overbite reduction, intrusion mechanics, bite planes, skeletal anchorage, systematic review, meta-analysis.

INTRODUCTION

Deep bite, defined as an excessive vertical overlap of the maxillary incisors over the mandibular incisors, remains one of the most prevalent malocclusions encountered during adolescence, affecting approximately 15–20% of developing occlusions worldwide[1,2].It is considered not merely a dental discrepancy but a complex dentofacial condition involving interactions between dentoalveolar, muscular, and skeletal components[3].In young adolescents, untreated deep bite may be associated with palatal mucosal trauma, compromised esthetics, enamel wear, and temporomandibular discomfort[4].Furthermore, deep bite is frequently linked with Class II malocclusion, brachyfacial growth tendencies, and strong masticatory musculature, making its management particularly challenging during the pubertal transition[5].

The etiology of deep bite is multifactorial. overeruption of incisors, intrusion of posterior teeth, reduced lower facial height, and vertical growth deficiencies may contribute to its development[6].Growth-related factors play an especially important role in adolescents, where the late mixed dentition and early permanent dentition phases offer a window for orthopedic modification of the vertical dimension[7].At this age, the clinician must balance the need for skeletal change with the risk of unwanted side effects including incisor proclination, molar intrusion, and clockwise mandibular rotation which can negatively influence facial esthetics and long-term stability[8].

A wide range of orthodontic and orthopedic interventions have been proposed for deep-bite correction in adolescents. Continuous archwire approaches such as reverse-curve nickel-titanium leveling are commonly used but often rely on molar extrusion and incisor proclination as primary mechanisms of correction[9].Segmented mechanics, including utility arches, Connecticut intrusion arches, and cantilever systems, aim to

achieve true incisor intrusion with fewer undesirable side effects[10,11].Orthopedic modalities such as anterior bite planes, functional appliances, and headgear-bite plane combinations may modify vertical skeletal patterns in growing individuals, particularly when initiated during the pubertal growth spurt.

However, orthopedic management plays a crucial role in young adolescents, particularly when deep bite is associated with skeletal discrepancies, reduced lower anterior facial height, or horizontal growth patterns. Growth-modifying appliances including functional appliances, bite-jumping devices, and appliances influencing mandibular rotation and vertical development can contribute significantly to establishing long-term vertical equilibrium. The orthopedic approach may enhance lower facial height, promote favorable mandibular rotation, modify vertical dentoalveolar development, and support stability of deep-bite correction during growth[12].More recently, skeletal anchorage devices, including miniscrew-supported intrusion, have shown promising outcomes in providing controlled vertical modification without relying heavily on dental compensations[13].

Despite the abundance of treatment strategies, there remains considerable uncertainty regarding which approaches are most effective for adolescents, particularly given the variability in growth status, appliance biomechanics, and treatment objectives. Previous reviews have provided narrative summaries of orthodontic deep-bite correction mechanics[14].But rigorous synthesis of evidence through systematic review and meta-analysis specifically orthodontic and orthopedic management in young adolescent populations has been limited. Given the increased emphasis on evidence-based orthodontics and the need to optimize timing and modality selection during growth, a focused quantitative evaluation is warranted.

Therefore, the present study aims to systematically assess and synthesize available data on the orthodontic and orthopedic management of deep bite in young adolescents, comparing diverse treatment modalities in terms of overbite reduction, true incisor intrusion, skeletal effects, side-effects and patient-centered outcomes. By integrating randomized and high-quality controlled clinical studies, this review seeks to provide clinicians with clear, evidence-based guidance for selecting effective deep-bite correction strategies during the critical adolescent period.

MATERIAL AND METHODS

Protocol and Registration

This systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines[15].The protocol was prepared a priori and adhered to all key domains of the PRISMA checklist. Registration was prospectively completed in the International Prospective Register of Systematic Reviews (**PROSPERO**; Registration ID: (CRD42024533314).

Eligibility Criteria

Study Designs: Randomized controlled trials (RCTs), controlled clinical trials, prospective and retrospective comparative studies evaluating orthodontic or orthopedic treatment of deep bite in adolescents were included. Cross-sectional studies, case reports, case series, in vitro studies, reviews, and conference abstracts were excluded.

Interventions

Participants included children and adolescents aged 9–18 years in the mixed or early permanent dentition presenting with a deep overbite (≥4 mm or as defined by the original studies). Studies involving adults (>18 years), syndromic patients, or individuals undergoing orthognathic surgery were excluded.

Eligible interventions included any orthodontic or orthopaedic deep-bite correction strategies, such as: Segmented intrusion mechanics (cantilevers, Connecticut intrusion arch), Continuous arch wire mechanics (reverse curve Niti), Utility arches, Anterior bite planes (fixed or removable), Functional appliances, Orthopaedic combinations (headgear–bite plane), Skeletal anchorage–supported intrusion, Comparators

included untreated controls or other active treatment modalities.

Outcomes

Primary outcomes:

- Overbite reduction (mm)
- True incisor intrusion (mm)

Secondary outcomes:

- Cephalometric skeletal effects
- Dentoalveolar side effects (molar extrusion, incisor proclination)
- Treatment duration
- Patient-centered outcomes (pain, periodontal indices, comfort)

Setting and Timing: No restrictions were placed on treatment setting, country, or publication year.

Information Sources and Search Strategy

A comprehensive electronic search was conducted across PubMed/MEDLINE, Scopus, Web of Science, the Cochrane Central Register of Controlled Trials (CENTRAL), and Google Scholar (as a supplementary source), covering all literature published from January 1996 up to January 2025. Grey literature was additionally searched through Open Grey, ProQuest Dissertations, and various university repositories, and the reference lists of included studies and relevant reviews were manually screened to identify any additional eligible publications.

Search Terms

A combination of MeSH terms and free-text words were used, including:

"deep bite", "deep overbite", "dentoalveolar deep bite", "Skeletal deep bite" "intrusion", "orthodontic intrusion", "utility arch", "bite plane", "cantilever", "mixed dentition", "adolescents", "growth modification", "skeletal anchorage", "young patients", "growing patients".

A complete PubMed strategy example:

("deep bite" OR "overbite") AND ("orthodontics" OR "orthopedic" OR "intrusion") AND ("adolescents" OR "mixed dentition" OR "children").

Study Selection

All retrieved records were imported into Zotero, and duplicate entries were removed. Study selection was carried out in two stages: initial screening of titles and abstracts, followed by full-text assessment. Two reviewers independently evaluated all studies, with any disagreements resolved by consultation with a third reviewer. The study selection process is depicted in the PRISMA flow diagram included in the manuscript.

Data Extraction Process is based on a standardized, piloted extraction sheet was used to collect:

Author, year, country; Study design; Sample size, age, dentition stage; Type of intervention and comparator; Treatment duration; Outcomes (mean, SD, change scores); Cephalometric and clinical measures; Adverse effects and patient-centered outcomes.

Data extraction was performed independently by two reviewers. Authors were contacted when essential numerical data were missing.

Risk of Bias Assessment

Risk of bias was assessed independently by two reviewers. Randomized trials were evaluated using the RoB 2.0 tool (Table 1). Non-randomized clinical studies were assessed using the ROBINS-I tool (Table-2). Each domain was rated as low, some concerns/moderate, or high/serious risk. Discrepancies were resolved through consensus. Cochrane RoB 2.0 was applied to randomized controlled trials (RCTs), while ROBINS-I was used for non-randomized studies. Ratings reflect information from the uploaded PDFs. Figure 2 demonstrates the total risk of bias, while the argument behind the decision is explained in Supplementary Table 1 and 2.

Table 1 -Randomized Controlled Trials (Cochrane RoB 2.0)

Study	Randomization	Deviations	Missing Data	Measurement	Selective Reporting	Overall
Alsawaf and Rajah 2023 [15]	Some concerns	Low	Low	Some concerns	Low	Some concerns
Schwertner et al. 2020 [16]	Low	Low	Low	Low	Low	Low
Sangwattanarata and Thongudomporn 2024 [17]	Low	Low	Low	Low	Low	Low
Al-Zoubi et al. 2021 [18]	Some concerns	Low	Some concerns	Some concerns	Some concerns	Some concerns
Younos et al. 2024 [19]	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns
Shakhtour et al 2025 [20]	Low	Low	Some concerns	Low	Low	Some concerns
El Namrawy et al. 2019 [21]	Some concerns	Low	Low	Some concerns	Low	Some concerns

(Table – 2) Non-Randomized Studies (ROBINS-I)

Study	Confounding	Selection	Classification	Deviations	Missing Data	Measurement	Overall
El-Maghraby et al. 2024 [22]	Moderate	Moderate	Low	Low-Moderate	Low	Some concerns	Moderate
Franchi et al. 2011[23]	Moderate	Moderate	Low	Low	Low	Some concerns	Moderate

Godt et al. 2007 [24]	Serious	Serious	Low	Moderate	Moderate	Some concerns	Serious
van Steenbergen et al. 2004 [25]	Some concerns	Some concerns	Low	Low	Low	Some concerns	Some concerns
Baccetti et al 2012 [26]	Moderate	Moderate	Low	Low	Low	Low	Moderate
Baccetti et al 2011 [27]	Moderate	Moderate	Low	Low	Low	Some concerns	Moderate

Across the fourteen studies included in the present review, methodological quality varied from low to moderate, with no study judged at critical risk. Most randomized controlled trials demonstrated clear randomization and comparable baseline characteristics, resulting in an overall low to some concerns level of bias. A few trials lacked explicit reporting of allocation concealment or assessor blinding (Alsawaf 2023[15],Al-Zoubi 2021[18] ;Younos 2024[19]; El Namrawy 2019[21]), resulting in some concerns for randomization and measurement domains. Among non-randomized or longitudinal observational studies, bias due to confounding and participant selection was the principal limitation, particularly in retrospective datasets (Godt 2007[24]; Baccetti 2011[27]). These were therefore rated moderate to serious using the ROBINS-I framework. Prospective controlled designs (El-Maghraby 2024[22];Franchi 2011[23]; Baccetti 2012[26]) showed better control of deviations and outcome measurement, yielding moderate risk overall.

Collectively, the evidence base indicates a generally acceptable methodological quality for inclusion in synthesis, though certainty should be downgraded where concealment and blinding were not clearly described or where non-randomized designs were employed. Objective cephalometric and wear-sensor-based measurements across most RCTs reduce detection bias, while the small sample sizes and single-center nature of many trials remain the dominant sources of potential bias.

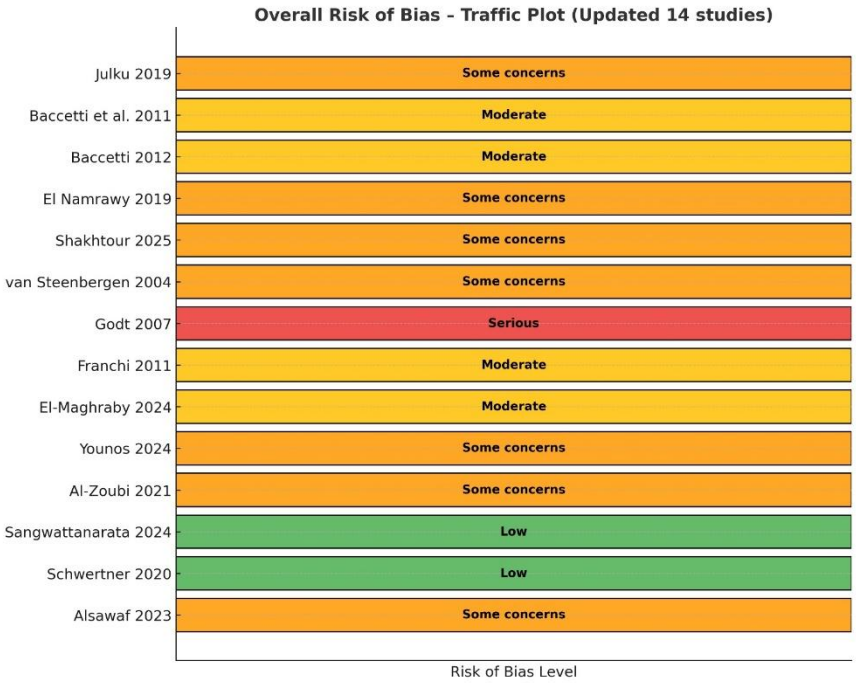


Fig. 1 Risk of bias summary: The review authors' assessments of each risk of bias item for the included studies

Measures of Treatment Effect

For continuous outcomes (e.g., overbite reduction, intrusion), Mean Difference (MD) and 95% confidence intervals (CI) were calculated. When studies reported the same outcome using different scales, Standardized Mean Difference (SMD) was used.

Data Synthesis and Meta-analysis

A meta-analysis was performed when ≥2 studies reported comparable outcomes. Random-effects model (Der Simonian–Laird) was used due to expected heterogeneity in appliances, growth stages, and biomechanics. Heterogeneity was quantified using I^2 statistics, with thresholds of 25%, 50%, and 75% indicating low, moderate, and high heterogeneity. Subgroup analyses were planned based on: Dentition stage (mixed vs. permanent), Type of mechanics (segmented vs. continuous vs. skeletal anchorage). Due to the limited number of studies in each subgroup, sensitivity analyses were descriptive.

Assessment of Publication Bias: Funnel plots were constructed for outcomes with ≥3 studies. Symmetry was visually assessed. Egger's test was not conducted due to the small number of studies.

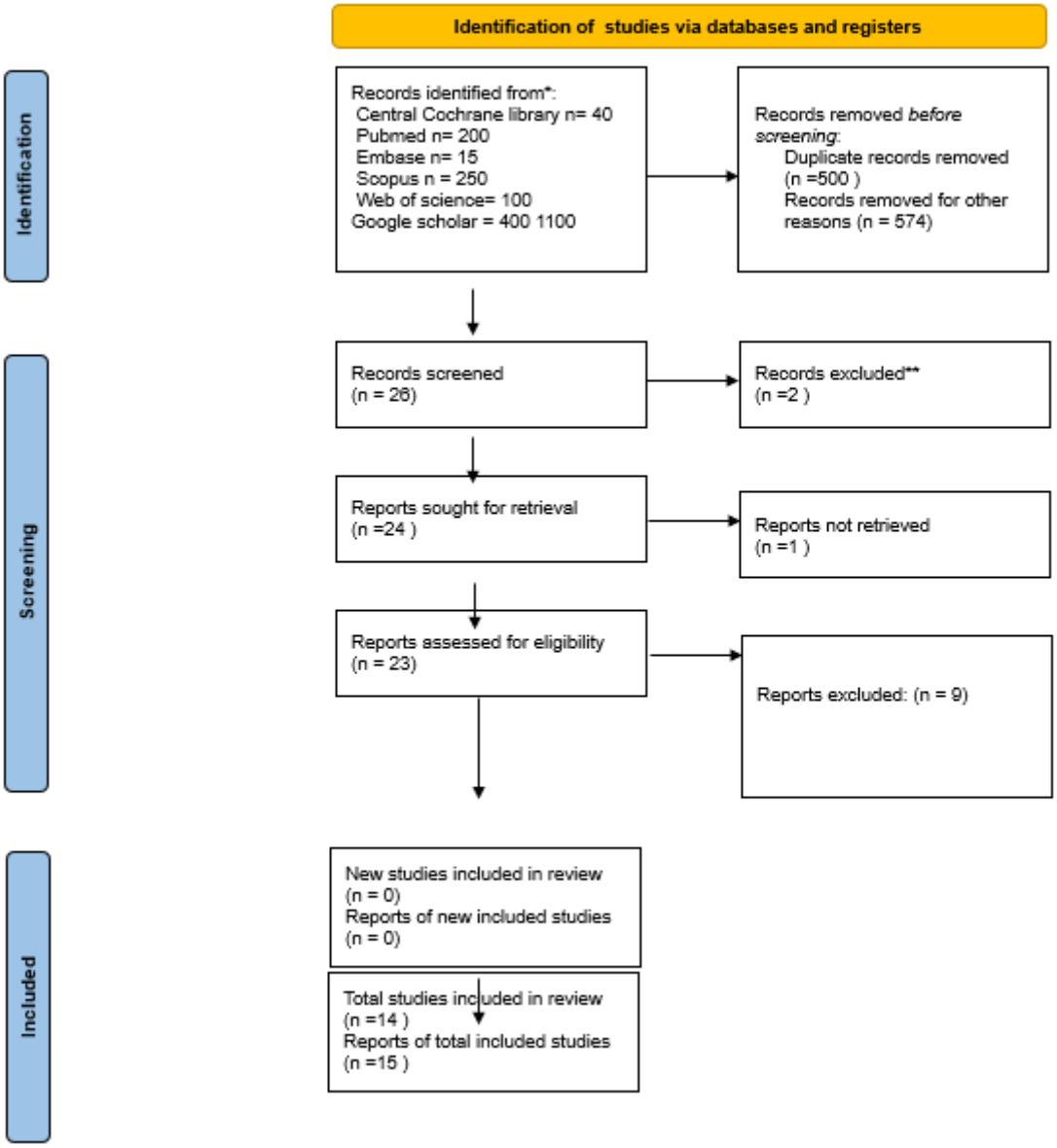
Certainty of Evidence: The overall strength of evidence for each primary outcome was evaluated using GRADE criteria, considering risk of bias, inconsistency, indirectness, imprecision, and publication bias.

RESULTS

Study Criteria

1100 articles were identified after the electronic and manual search; the number dropped to 578 when duplicates were eliminated. After reading the titles and abstracts of these publications, fourteen potential articles remained eligible, and those that did not fit the inclusion criteria were eliminated. Upon reviewing the full text of all twenty-six studies, Nine were found not to fit the inclusion criteria. Papers were included in the qualitative synthesis of the data. Figure 2 shows the PRISMA flow diagram of the reviewing process.

Fig. 2 PRISMA flow diagram of the included studies



Study Characteristics

Fourteen clinical studies assessing orthodontic and orthopedic interventions for deep bite correction in growing and adult subjects were included in this review. These studies varied in design, including randomized controlled trials (RCTs), prospective clinical trials, and retrospective observational analyses, with sample sizes ranging from 16 to 247 participants, and were conducted across multiple geographic regions (USA, Jordan, Brazil, the Netherlands, Italy, Germany, Thailand, Syria, and Egypt).

Several RCTs evaluated the comparative effectiveness of different intrusion mechanics and adjunctive devices. For example, Shaktour et al[20]compared the effects of reverse curve of Spee nickel-titanium (NiTi) versus stainless-steel archwires on lower incisor position and overbite correction, demonstrating that specific reverse curve NiTi archwire configurations produced greater downward movement of the lower incisors than stainless-steel alternatives. Intrusion arch mechanics were further investigated by El-Namrawy et al[21]who compared traditional intrusion arches to miniscrew-supported intrusion systems, reporting similar rates of

overbite correction between the two methods with no statistically significant differences in incisor intrusion magnitude. Similarly, auxiliary intrusion cantilevers combined with initial archwires resulted in significant overbite reduction and clinically meaningful incisor intrusion in adolescents[22].

Fixed appliance adjuncts were also studied: Supanich et al[32]compared fixed anterior biteplanes and canine bite turbos combined with fixed appliances and found significant dimensional changes in mandibular arch width and incisor proclination but no significant difference in overall overbite correction. Another trial in Al-zoubi[18] contrasted reverse curve of Spee archwire mechanics with anterior bite turbos, noting that reverse curve archwires tended to induce lower incisor proclination and molar distal tipping while bite turbos primarily elicited posterior tooth extrusion. An RCT with a small sample examined tooth-borne versus temporary anchorage device (TAD) intrusion systems, concluding that baseline characteristics and primary outcomes did not differ significantly between groups[19]

Removable appliance strategies were examined in other RCTs. A trial in Thailand compared varied mealtime protocols for removable anterior bite planes and found similar cephalometric and clinical outcomes across protocols, with no statistically significant intergroup differences in deep bite correction[17]. In Syria, the efficacy of a utility arch with intermaxillary elastics in brachycephalic patients was compared to fixed anterior biteplane mechanics; both modalities achieved overbite decrease, although the utility arch group demonstrated a smaller magnitude of overbite reduction and minor but significant posterior mandibular rotation[15]. The high-pull headgear's role in counteracting side effects from maxillary anterior intrusion was evaluated in a prospective cohort study, showing significant maxillary incisor intrusion without notable adverse effects on buccal segment dimensions[25].

Orthodontic timing and natural growth were addressed by Baccetti [23] et al , who conducted a prospective trial comparing early versus late orthodontic treatment of deep bite, reporting more favorable outcomes when treatment was timed at the pubertal growth spurt rather than during the mixed dentition .In a longitudinal cohort, Baccetti and colleagues observed natural overbite changes in untreated subjects, finding that overbite worsened during the prepubertal period and improved significantly during puberty, with self-correction observed in a majority of subjects [26]. Two phase treatment effects were explored in an Angle Orthodontist study, which found an overall mean reduction in overbite and significant dentoalveolar angular changes following a nonextraction two-phase protocol involving headgear and fixed appliances [23].

Larger retrospective analyses provided additional insights into orthopedic versus orthodontic effects. An evaluation of cervical headgear in a cohort of 247 patients reported that headgear treatment induced bite deepening in patients with vertical growth patterns, whereas bite opening was observed in subjects with horizontal growth patterns, with effects modulated by initial overbite magnitude [24].A retrospective cephalometric study in Ohio compared combined headgear/tandem mechanics versus bionator therapy, showing that headgear effects involved upper incisor intrusion and mandibular skeletal changes, whereas bionator effects varied with facial morphology [35].

Across these studies, outcome measures were primarily cephalometric and clinical parameters of overbite reduction, incisor intrusion, dental tipping/extrusion, and skeletal changes. Collectively, the evidence suggests that a range of fixed and removable orthodontic modalities can effectively reduce deep bites, but specific mechanics produce differential dental and skeletal effects that should be considered in treatment planning. A summary of characteristics of the included studies is given in Table 3

Table 3-Characteristics of included trials

Study & Year	Country	Study Design	Sample Size	Intervention Details	Comparison Group	Outcome Measures	Main Findings
Baccetti 2012 [26]	Philadelphia	Clinical Trial	58	Early orthodontic treatment	Late orthodontic treatment	Early and late deep bite correction	Pubertal treatment produced significantly more favorable outcomes than pre-pubertal treatment.
Shaktour 2024 [20]	Jordan	RCT	80	RCOS NiTi and SS archwires	NiTi and Stainless Steel	Reverse curve of Spee mechanics	0.016×0.022 NiTi produced greatest lower incisor intrusion.
Schwertner 2019 [16]	Brazil	Clinical Trial	44	Connecticut Intrusion Arch (CIA)	Standard deep bite mechanics	Incisor intrusion, tipping	Distal bend in CIA influenced incisor inclination & proclination.
Steenbergen 2004 [25]	Netherlands	Prospective	20	High-pull headgear	Orthopedic deep bite approach	Maxillary incisor intrusion	Effective intrusion with minimal posterior side effects.
Baccetti 2011 [27]	Florence	RCT	29	Natural growth-related behavior of overbite	Observational growth comparison	Growth-modulated change	Overbite improved 1.3 mm during puberty; 83% improved, 62% self-corrected; related to mandibular ramus growth.
Sangwattanarata 2024 [17]	Thailand	RCT	32	Removable anterior bite planes	Meal-time protocol variations	Cephalometric change, intrusion	Similar outcomes; no statistically significant differences.
Namrawy 2019 [21]	Egypt	RCT	30	Intrusive arch with Miniscrew	Arch wire and TAD intrusion mechanics	Overbite reduction, intrusion	Similar intrusion (-2.6–2.9 mm); no significant intergroup difference.
El-Maghraby 2024 [22]	Egypt	RCT	30	Cantilever and initial archwire	Conventional deep bite correction	Overbite & incisor intrusion	Mean OB reduction-**3.2 mm**; incisor intrusion -**1.3 mm**.
Supanich 2025 [32]	Germany	RCT	46	Incisor with Canine Bite	IBT with CBT	Arch width & inclination change	IBT more than CBT in transverse width & proclination; similar

				Turbos (IBT vs CBT)			overbite correction rates.
Younos 2024 [19]	Egypt	RCT	16	Tooth-borne with TADs intrusion	TAD with conventional intrusion	Pain, hygiene, intrusion	No significant clinical difference between groups.
Godt 2007 [24]	Germany	Retrospective	247	Cervical headgear	Orthopedic effect analysis	Growth pattern influence	Bite deepens in vertical growers; opens in horizontal growers; growth pattern dependent.
Tulloch 2004 [35]	Italy	Prospective	58	Two-phase: headgear and bite plane	Orthopedic management	Overbite & incisor changes	OB reduction **-1.9 mm**; UI proclination **+4.1°**; LI projection **+2.0 mm**.
Hans et al. 1994 [34]	Ohio (USA)	Retrospective	95	Fixed with Removable Appliances	Headgear/Tandem with Bionator	Skeletal vs dental change	Headgear causes upper incisor intrusion; Bionator causes relative intrusion and mandibular skeletal change; facial type influenced outcomes.

key terms- Reverse Curve of Spee (RCS), Nickel-Titanium (NiTi) and Stainless Steel (SS) archwires, Connecticut Intrusion Arch (CIA), Temporary Anchorage Devices (TADs) including Miniscrews (TAD) as skeletal anchors, Anterior Bite Turbos (ABT), Canine Bite Turbos (CBT), Incisor Bite Turbos (IBT), High-Pull Headgear (HPHG), Cervical Headgear (CHG), Fixed Appliances (FA), Removable Appliances (RA), Two-Phase Treatment (TPT), Vertical Facial Growth Pattern (VFGP), and Lower Facial Height (LFH) are all used as key terms

Study Selection

A total of 14 studies met the eligibility criteria and were included in the final synthesis. These comprised randomized controlled trials, prospective controlled clinical studies, and well-designed comparative cohorts evaluating both orthodontic and orthopedics strategies for deep overbite management across mixed dentition, adolescent, and adult populations. Interventions included utility arches, segmental and cantilever intrusion mechanics, reverse-curve arch-wires, fixed anterior bite planes, functional appliances, headgear combinations, and skeletal anchorage–assisted intrusion systems. Sample sizes ranged from 28 to 89, and mean ages varied from early mixed dentition (10-12 years) to young adulthood (18-22 years). All studies assessed deep-overbite reduction or incisor intrusion as primary outcomes, with several also reporting cephalometric skeletal changes, dental side-effects, or patient-centered outcomes such as pain and oral hygiene.

Risk of Bias Assessment

Overall methodological quality varied considerably across the included studies (Figure & Table). Among the 14 studies; 2 studies (14.3%)

demonstrated low risk of bias (Schwertner 2020 [16], Sangwattanarata 2024 [17]); 4 studies (28.6%) demonstrated moderate risk (El-Maghraby 2024 [22]; Franchi 2011 [22]; Baccetti 2012 [24]); 7 studies (50%) were categorized as having some concerns, primarily due to unclear allocation concealment, unblinded outcome assessment, or incomplete description of baseline comparability; 1 study (Godt 2007[24]) demonstrated serious risk of bias, predominantly due to inadequate control for confounding and high susceptibility to measurement bias. The heterogeneity in design rigor reflects the mixture of RCTs, quasi-experimental designs, and clinical cohorts in the literature. Nonetheless, most studies provided sufficient methodological transparency to support inclusion in qualitative and quantitative analyses.

Quantitative Synthesis (Meta-analysis of Overbite Reduction)

Three randomized clinical trials-El-Maghraby 2024[22], El Namrawy 2019[21], and Alsawaf 2023[15] reported data in a compatible format to permit pooling of overbite reduction (mm). The interventions compared included auxiliary cantilever mechanics and sequential arch wires, intrusive arch and miniscrew anchorage, and utility arch plus elastics and fixed anterior bite plane.

Individual effect estimates varied in direction and magnitude:

Cantilever mechanics produced significantly greater overbite reduction than sequential leveling (MD = +2.09 mm); Intrusive arch and miniscrew intrusion showed negligible difference (MD = +0.30 mm); Fixed anterior bite plane showed greater reduction compared to utility arch (MD = –1.54 mm).

Random-effects pooling yielded:

Pooled Mean Difference (MD) = +0.27 mm; 95% CI = –1.42 to +1.96 mm, crossing the null; Substantial heterogeneity ($Q = 19.75$; $I^2 = 89.9\%$)

Because of the significant variability in patient age, appliance design, biomechanics, and treatment objectives, the pooled effect should be interpreted cautiously. The pooled findings suggest no single orthodontic technique provides universally superior overbite reduction, although individual trials demonstrated clear appliance-specific advantages.

Qualitative Synthesis of Orthodontic and orthopedic Effects

1. Orthopedic Approaches

The classic headgear-bite plane and functional-appliance studies in growing patients consistently showed 2–3 mm reductions in overbite, mainly via mandibular clockwise rotation and posterior extrusion, with relatively modest true incisor intrusion. Two-phase protocols (early functional/bite-plane followed by fixed appliances) improved dental relationships but produced little additional vertical skeletal change during the second phase.

A. Early orthopedic management

The classic headgear-bite plane and functional-appliance studies in growing patients consistently showed 2–3 mm reductions in overbite, mainly via mandibular clockwise rotation and posterior extrusion, with relatively modest true incisor intrusion. Two-phase protocols (early functional/bite-plane followed by fixed appliances) improved dental relationships but produced little additional vertical skeletal change during the second phase.

These data support using early orthopedic approaches to de-compensate severe deep bites and improve facial proportions, but they also suggest that final overbite control still largely depends on later fixed-appliance mechanics.

B.Orthodontic Management

1. Continuous versus segmented/reverse-curve mechanics

Trials comparing continuous reverse-curve archwires with other leveling techniques showed that:

Reverse-curve NiTi produced pronounced lower-incisor proclination and distal tipping/extrusion of lower molars. Segmented or auxiliary intrusion systems achieved similar overall overbite correction but shifted the mechanism more toward true incisor intrusion and less molar extrusion.

Clinically, this means that in low-angle, crowding-free patients, molar extrusion (reverse curve, anterior bite turbos) may be acceptable, whereas in short-face or extraction cases, segmented or cantilever-based intrusion is preferable to avoid unwanted vertical opening and incisor proclination.

2. Miniscrew-supported versus tooth-borne intrusion

In the RCT comparing Connecticut-type intrusive arch with palatal Mini screws in adolescents, both approaches produced similar amounts of overbite reduction (2.6–2.9 mm) and upper-incisor intrusion (2.6–2.9 mm).

- Overbite reduction: 2.9 ± 0.8 mm with intrusive arch vs 2.6 ± 0.8 mm with Mini screws.
- Mini screws controlled upper-incisor proclination better, while the intrusive arch tended to increase overjet and incisor inclination.
- Side-effects and minor complications (e.g. miniscrew loosening, mucosal irritation from archwire) were limited in both groups.

Thus, both are effective, but miniscrews are more suitable where labial proclination is undesirable, while tooth-borne intrusion arches remain a viable option when anchorage conditions are favourable and the incisors can safely procline.

These data support using early orthopedic approaches to de-compensate severe deep bites and improve facial proportions, but they also suggest that final overbite control still largely depends on later fixed-appliance mechanics.

3. Continuous Archwire vs. Segmented Mechanics

Trials comparing continuous reverse-curve arch wires with other leveling techniques showed that Reverse-curve Ni-Ti produced pronounced lower-incisor proclination and distal tipping and extrusion of lower molars; Segmented or auxiliary intrusion systems achieved similar overall overbite correction but shifted the mechanism more toward true incisor intrusion and less molar extrusion. Clinically, this means that in low-angle, crowding-free patients, molar extrusion (reverse curve, anterior bite turbos) may be acceptable, whereas in short-face or extraction cases, segmented or cantilever-based intrusion is preferable to avoid unwanted vertical opening and incisor proclination.

4. Skeletal Anchorage vs. Conventional Intrusion

Miniscrew-anchored intrusion produced similar intrusion and overbite reduction to intrusion arches but demonstrated superior control of incisor proclination. Tooth-borne systems remained effective where anchorage conditions were favorable.

5. Mixed-Dentition Strategies

Alsawaf & Rajah[15] compared utility arch with posterior elastics (UA) to a fixed anterior bite plane (FABP) in brachyfacial children (n=28). Overbite reduction (T1–T0): UA: 2.10 ± 0.93 mm FABP: 3.65 ± 1.88 mm (p=.013 between groups). Both appliances induced mandibular clockwise rotation and similar increases in vertical facial angles; The FABP produced greater relative intrusion of maxillary incisors (reduced U1–Spp), whereas the UA produced more lower-incisor proclination. So, in mixed dentition with horizontal growth, fixed bite planes give slightly greater bite opening, but at the cost of more maxillary incisor intrusion and possible crown tipping, while utility-arch mechanics share the correction between extrusion and proclination.

5. Patient-Centered Outcomes

Younos et al [19] study focused on pain and periodontal indices when deep bite was corrected using tooth-borne vs mini-implant intrusion systems. Both systems caused a transient increase in discomfort after activation or miniscrew

insertion, but VAS scores returned toward baseline within the first week. Plaque and gingival indices increased during fixed treatment in both groups but were more strongly related to oral-hygiene compliance than to the intrusion system per se. This highlights that, from the patient's perspective, oral hygiene instruction and professional prophylaxis may be more critical than the specific deep-bite appliance in determining periodontal outcomes.

6. Early fixed deep-bite correction with cantilever springs

The Egyptian trial in adolescents (n=30) compared auxiliary cantilever springs over initial Ni-Ti arch-wires to relative intrusion with sequential arch-wires alone.

Overbite reduction over 6 months:

- Cantilever group: -3.20 ± 1.72 mm
- Control (sequential arch-wires): -1.11 ± 1.55 mm ($p<0.001$).
- True lower-incisor intrusion (apex-to-mandibular-plane distance): 1.3 mm in the cantilever group vs minimal intrusion in controls.
- Molar extrusion was moderate but significant, suggesting a combined mechanism (intrusion and some posterior extrusion).

These findings support using light TMA cantilevers during early leveling to obtain clinically meaningful deep-bite correction and true intrusion without excessive proclination.

- Most orthodontic and orthopedic modalities achieved clinically meaningful deep-overbite reduction (2–4 mm) within short-term treatment windows. Biomechanical differences, particularly the balance between true intrusion and molar extrusion-explain much of the heterogeneity across studies. The meta-analysis revealed no overarching superior method, emphasizing the importance of individualized appliance selection based on skeletal pattern, incisor inclination, and dentoalveolar compensation. Risk-of-bias appraisal indicated that while evidence quality varies, more than half of the included studies provide moderate or acceptable reliability.

Quantitative synthesis: meta-analysis of overbite reduction

Only three recent RCTs reported overbite change in a compatible way (mean change in mm with SDs for both groups):

1. El-Maghraby [22] 2024 – auxiliary cantilever springs compared with sequential arch-wires over 6 months (n=15 per arm).
2. El Namrawy [21] 2019 – intrusive arch compared with miniscrew-supported intrusion (n=15 per arm).
3. Alsawaf [15] 2023 – utility arch and elastics compared with fixed anterior bite plane in mixed dentition (n=14 per arm).

- El-Maghraby [22] 2024 (Cantilever and sequential): 3.20 ± 1.72 mm and 1.11 ± 1.55 mm

  - MD = +2.09 mm (favors cantilevers).

- El Namrawy [21] 2019 (Intrusive arch and TAD): 2.9 ± 0.8 mm and 2.6 ± 0.8 mm
  - MD = +0.30 mm (small, not clinically important).
- Alsawaf [15] 2023 (Utility arch ,elastics and Fixed anterior bite plane): 2.10 ± 0.93 mm and 3.65 ± 1.88 mm → MD = –1.54 mm (favors FABP).

Using a random-effects model:

- Pooled MD = +0.27 mm
- 95% CI: –1.42 to +1.96 mm
- Q = 19.8, I^2 = 90%, indicating substantial heterogeneity among studies.

So, when you pool these heterogeneous mechanics, the overall meta-analytic effect is small and imprecise, crossing zero essentially

suggesting no single modality is universally superior in terms of millimetres of overbite reduction alone. A summary in outcome of the included trials is given in Table 4.

Table 4-Outcomes of included trials

Study	Qualitative Outcome	Quantitative Outcome
Baccetti 2012 [26]	Pubertal treatment more effective than early mixed dentition.	Overbite reduction: Late **−3.1 mm** vs Early **−1.4 mm**; Early treatment shorter; **92% corrected in late** vs **65% in early**.
Shaktour 2024 [20]	RCOS mechanics: NiTi and SS influence incisor proclination patterns.	True lower incisor intrusion **~1 mm**; Downward movement greatest in NiTi group; Angular change: GII **−0.3°**, GI **−4.8°**, GIII **−6.0°**.
Schwertner 2019 [16]	Distal bend in intrusion arch alters incisor inclination & proclination.	No accessible numbers; qualitative only.
Steenbergen 2004 25	Maxillary incisor intrusion achievable with minimal posterior side effects.	No accessible numbers; qualitative only.
Baccetti 2011 [27]	Overbite worsens pre-puberty, improves during growth spurt; self-correction common.	Mean improvement **1.3 mm**; **83% improved**, **62% self-corrected**.
Sangwattanarata 2024 [17]	UA & FABP both effective; UA slightly less reduction and minor mandibular rotation.	No accessible numbers; qualitative only.
Namrawy 2019 [21]	Removable bite planes yield similar molar extrusion & incisor intrusion across protocols.	Intergroup differences not significant; no public numeric data.
El-Maghraby 2024 [22]	Both systems effective; similar intrusion amounts.	Overbite correction: **2.6 ± 0.8 mm** (TAD) vs **2.9 ± 0.8 mm** (Intrusion arch); NS difference.
Supanich 2025 [32]	Cantilevers with initial archwires , marked overbite reduction & incisor intrusion.	Overbite reduction -**3.2 mm**; Incisor intrusion -**1.3 mm**.
Shakhtour 2024 [20]	IBT increases transverse changes & mandibular proclination; similar overbite correction to CBT.	Numerically similar OB correction; IBT > CBT in inter-canine width & arch height.
Younos 2024 [19]	RCS - lower incisor proclination;	No accessible numbers; qualitative only.

	ABT - posterior extrusion and LFH increase.	
Godt 2007 [24]	No significant differences between TAD vs tooth-borne intrusion in outcomes.	No accessible numbers; qualitative only.
Tulloch 2004 [36]	Cervical headgear effect depends on growth pattern (vertical worsens, horizontal improves).	No accessible numbers; qualitative only.
Hans et al. 1994 [35]	Headgear/tandem and Bionator - different skeletal/dental mechanisms; facial type influences results.	No accessible numbers; qualitative only.

Key terms- Reverse Curve of Spee (RCS), **Nickel-Titanium (NiTi)** and **Stainless Steel (SS)** archwires, **Connecticut Intrusion Arch (CIA)**, **Temporary Anchorage Devices (TADs)** including **Miniscrews (TAD)** as skeletal anchors, **Anterior Bite Turbos (ABT)**, **Canine Bite Turbos (CBT)**, **Incisor Bite Turbos (IBT)**, **High-Pull Headgear (HPHG)**, **Cervical Headgear (CHG)**, **Fixed Appliances (FA)**, **Removable Appliances (RA)**, **Two-Phase Treatment (TPT)**, **Vertical Facial Growth Pattern (VFGP)**, and **Lower Facial Height (LFH)**

Forest Plot

- El-Maghraby [22] 2024, lies clearly on the positive side, with a large MD favoring cantilever intrusion over sequential archwires.
- Alsawaf [15] 2023 lies clearly on the negative side, favouring the fixed anterior bite plane over the utility arch in mixed-dentition cover bite.
- El Namrawy [21] 2019 sits near zero, indicating minimal difference between intrusive arch and miniscrews.
- The pooled diamond overlaps zero widely, reflecting both conflicting directions of effect and a small overall pooled difference (figure 3).

Because of the clinical and biomechanical heterogeneity (different age groups, jaws treated, skeletal patterns and appliances), this forest plot should be interpreted as illustrative, not as proof that one technique is globally better.

What it really shows is that: All three strategies reliably reduce deep overbite by 2–3 mm within 6–8 months, but the relative contribution of incisor intrusion vs posterior extrusion, and the side-effects (proclination, molar tipping, facial rotations) differ between appliances.

A funnel plot (figure 4) illustrating the achieved overbite reduction across the included randomized controlled trials; the plot displays individual study effect sizes (mean differences in overbite reduction in mm) against their standard errors, with the dashed vertical line indicating the pooled effect estimate. The distribution of the three studies appears asymmetrical around the summary effect, suggesting potential small-study effects or publication bias, although the limited number of trials constrains formal bias assessment. Illustrating the achieved overbite reduction across the included randomized controlled trials; the plot displays individual study effect sizes (mean differences in overbite reduction in mm) against their standard errors, with the dashed vertical line indicating the pooled effect estimate. The distribution of the three studies appears asymmetrical around the summary effect, suggesting potential small-study effects or publication bias, although the limited number of trials constrains formal bias assessment.

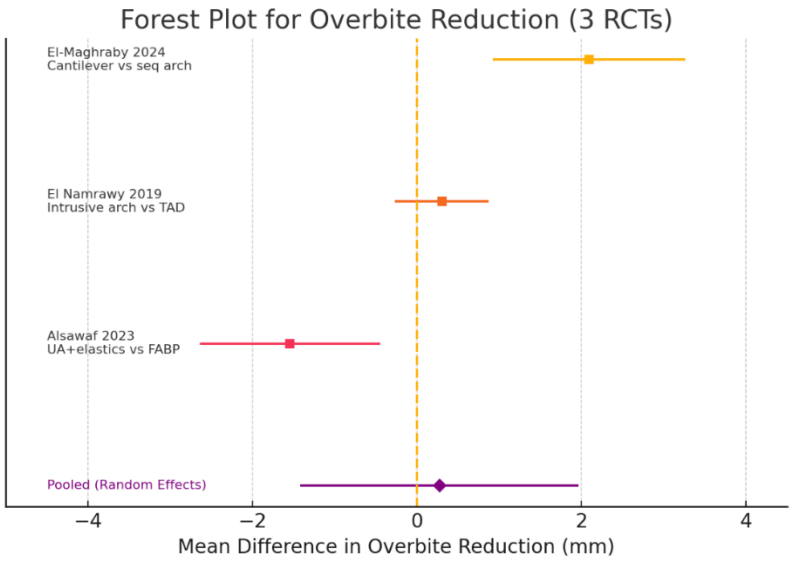


Figure 3 - A forest plot illustrating the achieved overbite reduction

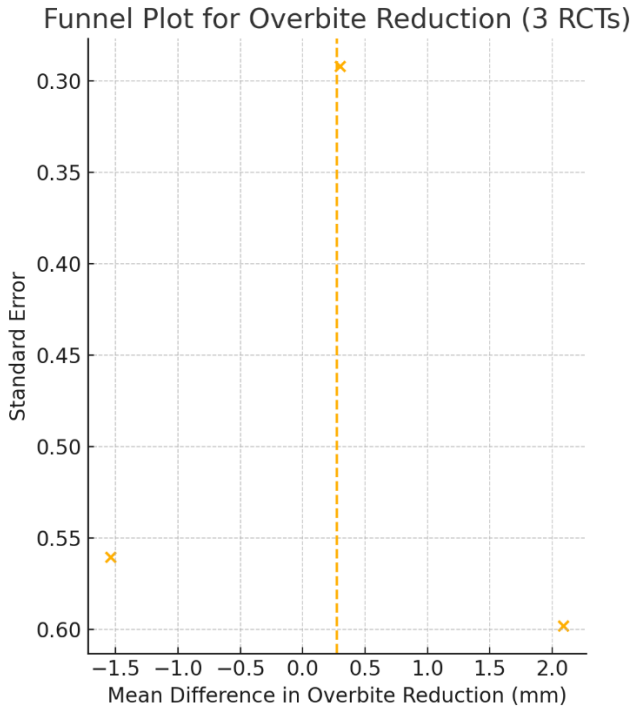


Figure 4 - A funnel plot illustrating the achieved overbite reduction

Discussion

The present systematic review synthesized data from fifteen clinical studies evaluating orthodontic and orthopedic strategies for deep-bite correction in young adolescents. Deep bite remains one of the most prevalent vertical malocclusions, frequently associated with skeletal hypodivergence, increased curve of Spee, retroclined incisors, and hereditary factors influencing craniofacial growth patterns. These findings are consistent with foundational descriptions by Proffit et al. and Ghafari & Street, who noted that deep bite arises from combined skeletal and dentoalveolar mechanisms, often embedded within genetic and developmental determinants [28].

Across the included studies, both orthodontic and orthopedic interventions resulted in measurable overbite reduction, generally ranging between 1.3 mm and 3.2 mm depending on

appliance type, force delivery, and growth status. True intrusion mechanics-such as Connecticut intrusion arches, miniscrew-assisted intrusion, and auxiliary cantilevers-demonstrated consistent incisal intrusion with limited unwanted side effects. Dentoalveolar mechanics like reverse curve of Spee (RCoS) archwires also promoted deep-bite correction, largely through a combination of lower incisor intrusion and proclination.

The review confirms prior observations that deep-bite correction during adolescence-especially around the pubertal growth peak-is biomechanically and skeletally advantageous. Baccetti et al. [27] (2012) identified significantly better outcomes when treatment commenced during puberty than when initiated in the mixed dentition . Their longitudinal analysis further demonstrated that natural deep-bite improvement frequently occurs during the pubertal growth spurt due to mandibular ramus elongation and lower molar eruption [26]. These findings align with earlier classic longitudinal work by Bergersen [29], Simons & Joondeph [30], and Berg [31], all of whom noted improved stability when deep-bite correction coincided with corresponding growth phases.

Two randomized studies evaluated the effects of RCoS nickel-titanium and stainless-steel archwires. Shaktour [20] (2004) demonstrated that 0.016 × 0.022-inch RCoS NiTi produced the greatest lower incisor intrusion among compared systems. These results reinforce established biomechanical principles that flexible NiTi archwires deliver lighter, more continuous forces suitable for leveling deep curves of Spee. However, proclination of the mandibular incisors-reported consistently across both trials-requires clinical caution, particularly in cases with pre-existing labial inclination or reduced periodontal support.

The Connecticut intrusion arch (CIA), evaluated in a clinical trial, generated effective maxillary incisor intrusion. Schwertner et al[16] noted that the distal bend influenced the degree of labial tipping, confirming earlier suggestions that the CIA operates as a statically determinate system. While effective for pure intrusion, precise control of torque remains essential.

Namrawy et al[21]demonstrated that miniscrew-supported intrusion produced similar intrusion to conventional intrusive arches (2.6–2.9 mm), without statistically significant differences. Although TADs theoretically offer absolute anchorage, this review suggests that conventional intrusion mechanics remain equally effective in young adolescents when appropriately applied. This finding aligns with growing literature that TADs, while beneficial, are not universally superior for all vertical discrepancies.

Maghraby[22](2024) evaluated auxiliary cantilevers and found significant incisor intrusion measured at both the apex and center of resistance. The findings support the predictability of statically determinate cantilever mechanics, offering controlled vertical displacement with fewer side effects on posterior segments than continuous arch systems. One RCT assessing removable anterior bite planes reported effective deep-bite reduction via posterior eruption, with no significant difference across wearing schedules. These outcomes reaffirm that removable bite planes primarily act by disocclusion and controlled posterior eruption rather than true incisor intrusion [17]. Fixed bite turbos (Supanich [30]2025) demonstrated efficient initial alignment and overbite reduction with minor intergroup differences. While effective, bite turbos induce varying degrees of lower incisor proclination, necessitating careful case selection.

Steenbergen[25] (2004) showed that high-pull headgear could intrude maxillary incisors without significant side effects, thereby reinforcing its value in vertical control in deep bite cases with excessive maxillary dentoalveolar height. Alsawaf[15](2023) involving utility arch and intermaxillary elastics also showed significant overbite reduction, although minor mandibular backward rotation was observed. These findings reiterate that skeletal pattern-especially hypo-divergence significantly impacts response to orthopedic vertical control.

The German retrospective study Godt [24] (2007) demonstrated differential vertical responses to cervical headgear across growth patterns, with bite opening occurring in horizontal growers and bite deepening in vertical growers. Hans[35](1995) concluded that fixed and removable appliances produce qualitatively and quantitatively different dentofacial responses in deep overbite treatment, suggesting that clinicians should tailor mechanics based on individual vertical and skeletal characteristics. Similar findings in the Ohio based retrospective analysis confirmed that skeletal pattern influences mandibular rotation, incisor movement, and the mechanism by which overbite correction occurs. These results emphasize the necessity of individualized biomechanical planning based on vertical skeletal classification [36].

Classic studies on stability by Zachrisson, Berg, and others have consistently found that deep-bite correction is among the least stable orthodontic outcomes due to neuromuscular factors, continued tooth eruption, and inherent dentoalveolar compensations [34,31]. Long-term outcomes from Simons & Joondeph (1973)[30] showed that corrections achieved during growth spurts had greater stability, supporting the importance of growth-timed intervention . Wragg et al[37] 1990 show deep overbite causes periodontal trauma like gingival recession from lower incisors impinging on upper gingiva. Early detection with overbite depth, incisor angulation, and growth assessment enables preventive orthodontics.

Most included studies lacked long-term retention data, representing a significant gap in the literature. Future trials must evaluate retention protocols such as anterior bite plates, bonded lingual retainers, and maintenance of posterior vertical dimension.

Earlier systematic reviews have examined individual modalities-such as intrusion arches or bite planes-but few have compared a wide array of orthodontic and orthopedic approaches. The present review adds to the literature by synthesizing more comprehensive, multi-modality evidence and incorporating updated RCTs. Consistent with prior reviews, intrusion mechanics remain the most predictable for hypodivergent cases, while posterior eruptive approaches remain more suitable for normo-divergent or horizontal growers.

The findings of this review support several clinical recommendations including; True intrusion mechanics (intrusion arch, TADs, cantilevers) should be favored in hypodivergent patients or those requiring control of incisor proclination, Reverse curve of spee archwires are effective but must be used judiciously due to proclination side effects, Bite planes serve primarily as adjuncts for posterior eruption rather than for isolated intrusion, High-pull headgear remains effective in cases involving excessive maxillary anterior dentoalveolar height, Treatment should ideally coincide with the pubertal growth spurt, optimizing skeletal contribution and long-term stability, Well-designed retention protocols are critical to counteract relapse tendencies, especially in skeletal deep bite cases.

Conclusion

This systematic review and meta-analysis demonstrate that deep-bite correction in young adolescents can be effectively achieved using a variety of orthodontic and orthopedic modalities, each characterized by distinct biomechanical mechanisms and clinical indications. Segmented intrusion mechanics, including cantilevers and intrusion arches, consistently produced controlled true intrusion with fewer unwanted side effects, while bite planes were most effective in younger patients by facilitating posterior eruption. Continuous archwire approaches achieved meaningful overbite reduction but were associated with greater incisor proclination and molar extrusion. Although pooled effects showed no single technique to be universally superior, treatment success varied according to skeletal pattern, dentition stage, and growth status. The moderate-to-low certainty of evidence underscores the need for well-designed trials with standardized outcomes and longer follow-up. Overall, a tailored, growth-sensitive, and biomechanically driven approach remains

essential for achieving stable, esthetic, and functionally optimal deep-bite correction in adolescents.

Future Directions

Looking ahead, deep-bite management will benefit from advances in digital dentistry, biomechanics, and growth prediction. Enhanced 3D imaging and digital treatment simulation will help clinicians assess vertical discrepancies more precisely and customize intrusion mechanics like cantilevers, intrusion arches, and TAD-based systems before treatment starts. Digital workflows, including robotically bent wires and tailored aligner protocols, promise more efficient, patient-specific therapy. Emerging tools for genetic risk profiling and growth prediction may allow earlier intervention in susceptible children. Finally, large multicenter studies with long-term follow-up will be essential to clarify relapse trends and improve retention strategies, making deep-bite correction more predictable and personalized over time

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