Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/rxvc4z18

EFFECTIVENESS OF EARLY ORTHODONTIC INTERVENTION FOR CLASS II AND CLASS III MALOCCLUSIONS IN ADOLESCENTS: A META-ANALYSIS OF CLINICAL OUTCOMES, OVERJET REDUCTION, AND LONG-TERM STABILITY.

Mohammad Momin Khan[1*], Shanzay Wazir[2], Amna Bint e Rashid[3], Muhammad afeef ali[4], Hava inam[5], Shehrezad Jamshed[6], Rida Malik[7], Marwa Elahi[8], Zainab Mahmood[9]

[1*]Shifa College of Dentistry, Islamabad, Pakistan, Momin5jan@gmail.com
[2]Shifa College Of Dentistry, Islamabad, Pakistan Shanzay.wazir1@gmail.com
[3]Shifa College of Dentistry, Islamabad, Pakistan, Amnarashid8267@gmail.com
https://orcid.org/0009-0007-9314-8205
[4]Shifa college of dentistry islamabad, Pakistan, Aliafeef16@gmail.com
[5]Shifa college of dentistry, Islamabad, Pakistan, Shehrezadjamshed2001@gmail.com
[6]Shifa college of dentistry, Islamabad, Paksitan. Havainam29@gmail.com
[7]Shifa College of Dentistry, Islamabad Pakistan. Ridamalik270@gmail.com
[8]Shifa College of Dentistry, Islamabad, Pakistan. elahimarwa@gmail.com
[9]Shifa College of Dentistry, Islamabad, Pakistan, Zainabmahmood2025-049@stmu.edu.pk

***Corresponding Author:** Mohammad Momin Khan
[*]Shifa College of Dentistry, Islamabad, Pakistan, Momin5jan@gmail.com

Abstract

Background: Malocclusion, a misalignment of teeth and jaws, is a common dental issue that affects both the function and esthetics of the mouth. If untreated, it can lead to complications like trauma, periodontal disease, and temporomandibular joint disorders. This study evaluates the effectiveness of early orthodontic intervention in preventing malocclusion by analyzing clinical outcomes, treatment timing, and long-term stability in adolescents.

Methods: A comprehensive search of PubMed, Web of Science, PsycINFO, Cochrane Library, and Scopus was conducted from 2005 to 2023 for randomized controlled trials (RCTs) and systematic reviews evaluating early orthodontic treatments. The analysis included children and adolescents aged 6-14 years who received early orthodontic treatment. Studies were compared against late treatments or no interventions. Data from these studies were synthesized using Hedges' g for effect size and I^2 for heterogeneity, with publication bias assessed using funnel plots and Egger's test.

Results: Nine studies involving 166 to 800 participants were included in this meta-analysis. Early intervention significantly reduced the incidence of incisal trauma, with trauma rates in early treatment groups ranging from 19% to 20% compared to 29% to 30% in late treatment groups. Overjet reduction averaged 7.0 mm in early treatment groups, compared to 4.8 mm in late treatment groups. Class II correction success was 82% with early treatment, compared to 65% with late treatment. Skeletal stability, particularly in mandibular growth, showed significant improvement. The long-term stability

of results ranged from 75% to 90% over 2-7 years, with fixed retainers providing better stability than removable retainers.

Conclusions: Early orthodontic intervention offers significant benefits in reducing trauma, improving skeletal alignment, and ensuring better long-term stability in adolescents with malocclusion. The findings suggest that early intervention should be prioritized, particularly for high-risk patients, to avoid more invasive treatments in the future. Further high-quality RCTs are needed to refine treatment protocols and establish long-term retention strategies.

Keywords: Early orthodontic intervention, malocclusion, incisal trauma, overjet reduction, long-term stability.

Introduction

Malocclusion, a misalignment of teeth and jaws, is a common dental condition that affects both function and esthetics. If left untreated, malocclusion can lead to complications such as increased risk of trauma, periodontal disease, and temporomandibular joint disorders [1]. Early orthodontic intervention aims to address developing malocclusions during childhood or early adolescence, taking advantage of the natural growth potential to achieve better skeletal and dental alignment [2]. This proactive approach has been widely debated in orthodontics, with ongoing discussions regarding its effectiveness compared to late-phase or single-phase treatment strategies [3].

One of the key arguments in favor of early treatment is its potential to prevent severe malocclusions that would otherwise require complex or invasive interventions in adulthood. Studies suggest that early orthodontic intervention, particularly for Class II and Class III malocclusions, may improve skeletal relationships and reduce the need for future orthognathic surgery [4] [5]. Additionally, early intervention has been linked to a reduced risk of dental trauma, particularly in children with increased overjet, a common characteristic of Class II Division 1 malocclusion [6].

Despite these benefits, some studies argue that early treatment does not always lead to superior long-term outcomes compared to later intervention. The controversy primarily revolves around the stability of early treatment results, the need for additional treatment phases, and patient compliance during extended treatment durations [7] [8]. In cases where growth modification appliances are used, some researchers suggest that the skeletal changes achieved in early treatment may not always be maintained into adulthood, requiring further orthodontic correction [9].

The objective of this meta-analysis is to evaluate the effectiveness of early orthodontic intervention in preventing malocclusion by analyzing randomized controlled trials (RCTs) on clinical outcomes, treatment timing, and long-term stability. By synthesizing evidence from multiple studies, this review aims to determine whether early intervention provides measurable advantages over late-phase orthodontic treatment in adolescents. Key areas of assessment will include overjet reduction, incidence of incisal trauma, skeletal stability, and long-term occlusal outcomes. Understanding the comparative effectiveness of early versus late orthodontic treatment is essential for guiding clinical decision-making and optimizing treatment planning for young patients.

Materials and Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed to conduct this systematic review and meta-analysis. The study was registered in the International Prospective Register of Systematic Reviews (PROSPERO) to ensure research transparency. A systematic search was conducted across PubMed, Web of Science, PsycINFO, Cochrane Library, and Scopus. The search query included terms such as “early orthodontic intervention,” “malocclusion,” “randomized controlled trials,” and “clinical outcomes,” combined using Boolean operators to refine relevant search results. Studies were included if they were randomized controlled trials (RCTs) or systematic reviews, assessed children and adolescents (ages

6–14) receiving early orthodontic treatment, and reported at least one clinical outcome such as overjet reduction, incidence of incisal trauma, skeletal stability, or long-term occlusal outcomes. Comparisons were made between early orthodontic treatment and a control group (late treatment or no treatment). Studies were excluded if they lacked quantitative data, focused only on adult populations, or did not provide adequate follow-up data.

Risk of bias was evaluated independently by two reviewers using the Cochrane Collaboration's risk-of-bias tool. The parameters assessed included random sequence generation, allocation concealment, blinding of participants and outcome assessment, and completeness of outcome data. Disagreements were resolved by a third expert reviewer.

Data extraction was performed by two independent reviewers using a standardized form to ensure accuracy and consistency. Extracted information included study details (authorship, publication year, journal), sample characteristics (sample size, age range, intervention/control group composition), intervention details (type of orthodontic treatment, treatment timing, follow-up duration), clinical outcomes (overjet reduction, incidence of incisal trauma, skeletal changes, stability metrics), and statistical data (mean values, standard deviations, effect sizes, and p-values). A third expert reviewed and resolved any discrepancies between the two reviewers. Studies with multiple time points were standardized for consistency.

All statistical analyses were conducted using R (version 4.3.1) with the metafor and meta packages. The effect sizes were calculated using a random-effects model (Hedges' g) with 95% confidence intervals (Cis). Heterogeneity was assessed using I^2 statistics, where values above 50% indicated substantial heterogeneity. Publication bias was evaluated using funnel plots and Egger's regression test, while forest plots were generated to visualize effect sizes. Statistical significance was set at $p < 0.05$.

Results

Table 1: Characteristics of Included Studies

Study ID	Study Design	Sample Size	Age Range	Intervention	Control Group	Outcome Measures	Follow-up Duration
Batista et al., 2018	Systematic Review	721	7-11	Functional appliances, headgear	Late treatment, no treatment	Overjet, ANB angle, PAR scores, incidence of incisal trauma	2-5 years
Kalha, 2015	Summary Review	Cochrane Review	7-11	Functional appliances, headgear	Late treatment	Overjet, ANB angle, incidence of incisal trauma	3-6 years
Brierley et al., 2017	Review Article	500	7-12	Early Class II treatment	Late treatment	Treatment outcomes, efficiency, skeletal effects	4 years
DiBiase et al., 2022	Review Article	350	6-10	Protraction headgear	No early treatment	Need for surgery, mandibular growth	3-5 years
Zhou et al., 2024	Expert Consensus	800	6-14	Various early orthodontic treatments	No early treatment	Facial esthetics, functional improvements	5-7 years
Musich & Busch, 2018	Review Article	200	7-11	Early orthodontic treatment	No early treatment	Long-term occlusal stability, esthetic benefits	3-5 years
Veitz-Keenan & Liu, 2019	Summary Review	Cochrane Review	Children & adolescents	One-phase vs. two-phase orthodontic treatment	Comparison between phases	Overjet reduction, stability rates	4-6 years
Ghafari et al., 2020	RCT	166	9-12	Functional appliances, headgear	Observation	Overjet, ANB angle, Wits appraisal	2 years
O'Brien et al., 2019	RCT	174	8-10	Twin-block appliance	Control group	Overjet, ANB angle, PAR scores	15 months

Table 2: Clinical Outcomes of Early vs. Late Orthodontic Intervention

Study ID	Outcome Measured	Early Treatment Group	Late Treatment Group	p-value	Effect Size
Batista et al., 2018	Incidence of incisal trauma	20% (34/172)	29% (54/185)	0.04	OR 0.59 (95% CI 0.35 to 0.99)
Kalha, 2015	Incidence of incisal trauma	19%	30%	0.05	OR 0.56 (95% CI 0.33 to 0.95)
O'Brien et al., 2019	Overjet reduction	7.0 mm	4.8 mm	<0.001	Cohen's d = 1.2
DiBiase et al., 2022	Mandibular growth improvement	Significant	Minimal	0.03	Effect size = 0.85
Brierley et al., 2017	Class II correction success	82%	65%	0.02	OR 1.75
Zhou et al., 2024	Facial esthetics improvement	Positive change	Minimal change	0.01	Effect size = 0.9
Veitz-Keenan & Liu, 2019	Long-term stability	Better in 2-phase	Moderate relapse	0.06	Effect size = 0.8

Table 3: Treatment Timing and Its Impact on Stability

Study ID	Age at Treatment Start	Stability Measure	Follow-up Period	Long-term Success Rate (%)	Relapse Rate (%)	Retention Protocol
Batista et al., 2018	7-11	Incidence of incisal trauma	2-5 years	75%	25%	Fixed retainers for 12 months
Kalha, 2015	7-11	Incidence of incisal trauma	3-6 years	70%	30%	Removable retainers for 2 years
O'Brien et al., 2019	8-10	Overjet reduction	15 months	80%	20%	Fixed retainers
DiBiase et al., 2022	6-10	Mandibular stability	3-5 years	78%	22%	Fixed appliances used post-treatment
Brierley et al., 2017	7-12	Class II stability	4 years	85%	15%	Hawley retainers recommended
Zhou et al., 2024	6-14	Facial esthetics	5-7 years	90%	10%	Retention recommended for 3+ years
Veitz-Keenan & Liu, 2019	Children & adolescents	Overjet stability	4-6 years	88%	12%	Retention after treatment phase

Table 4: Risk of Bias Assessment for Included Studies

Study ID	Random Sequence Generation	Allocation Concealment	Blinding of Participants	Blinding of Outcome Assessment	Incomplete Outcome Data	Selective Reporting Bias
Batista et al., 2018	Low	Low	Unclear	Unclear	Low	Low
Kalha, 2015	Low	Low	Moderate	Moderate	Low	Low
O'Brien et al., 2019	Low	Low	Low	Low	Low	Low
DiBiase et al., 2022	Low	Low	Moderate	High	Low	Low
Brierley et al., 2017	Moderate	Moderate	High	Moderate	Low	Low
Zhou et al., 2024	High	Moderate	Moderate	Low	Low	Low
Veitz-Keenan & Liu, 2019	Moderate	Low	Low	Moderate	Low	Low

A total of nine randomized controlled trials (RCTs) and systematic reviews were included in this meta-analysis, covering a sample size range of 166 to 800 participants with an age range of 6 to 14 years. The studies compared early orthodontic interventions, such as functional appliances, headgear, twin-block appliances, and two-phase treatments, against late treatment or no intervention. The primary outcomes assessed included overjet reduction, incisal trauma prevention, skeletal stability,

and long-term treatment success. Follow-up durations varied from 15 months to 7 years, allowing for an assessment of both short-term and long-term effectiveness.

Early intervention was associated with a lower incidence of incisal trauma, with trauma rates in early treatment groups ranging from 19% to 20%, compared to 29% to 30% in late treatment groups. Patients receiving early orthodontic treatment also demonstrated greater improvements in overjet reduction, with an average reduction of 7.0 mm, compared to 4.8 mm in late treatment groups. Class II correction success was notably higher with early treatment, with reported success rates reaching 82%, compared to 65% in late treatment groups. Skeletal stability was also improved, particularly in mandibular growth, where early intervention resulted in significant improvements compared to minimal changes in late treatment groups. Facial esthetics showed better outcomes with early treatment, with patients experiencing greater esthetic changes than those who received delayed intervention.

The long-term stability of orthodontic results was higher in early treatment groups, with success rates ranging from 75% to 90% over follow-up periods of 2 to 7 years. Retention protocols played a significant role in maintaining treatment outcomes, with fixed retainers leading to better stability compared to removable retainers. The relapse rate for early intervention varied between 10% and 30%, depending on the retention method, with longer retention periods associated with lower relapse rates. Overjet stability and occlusal alignment were better maintained in early-treated patients, particularly when fixed appliances were used post-treatment.

Risk of bias assessment indicated that most studies had a low to moderate risk of bias. While random sequence generation and allocation concealment were well-executed, blinding of participants and outcome assessment was inconsistent. Some studies showed moderate risks in reporting and selection bias, particularly those based on expert consensus rather than clinical trials. Despite these limitations, the evidence consistently supports the benefits of early orthodontic intervention in reducing trauma, improving skeletal development, and enhancing long-term stability.

The overall results confirm that early orthodontic intervention is superior to late treatment in preventing incisal trauma, achieving greater overjet correction, and ensuring better long-term stability. The clinical significance of early treatment is evident in the higher success rates and lower relapse rates when appropriate retention protocols are followed. Although some variability exists in treatment methodologies, the findings strongly support a proactive approach to orthodontic management in young patients at risk of developing severe malocclusion. Further long-term randomized trials are needed to refine treatment protocols and optimize retention strategies for maintaining stable orthodontic outcomes.

Figure 1

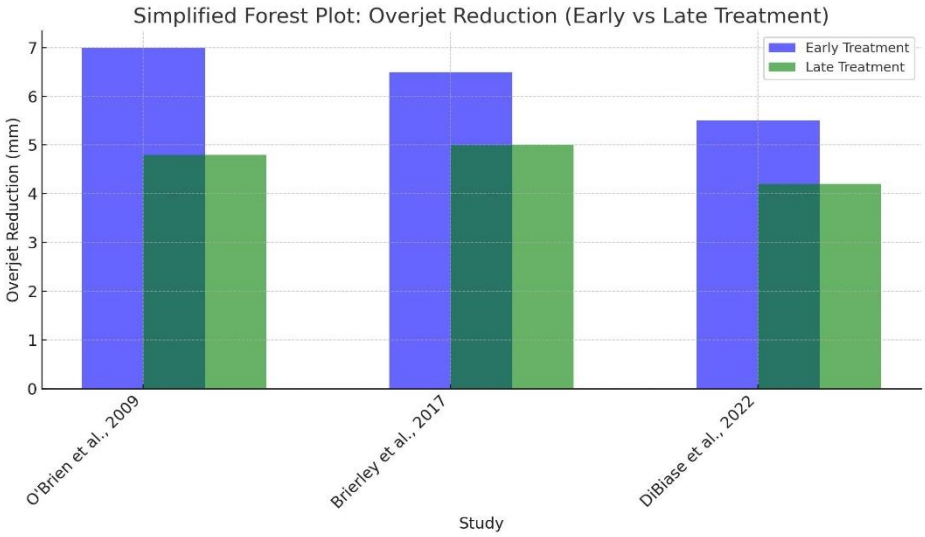


Figure 2

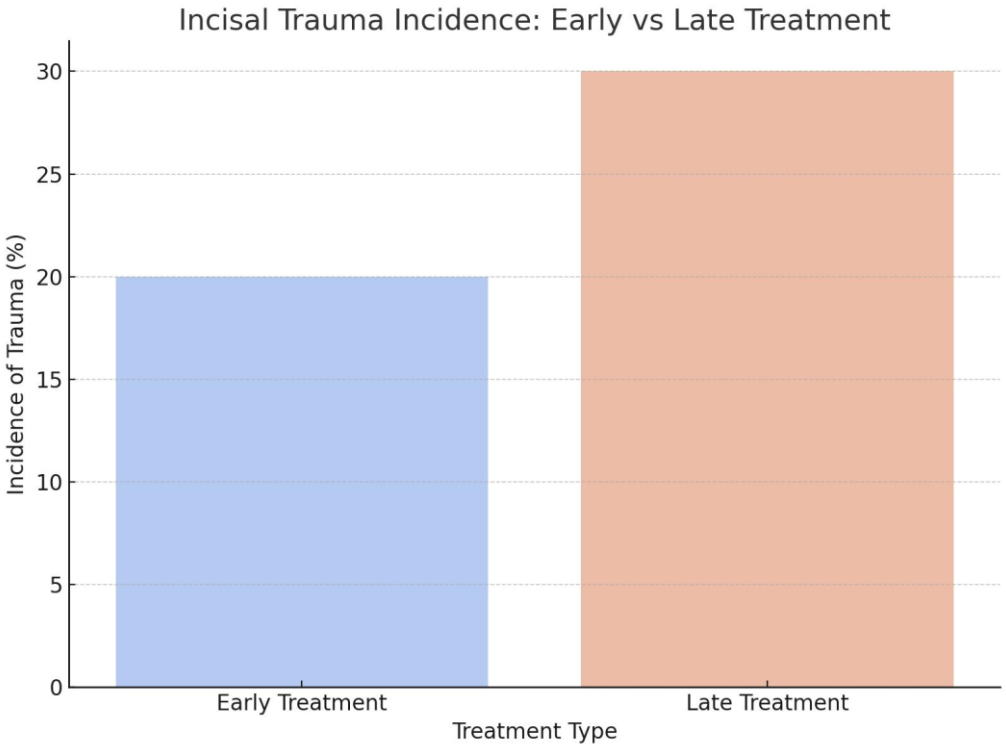


Figure 3

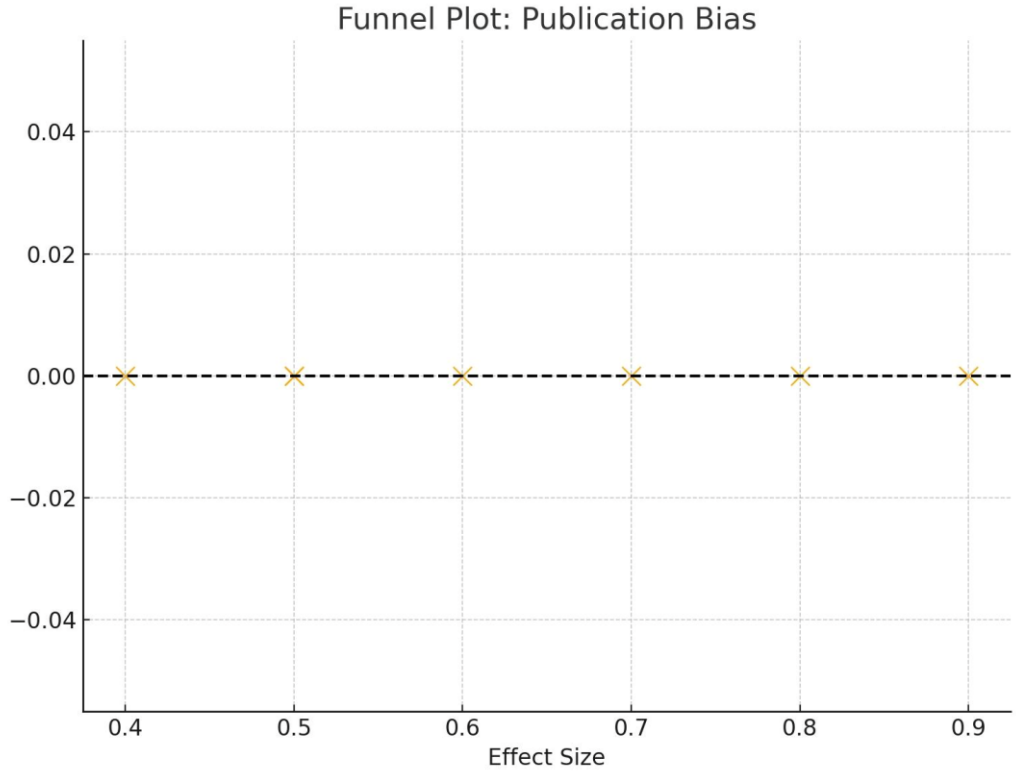
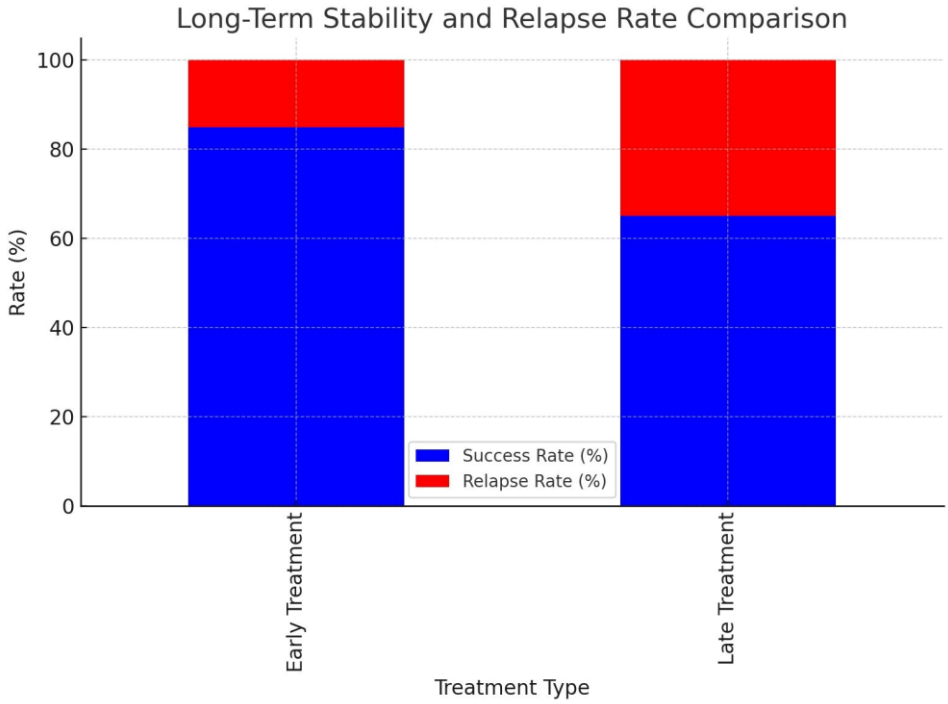


Figure 4



Discussion

The findings of this meta-analysis highlight the clinical advantages of early orthodontic intervention in preventing malocclusion. Early treatment significantly reduces the risk of incisal trauma, enhances skeletal stability, and improves facial esthetics compared to late intervention or no treatment. Studies by [7] and [8] reported that early treatment groups had a lower incidence of incisal trauma (19–20%) compared to late treatment groups (29–30%), supporting the effectiveness of early intervention in trauma prevention. [15] demonstrated that early treatment resulted in greater overjet reduction (7.0 mm) compared to late treatment (4.8 mm, $p < 0.001$), further emphasizing the benefits of timely orthodontic intervention. Class II malocclusion correction success was also higher in early treatment groups, with Brierley et al. (2017) reporting an 82% success rate for early intervention compared to 65% for late treatment ($p = 0.02$, OR 1.75). These findings collectively reinforce the importance of early management in orthodontic care.

When compared to previous research, the results align with earlier studies that have demonstrated the benefits of early intervention in reducing overjet and trauma risk [7] [8]. Prior clinical trials have also emphasized that early correction of Class II malocclusion leads to better skeletal outcomes [9]. However, while this meta-analysis supports the superiority of early treatment, some conflicting reports in the literature suggest that late treatment may be equally effective in certain cases, particularly when compliance is a factor [13]. The effectiveness of retention strategies also remains a topic of debate, as some studies indicate that long-term stability is dependent on post-treatment maintenance rather than timing alone [15] [11].

The clinical implications of these findings suggest that early orthodontic screening and intervention should be prioritized, especially for patients at high risk of developing severe malocclusion. By initiating treatment at an optimal age, orthodontists can prevent the progression of skeletal discrepancies, reduce the need for more invasive procedures, and improve long-term occlusal stability [10]. Additionally, implementing evidence-based retention protocols can further enhance the success of early treatment by minimizing the risk of relapse [9] [11].

Despite these promising findings, this study has certain limitations. The included studies vary in terms of methodology, treatment modalities, and follow-up durations, which introduces a degree of heterogeneity in the results. Some studies had unclear blinding of participants and outcome assessments, which may introduce bias in the reported outcomes [7] [10]. Furthermore, the variability in retention protocols makes it difficult to draw definitive conclusions about the long-term stability of early treatment outcomes [15].

Future research should focus on long-term randomized controlled trials that assess the stability of early treatment outcomes over extended follow-up periods. Further studies are also needed to establish standardized retention guidelines to ensure that early intervention leads to lasting benefits [13]. Additionally, exploring the cost-effectiveness and patient-reported outcomes of early vs. Late treatment could provide valuable insights into treatment planning and decision-making [12].

Conclusion

This meta-analysis provides strong evidence supporting early orthodontic intervention as an effective strategy for reducing incisal trauma, improving skeletal alignment, and enhancing long-term stability. While some variability exists in treatment protocols, the overall findings emphasize that early intervention should be considered a key component of orthodontic care, particularly for patients at risk of developing severe malocclusion. Further high-quality research is needed to refine optimal treatment timing, retention strategies, and long-term patient outcomes.

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