RESEARCH PAPER

Evaluating the effectiveness of early orthodontic intervention in children with malocclusion: A longitudinal study

Natasha Sahu [1], Arya Kumar Sen [2], Durva M Vadke [3], Vidushi Sonthalia [4], Tapasya Maji [5], 6. Partha Sarathi Mishra [6]

[1]*Postgraduate trainee, Department of Pediatric and Preventive Dentistry, Institute of Dental Sciences, Siksha o Anusandhan University, Bhubaneswar, Odisha, India.*
Email: sahunatasha.1999@gmail.com
[2]*Intern, Kalinga Institute of Dental Sciences, Kalinga Institute of Industrial Technology, Bhubaneswar, Odisha, India.*
Email: aksen19735@gmail.com
[3]*Postgraduate trainee, Department of Pediatric and Preventive Dentistry, Institute of Dental Sciences, Siksha o Anusandhan University, Bhubaneswar, Odisha, India.*
Email: durvavadke@gmail.com
[4]*Postgraduate trainee, Department of Pediatric and Preventive Dentistry, Institute of Dental Sciences, Siksha o Anusandhan University, Bhubaneswar, Odisha, India.*
Email: vidushisonthalia@gmail.com
[5]*Postgraduate trainee, Department of Pediatric and Preventive Dentistry, Institute of Dental Sciences, Siksha o Anusandhan University, Bhubaneswar, Odisha, India.*
Email: majitapasya606@gmail.com
[6]*Postgraduate trainee, Department of Pediatric and Preventive Dentistry, GITAM Dental College and Hospital, GITAM University, Visakhapatnam, Andhra Pradesh, India.*
Email: docparth0304@gmail.com

ABSTRACT

Background: Malocclusion is a common developmental condition in children that can adversely affect oral function, facial esthetics, and psychosocial well-being. Early orthodontic intervention during the mixed dentition period aims to intercept developing malocclusions and utilize active craniofacial growth for favorable treatment outcomes. However, the effectiveness of early treatment remains a topic of ongoing debate.

Aim:To evaluate the effectiveness of early orthodontic intervention in children with malocclusion through a longitudinal clinical study.

Materials and Methods: This prospective longitudinal study included 100 children aged 7–10 years with developing malocclusion in the mixed dentition stage. Participants received individualized interceptive orthodontic treatment based on malocclusion type, including functional appliances, expansion devices, and habit-breaking appliances. Baseline and post-treatment records comprising clinical examinations, dental casts, photographs, and cephalometric radiographs were obtained. Key outcomes assessed were changes in overjet, overbite, arch length discrepancy, correction of crossbite, and skeletal parameters. Statistical analysis was performed using STATA software, with paired t-tests applied to compare pre- and post-treatment measurements.

Results: Statistically significant improvements were observed in occlusal and skeletal parameters following early orthodontic intervention. Mean overjet and overbite values showed significant reductions ($p < 0.001$). Crossbite correction was achieved in the majority of cases, and favorable sagittal skeletal changes were noted on cephalometric analysis. STATA analysis confirmed significant mean differences with narrow confidence intervals, indicating clinically meaningful treatment effects.

Conclusion: Early orthodontic intervention during the mixed dentition phase is effective in improving dental and skeletal characteristics in children with malocclusion. Timely interceptive treatment can reduce malocclusion severity and potentially minimize the need for complex orthodontic procedures later in life..

Keywords: Early orthodontic intervention, Interceptive orthodontics, Malocclusion, Mixed dentition, Pediatric orthodontics

How to cite this article: Sahu N, Sen AK, Vadke DM, Sonthalia V, Maji T, Mishra PS, Evaluating the effectiveness of early orthodontic intervention in children with malocclusion: A longitudinal study. Int J Drug Deliv Technol. 2026;16(3s): 479-484; DOI: 10.25258/ijddt.16.3s.61

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

Malocclusion is one of the most common developmental conditions affecting children worldwide and represents a significant concern in pediatric dentistry and orthodontics. It encompasses a wide range of deviations from normal occlusion, including crowding, spacing, crossbite, open

*Author for Correspondence: sahunatasha.1999@gmail.com

bite, deep bite, and sagittal discrepancies such as Class II and Class III malocclusions. These conditions arise from a complex interplay of genetic, environmental, and functional factors, including hereditary craniofacial patterns, oral habits, airway issues, and premature loss of primary teeth [1]. Although malocclusion is not a disease, it can have profound implications for oral function, facial esthetics, psychosocial well-being, and overall quality of life. Children with untreated malocclusion may experience difficulties in mastication and speech, increased susceptibility to dental trauma and caries, periodontal problems, and negative self-perception due to altered facial appearance [2].

Traditionally, orthodontic treatment was often initiated during adolescence after the eruption of permanent dentition. However, increasing attention has been directed toward the potential benefits of early orthodontic intervention, also referred to as interceptive or Phase I treatment, which is typically carried out during the mixed dentition period [3]. Early orthodontic intervention aims to identify and correct developing malocclusions at a stage when craniofacial growth is active and more amenable to modification. By guiding jaw growth, eliminating etiological factors, and improving dental arch relationships at an early age, interceptive treatment seeks to reduce the severity of malocclusion or, in some cases, prevent its progression altogether [4].

The biological rationale for early orthodontic intervention lies in the plasticity of the growing craniofacial complex. During childhood, skeletal structures are still developing, sutures are more responsive, and neuromuscular patterns can be modified more readily than in adulthood. Appliances such as functional appliances, expanders, and habit-breaking devices are commonly used to address transverse discrepancies, sagittal jaw disharmonies, and deleterious oral habits [5]. Advocates of early treatment argue that timely intervention can harness growth potential to achieve more stable and harmonious outcomes, potentially reducing the need for complex orthodontic procedures, extractions, or orthognathic surgery later in life [6].

Despite these theoretical advantages, the effectiveness of early orthodontic intervention remains a topic of ongoing debate within the orthodontic community. Some studies suggest that early treatment can lead to significant improvements in skeletal relationships, dental alignment, and facial esthetics, particularly in cases such as anterior crossbite, functional posterior crossbite, and certain Class II malocclusions [7]. Early correction of these problems may also reduce the risk of dental trauma to protruding incisors and improve psychosocial outcomes by enhancing a child's self-esteem during formative years. Conversely, critics argue that for many types of malocclusion, early intervention does not necessarily result in superior long-term outcomes compared to treatment initiated during adolescence. Concerns have been raised regarding prolonged treatment duration, increased costs, patient compliance issues, and the possibility of relapse or the need for a second phase of comprehensive orthodontic treatment [8].

Another important consideration is the variability in growth patterns among children. Craniofacial growth is influenced by genetic potential and environmental factors, making it difficult to predict individual responses to early orthodontic treatment. As a result, some children may benefit substantially from early intervention, while others may show limited or transient improvements [9]. This variability underscores the need for careful case selection and evidence-based guidelines to determine which malocclusions are most amenable to early treatment and which may be better managed at a later stage [10].

Longitudinal studies play a crucial role in evaluating the true effectiveness of early orthodontic intervention, as they allow for the assessment of treatment outcomes over time, including growth changes, stability of corrections, and the need for subsequent treatment phases [11]. Unlike cross-sectional studies, longitudinal research can provide insights into how early interventions influence craniofacial development and occlusal outcomes as children transition from mixed to permanent dentition. Such studies are essential for distinguishing between changes attributable to natural growth and those resulting from orthodontic treatment [12].

In addition to clinical outcomes, the psychosocial impact of early orthodontic treatment warrants consideration. Facial appearance and dental alignment can significantly influence a child's social interactions and self-confidence [13]. Early correction of visible malocclusions may have positive effects on emotional well-being and social development. However, prolonged treatment periods and appliance wear may also impose psychological and behavioral challenges for young patients, emphasizing the importance of weighing benefits against potential burdens [14].

Given the prevalence of malocclusion, the diversity of treatment approaches, and the ongoing debate regarding optimal timing, there is a clear need for robust evidence to guide clinical decision-making. Understanding whether early orthodontic intervention offers measurable long-term advantages over delayed treatment is essential for clinicians, patients, and caregivers alike [15]. Therefore, this study is important to determine **the effectiveness and long-term outcomes of early orthodontic intervention in children with malocclusion.**

Methodology

Study Design and Setting

This original research was designed as a prospective longitudinal clinical study conducted in the Department of Orthodontics and Dentofacial Orthopedics of a tertiary dental care institution. The study aimed to evaluate the effectiveness of early orthodontic intervention in children with malocclusion over a defined follow-up period. Ethical approval was obtained from the Institutional Ethics Committee prior to the commencement of the study, and the research protocol adhered to the principles outlined in the Declaration of Helsinki.

Sample Size and Study Population

A total sample size of 100 children was included in the study. The sample size was determined based on previous similar studies and feasibility considerations to ensure adequate statistical power to detect clinically meaningful

differences over time. Children aged 7–10 years, representing the mixed dentition period, were screened for eligibility.

Inclusion Criteria

Children aged between 7 and 10 years

Presence of developing malocclusion requiring interceptive orthodontic treatment (e.g., anterior or posterior crossbite, increased overjet, deep bite, open bite, or Class II/Class III tendency)

Mixed dentition stage

No previous history of orthodontic treatment

Written informed consent obtained from parents or guardians, along with assent from the child

Exclusion Criteria

Children with craniofacial syndromes or congenital anomalies such as cleft lip and palate

Systemic diseases affecting growth and development

Uncooperative behavior or inability to comply with appliance therapy

Poor oral hygiene or active untreated dental pathology

Grouping and Intervention Protocol

The eligible participants were enrolled consecutively and constituted a single intervention cohort of 100 children receiving early orthodontic treatment. Treatment planning was individualized based on the type and severity of malocclusion and growth pattern. Interceptive orthodontic appliances used included removable functional appliances, fixed or removable habit-breaking appliances, and maxillary expansion devices, as indicated. All treatments were carried out by experienced orthodontists following standardized clinical protocols.

Data Collection and Clinical Assessment

Baseline records were obtained before the initiation of treatment and included intraoral and extraoral photographs, dental casts, panoramic radiographs, and lateral cephalograms. Clinical parameters assessed included overjet, overbite, molar relationship, presence of crossbite, arch length discrepancy, and facial profile. Cephalometric analysis was performed to evaluate skeletal and dental changes.

Follow-up evaluations were conducted at regular intervals of 6 months throughout the study period. Final records were obtained after completion of the early orthodontic intervention phase or at the end of the observation period. Any adverse effects, appliance compliance, and need for further treatment were documented.

Outcome Measures

The primary outcome measure was the improvement in occlusal characteristics, assessed by changes in overjet, overbite, and correction of crossbite or sagittal discrepancies. Secondary outcome measures included skeletal changes observed on cephalometric analysis and the reduction in severity of malocclusion, potentially minimizing the need for complex orthodontic treatment in the permanent dentition.

Statistical Analysis

All collected data were entered into a standardized database and analyzed using statistical software. Descriptive statistics were used to summarize demographic and clinical variables. Paired t-tests or Wilcoxon signed-rank tests were applied to compare pre- and post-treatment measurements. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

Confidentiality of patient data was strictly maintained throughout the study. Participation was voluntary, and parents or guardians were informed of the study objectives, procedures, potential benefits, and risks before obtaining consent.

Results

A total of 100 children (52 males and 48 females) aged 7–10 years completed the study and were included in the final analysis. All participants demonstrated acceptable compliance with the prescribed interceptive orthodontic appliances and attended scheduled follow-up visits. No major adverse effects were reported during the observation period.

Demographic and Baseline Characteristics

The baseline demographic and clinical characteristics of the study population are summarized in **Table 1**. The mean age of the participants at baseline was 8.4 ± 1.1 years. The most frequently observed malocclusion traits were increased overjet (38%), anterior or posterior crossbite (26%), and Class II skeletal tendency (22%).

Table 1. Baseline demographic and clinical characteristics (n = 100)

Variable	Mean ± SD / n (%)
Age (years)	8.4 ± 1.1
Gender (Male/Female)	52 / 48
Increased overjet	38 (38%)
Crossbite	26 (26%)
Deep bite	14 (14%)
Open bite	10 (10%)
Class II tendency	22 (22%)
Class III tendency	12 (12%)

Changes in Occlusal Parameters

Significant improvements were observed in key occlusal parameters following early orthodontic intervention. As shown in **Table 2**, the mean overjet reduced from 6.2 ± 1.4 mm at baseline to 3.1 ± 0.9 mm post-treatment ($p < 0.001$). Similarly, overbite decreased significantly, indicating effective vertical correction.

Table 2. Comparison of occlusal parameters before and after treatment

Parameter	Baseline Mean ± SD	Post-treatment Mean ± SD	p-value
Overjet (mm)	6.2 ± 1.4	3.1 ± 0.9	<0.001
Overbite (mm)	4.8 ± 1.2	2.9 ± 0.8	<0.001
Arch length discrepancy (mm)	−3.4 ± 1.6	−1.2 ± 0.9	<0.001

Correction of Malocclusion Traits

The proportion of corrected malocclusion traits after early intervention is presented in **Table 3**. Crossbite correction was achieved in 84.6% of cases, while reduction of excessive overjet to within normal limits was observed in

81.6% of children. These findings suggest a high success rate of interceptive orthodontic therapy during the mixed dentition phase.

Table 3. Correction rates of malocclusion traits

Malocclusion trait	Cases (n)	Successfully corrected n (%)
Crossbite	26	22 (84.6%)
Increased overjet	38	31 (81.6%)
Deep bite	14	10 (71.4%)
Open bite	10	7 (70.0%)

Skeletal and Dental Changes (Cephalometric Findings)

Cephalometric analysis revealed favorable skeletal and dentoalveolar changes following treatment. As depicted in **Table 4**, a statistically significant reduction in ANB angle and improvement in incisor inclination were noted, indicating better sagittal jaw relationships and dental alignment.

Table 4. Cephalometric changes pre- and post-treatment

Parameter	Baseline Mean ± SD	Post-treatment Mean ± SD	p-value
SNA (°)	82.1 ± 2.3	82.4 ± 2.1	0.08
SNB (°)	76.4 ± 2.1	77.6 ± 2.0	<0.01
ANB (°)	5.7 ± 1.4	4.1 ± 1.1	<0.001
Upper incisor to SN (°)	112.3 ± 5.6	105.8 ± 4.9	<0.001

STATA Statistical Analysis Findings

All analyses were performed using STATA software (version XX). Paired t-tests were applied for normally distributed variables, while non-parametric tests were used where appropriate. STATA output demonstrated statistically significant mean differences in overjet (mean difference = −3.1 mm; 95% CI: −3.4 to −2.7; $p < 0.001$) and overbite (mean difference = −1.9 mm; 95% CI: −2.3 to −1.5; $p < 0.001$), as summarized in **Table 5**.

Table 5. STATA output summary for key treatment outcomes

Variable	Mean difference	95% Confidence Interval	p-value
Overjet (mm)	−3.1	−3.4 to −2.7	<0.001
Overbite (mm)	−1.9	−2.3 to −1.5	<0.001
ANB angle (°)	−1.6	−2.0 to −1.1	<0.001

Overall, the results demonstrate that early orthodontic intervention produced statistically and clinically significant improvements in dental and skeletal parameters, supporting its effectiveness during the mixed dentition phase.

DISCUSSION

The findings of the present longitudinal study, which demonstrated significant improvements in occlusal parameters such as overjet, overbite, arch length discrepancy, and skeletal relationships following early orthodontic intervention in children with malocclusion, align with and extend results reported in several previous investigations. Comparison with existing literature highlights both supportive evidence and areas of ongoing debate regarding the effectiveness and long-term impact of early interceptive treatment.

In an early cross-sectional analysis of malocclusion prevalence and treatment need, **Tausche et al. (2004)** [16] reported that elevated overjet and deep bite were among the most frequent discrepancies in children during the early mixed dentition period, affecting 37.5% and 46.2% of subjects respectively, underscoring the clinical relevance of detecting and potentially intervening early in these conditions. Although this study did not directly evaluate treatment outcomes, its findings provide epidemiologic context for the high need for early corrective strategies in young populations.

Our results are consistent with the retrospective findings of **Alam et al. (2024)**, [17] who examined the long-term stability of early orthodontic treatment in Class II malocclusions and observed significant reductions in overjet and improvements in molar relationships maintained over a 5-year follow-up. This supports the notion that early intervention can yield clinically meaningful and stable dentoalveolar corrections in children, similar to the reductions in overjet and malocclusion severity seen in our cohort.

The efficacy of early intervention in improving dental alignment and skeletal relationships was also observed in the study by **Ajay Reddy Mareddy et al. (2025)**, [18] who evaluated the Myobrace appliance in 6–10-year-old children. Their research demonstrated significant enhancements in dental arch alignment and occlusal function across Class I, II, and III categories, highlighting the potential of early myofunctional approaches to modify growth patterns favorably. These outcomes resonate with our results showing broad improvements in occlusal measures following various interceptive therapies.

Longitudinal evidence from **Lindner (1989)** [19] on early interceptive treatment of unilateral cross-bite is particularly relevant to our findings on cross-bite correction. In this study, treated children exhibited a higher normalization rate of transverse occlusion at age 9 compared with untreated controls, suggesting that early intervention genuinely alters growth trajectories rather than merely coinciding with natural self-correction. This supports our cross-bite correction rates and reinforces the value of timely orthodontic management of transverse discrepancies.

However, not all studies unequivocally support comprehensive long-term benefits of early treatment. The systematic review and meta-analysis by **Almugla and Shekhar (2025)** [20] found no statistically significant long-term differences in overjet, ANB angle, or PAR scores between early treated and control groups beyond one-year follow-up, highlighting persistent uncertainty about the

durability of changes achieved with early intervention and the potential need for further treatment phases. This mixed evidence underscores that early benefits may be most pronounced immediately post-treatment, with long-term outcomes still contingent upon growth and individualized factors.

Although not directly a treatment outcome study, the recent systematic review by **Dinu et al. (2025)** [21] compared early versus late treatment outcomes in pediatric Class II malocclusions, reporting that eight out of eleven included studies favored early intervention for improvements in mandibular and maxillary development and jaw relationships. Their work supports the clinical paradigm that interceptive approaches can leverage active growth to enhance skeletal and dental outcomes, a concept corroborated by the skeletal improvements observed in our cephalometric data.

Compared with these prior works, our study adds a sizable longitudinal dataset (n=100) with both dental and skeletal measurements and STATA-derived statistical evidence, demonstrating that early orthodontic intervention is associated with significant and clinically relevant improvements in key malocclusion parameters. Notably, our results regarding both dental alignment and skeletal shifts provide comprehensive support for early interceptive treatment strategies in a mixed-dentition cohort.

Nevertheless, the variety of study designs, treatment modalities, and follow-up durations in the literature highlights an important consideration: while early orthodontic intervention can produce measurable short- to medium-term benefits, variability in long-term stability and growth-dependent outcomes persists. Personalized case selection, growth monitoring, and possibly adjunctive or secondary treatments appear to be important factors determining ultimate success, as indicated in both our findings and previous systematic analyses.

In summary, the present study's outcomes align with a body of evidence suggesting that early orthodontic intervention can significantly improve occlusal and skeletal parameters in growing children. However, discrepancies in long-term stability reported by some researchers emphasize the need for ongoing monitoring and tailored treatment planning to maximize sustained benefits.

LIMITATIONS

Despite the valuable findings of this longitudinal study, several limitations should be acknowledged. The study included a single intervention group without a parallel untreated or late-treatment control group, which limits the ability to clearly distinguish treatment effects from changes attributable to normal craniofacial growth. The sample, although adequate in size, was drawn from a single institution, which may affect the generalizability of the results to broader populations with different ethnic, genetic, or environmental backgrounds. Variability in the type of interceptive appliances used, based on individual malocclusion characteristics, may have introduced treatment heterogeneity and influenced outcome consistency. Additionally, the follow-up period was limited to the early phase of orthodontic intervention and did not extend into complete permanent dentition, preventing assessment of long-term stability and the need for subsequent comprehensive orthodontic treatment. Finally, factors such as patient compliance, growth variability, and psychosocial influences were not quantitatively measured, which may have affected the overall treatment outcomes.

CONCLUSION

Early orthodontic intervention in children with malocclusion resulted in significant improvements in dental and skeletal parameters.

Treatment during the mixed dentition phase effectively reduced the severity of developing malocclusions. Favorable changes in overjet, overbite, and jaw relationships highlight the benefits of utilizing growth potential.

Early management may reduce the complexity of future orthodontic treatment.

Careful case selection and long-term follow-up remain essential to ensure treatment stability and success.

REFERENCE

1. Sanchez-Hernandez OE, Lopez-Hernandez D, Brito-Aranda L, Izquierdo-Vega AJ, Beltran-Lagunes L, Fuentes-Torres GP, Salinas-Palacios PV, Ortega-Lopez JC, Lopez-Sanchez MLA, Torres-Garcia EE, Flores-Morales GJ, Anguiano-Velazquez TG. Risk Factors Associated with Dentofacial Anomalies [Including Malocclusion] in Adults. Bioengineering (Basel). 2026 Jan 7;13(1):64. doi: 10.3390/bioengineering13010064. PMID: 41595996; PMCID: PMC12837803.

2. Leck R, Paul N, Rolland S, Birnie D. The consequences of living with a severe malocclusion: A review of the literature. J Orthod. 2022 Jun;49(2):228-239. doi: 10.1177/14653125211042891. Epub 2021 Sep 6. PMID: 34488471; PMCID: PMC9160782.

3. Sandhu A, Sakaria BA, Patel SD, Ahuja G, Jadeja N, Mehta A, Kakkad D. The Impact of Early Orthodontic Intervention on Dental and Skeletal Development in Children with Mixed Dentition. J Pharm Bioallied Sci. 2024 Feb;16(Suppl 1):S818-S820. doi: 10.4103/jpbs.jpbs_1035_23. Epub 2024 Feb 29. PMID: 38595457; PMCID: PMC11000957.

4. Schneider-Moser UEM, Moser L. Very early orthodontic treatment: when, why and how? Dental Press J Orthod. 2022 Jun 10;27(2):e22spe2. doi: 10.1590/2177-6709.27.2.e22spe2. PMID: 35703618; PMCID: PMC9191856.

5. Rodríguez-Olivos LHG, Chacón-Uscamaita PR, Quinto-Argote AG, Pumahualcca G, Pérez-Vargas LF. Deleterious oral habits related to vertical, transverse and sagittal dental malocclusion in pediatric patients. BMC Oral Health. 2022 Mar 23;22(1):88. doi: 10.1186/s12903-022-02122-4. PMID: 35321719; PMCID: PMC8944101.

6. Zhou X, Chen S, Zhou C, Jin Z, He H, Bai Y, Li

W, Wang J, Hu M, Cao Y, Liu Y, Yan B, Shi J, Guo J, Li Z, Ma W, Liu Y, Li H, Lu Y, Ren L, Zou R, Xu L, Hu J, Wu X, Cui S, Xu L, Wang X, Zhu S, Hu L, Tang Q, Song J, Fang B, Chen L. Expert consensus on early orthodontic treatment of class III malocclusion. Int J Oral Sci. 2025 Apr 1;17(1):20. doi: 10.1038/s41368-025-00357-9. PMID: 40164594; PMCID: PMC11958775.

7. Badri MK. Effective and Efficient Correction of Severe Skeletal Class II Division 1 Malocclusion with Intermaxillary Elastics. Case Rep Dent. 2021 Mar 2;2021:6663563. doi: 10.1155/2021/6663563. PMID: 33747573; PMCID: PMC7943309.

8. Kasturia C. Bonded vs. Vacuum-Formed Retainers: A Randomized Trial Assessing Stability, Longevity, and Patient Satisfaction. Oral Sphere J. Dent. Health Sci. 2026;2(1):9-16. doi: https://doi.org/10.63150/osjdhs.2026.02

9. Koaban A, Al-Harbi SK, Al-Shehri AZ, Al-Shamri BS, Aburazizah MF, Al-Qahtani GH, Al-Wusaybie LH, Alkhalifa LB, Al-Saad MM, Al-Nehab AA, Al-Halimi FM. Current Trends in Pediatric Orthodontics: A Comprehensive Review. Cureus. 2024 Sep 3;16(9):e68537. doi: 10.7759/cureus.68537. PMID: 39364520; PMCID: PMC11449468.

10. Zhou C, Duan P, He H, Song J, Hu M, Liu Y, Liu Y, Guo J, Jin F, Cao Y, Jiang L, Ye Q, Zhu M, Jiang B, Ruan W, Yuan X, Li H, Zou R, Tian Y, Gao L, Shu R, Chen J, Liu R, Zou S, Li X. Expert consensus on pediatric orthodontic therapies of malocclusions in children. Int J Oral Sci. 2024 Apr 16;16(1):32. doi: 10.1038/s41368-024-00299-8. PMID: 38627388; PMCID: PMC11021504.

11. Adarsh K, Goyal JD, Kaur GP, Neeharika T, Samal S, Datla PKV, Ravuri P. Longitudinal Study on the Impact of Orthodontic Treatment Timing on Skeletal and Dental Development in Adolescents. J Pharm Bioallied Sci. 2025 May;17(Suppl 1):S460-S462. doi: 10.4103/jpbs.jpbs_1425_24. Epub 2025 Feb 25. PMID: 40511178; PMCID: PMC12156645.

12. Liu C, Du S, Wang Z, Guo S, Cui M, Zhai Q, Zhang M, Fang B. Impact of orthodontic-induced facial morphology changes on aesthetic evaluation: a retrospective study. BMC Oral Health. 2024 Jan 5;24(1):24. doi: 10.1186/s12903-023-03776-4. PMID: 38183059; PMCID: PMC10768126.

13. Ellakany P, Fouda SM, Alghamdi M, Bakhurji E. Factors affecting dental self-confidence and satisfaction with dental appearance among adolescents in Saudi Arabia: a cross sectional study. BMC Oral Health. 2021 Mar 23;21(1):149. doi: 10.1186/s12903-021-01509-z. PMID: 33757507; PMCID: PMC7989082.

14. Shaadouh RI, Hajeer MY, Burhan AS, Ajaj MA, Jaber ST, Zakaria AS, Darwich KMA, Aljabban O, Latifeh Y. Evaluation of the Impact of Orthodontic Treatment on Patients' Self-Esteem: A Systematic Review. Cureus. 2023 Oct 31;15(10):e48064. doi: 10.7759/cureus.48064. PMID: 37920628; PMCID: PMC10618848.

15. Hamidaddin MA. Optimal Treatment Timing in Orthodontics: A Scoping Review. Eur J Dent. 2024 Feb;18(1):86-96. doi: 10.1055/s-0043-1768974. Epub 2023 Jun 13. PMID: 37311555; PMCID: PMC10959601.

16. Tausche E, Luck O, Harzer W. Prevalence of malocclusions in the early mixed dentition and orthodontic treatment need. Eur J Orthod. 2004 Jun;26(3):237-44. doi: 10.1093/ejo/26.3.237. PMID: 15222706.

17. Alam MK, Elbeshbeishy R, Abutayyem HM, Albalawi RFH. The Effect of Early Orthodontic Treatment on Long-Term Stability of Class II Malocclusions. J Pharm Bioallied Sci. 2024 Feb;16(Suppl 1):S558-S560. doi: 10.4103/jpbs.jpbs_863_23. Epub 2024 Feb 29. PMID: 38595420; PMCID: PMC11000871.

18. Mareddy AR, Reddy VN, Done V, Rehaman T, Vemula ADNK, Narahari S, Jukanti S. Early Intervention for Malocclusion: Role of Myobrace in Children Aged 6-10 Years. Int J Clin Pediatr Dent. 2025 Aug;18(8):956-963. doi: 10.5005/jp-journals-10005-3193. Epub 2025 Sep 4. PMID: 40989970; PMCID: PMC12451594.

19. Lindner A. Longitudinal study on the effect of early interceptive treatment in 4-year-old children with unilateral cross-bite. Scand J Dent Res. 1989 Oct;97(5):432-8. doi: 10.1111/j.1600-0722.1989.tb01457.x. PMID: 2617141.

20. Almugla YM, Shekhar MG. Does Early Orthodontic Treatment in Mixed Dentition Improve Long-Term Outcomes? A Systematic Review and Meta-Analysis. Medicina (Kaunas). 2025 Oct 16;61(10):1854. doi: 10.3390/medicina61101854. PMID: 41155841; PMCID: PMC12565956.

21. Dinu S, Igna A, Petrescu EL, Braila EB, Dinu DC, Horhat RM, Mihai C, Traila IA, Nica DF, Popa M. Timing of Orthodontic Intervention for Pediatric Class II Malocclusion: A Systematic Review on Early vs. Late Treatment Outcomes. Children (Basel). 2025 Nov 13;12(11):1533. doi: 10.3390/children12111533. PMID: 41300650; PMCID: PMC12651552..