



Research Paper

Ravelling Of Skeletal, Dental and Soft Tissue Changes between Twin Block and HERBST Appliances in Growing Children with Class II Malocclusion: A Systematic Review

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ABSTRACT

Objective - Our systemic review aimed to evaluate the efficacy of applying Herbst and Twin Block appliances in the treatment of Class II malocclusion among children.

Materials and Methods - A systematic review following PRISMA guidelines was conducted to compare Twin Block and Herbst appliances in treating Class II malocclusion in growing children (12–18 years). Studies were identified through PubMed, ScienceDirect, Google Scholar, and Cochrane Library (2000–2024) using the terms: Twin Block OR Herbst Appliance AND Skeletal, Dental, Soft Tissue changes. Eligible studies included RCTs, CCTs, and cohort studies in English. Primary outcome assessed was skeletal changes; secondary outcomes included dental and soft tissue effects. Study quality was scored (0–9) based on design, sample details, error analysis, and statistics, and categorized as high, medium, or low quality.

Results - Eighteen studies met the inclusion criteria from an initial yield of 4306 records across four databases. The selected studies evaluated skeletal, dental, and soft tissue changes in growing patients treated with Twin Block or Herbst appliances for Class II malocclusion. Twin Block therapy predominantly demonstrated mandibular advancement and correction of molar relationship, with variable improvements in facial aesthetics. Herbst appliance use was associated with increased mandibular ramal height and similar skeletal corrections. However, direct comparisons were limited due to heterogeneity in study designs and outcome measures. Quality assessment classified nine studies as high quality and nine as medium. Although all studies had adequate sample sizes, only eight were randomized controlled trials, and comprehensive error analysis was reported in a minority. Statistical methods were adequate in most studies, though several relied solely on descriptive analysis.

Conclusion - Both Twin Block and Herbst appliances are effective in correcting Class II malocclusion through favourable skeletal, dental, and soft tissue modifications. While Herbst offers greater mandibular advancement due to its fixed design and superior compliance, Twin Block is associated with enhanced skeletal changes and improved facial aesthetics. Overjet reduction is comparable, though incisor proclination is more pronounced with the Herbst. Despite faster initial correction with the Herbst, overall treatment durations are similar. Long-term stability, gender-specific responses, and retention protocols warrant further investigation.

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I. INTRODUCTION

Class II malocclusion is a complex orthodontic condition, typically characterized by a convex facial profile due to maxillary protrusion, mandibular retrusion, or a combination of both. It affects a substantial portion of the population, with approximately one in three individuals presenting with this condition. Beyond its anatomical implications, Class II malocclusion can significantly impact orofacial functions such as chewing, speaking, and swallowing.¹ It also influences psychological and social well-being due to its effect on facial appearance. The severity of this condition often worsens with age, underscoring the importance of timely and effective intervention.²

Functional appliances—both fixed and removable—are widely recognized as effective treatment modalities for correcting Class II malocclusion in growing patients. Among fixed options, the Herbst appliance is frequently employed due to its rigid design and proven ability to produce meaningful skeletal changes within a relatively short treatment period of six to eight months.³ This timing coincides with the pubertal growth phase, making it particularly effective in stimulating mandibular advancement. Clinical findings suggest that the Herbst appliance promotes condylar growth and anterior remodelling of the glenoid fossa, leading to a more harmonious maxillomandibular relationship in skeletally developing patients.⁴

Among removable functional appliances, the Twin Block remains the most widely used for the correction of Class II malocclusion in growing children. Its effectiveness has been well documented, with treatment outcomes attributed to a combination of skeletal and dentoalveolar changes across both dental arches.⁵ Additionally, the Twin Block has been shown to enhance facial aesthetics through coordinated improvements in skeletal and soft tissue profiles.⁶

Comparative studies evaluating the Herbst and Twin Block appliances have yielded mixed results. Some randomized controlled trials have reported that the Herbst appliance achieves a more consistent and effective reduction in overjet compared to the Twin Block.⁷ Other studies, however, have indicated that the Twin Block may lead to more substantial improvements in soft tissue profile. Yet, additional research assessing perceived facial profile changes suggests no significant difference between the two appliances in terms of soft tissue enhancement.⁸⁻¹²

Given these conflicting findings and the lack of consensus in the literature regarding the relative efficacy of these two appliances, a comprehensive meta-analysis is warranted. This meta-analysis aims to systematically evaluate and compare the skeletal, dental, and soft tissue effects—measured through cephalometric radiographs—of the Herbst and Twin Block appliances in the treatment of Class II malocclusion among growing children.¹³ The results are intended to guide clinicians in selecting the most appropriate functional appliance for managing this malocclusion effectively.¹⁴⁻¹⁶

The aim of this study is to systematically review the evidence available regarding the effects of skeletal, dental and soft tissue changes between Twin block and Herbst appliance therapy in growing children with class-II malocclusion.

II. MATERIALS AND METHODS

Types of Studies - This systematic review included randomized clinical trials evaluating the effectiveness of Twin Block and Herbst appliance therapy in the treatment of Class II malocclusion. Additionally, controlled clinical trials, as well as retrospective and prospective cohort studies, were included to broaden the scope of evidence.¹⁷⁻²⁰

Participants - Studies involving growing children aged 12 to 18 years diagnosed with Class II malocclusion and undergoing treatment with either the Twin Block or Herbst appliance were considered eligible. Patients with a history of periodontal disease or other systemic conditions affecting growth were excluded.

Types of Intervention - Intervention Group : Subjects receiving treatment with the Twin Block functional appliance, Control Group : Subjects treated using the Herbst appliance.

Outcome Measures - Primary Outcome : Skeletal changes resulting from treatment, Secondary Outcomes : Associated dental and soft tissue changes following appliance therapy.

Review Protocol - This systematic review adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The research question was developed based on the PICO framework.

(Table I)

PICO Framework –

Table I: PICO Format	
Population	Subjects with Class II malocclusion who require orthodontic Treatment.
Intervention	Correction of Class II malocclusion with Twin Block.
Comparison	Correction of Class II malocclusion with Herbst Appliance.

Outcome	Skeletal, Dental and Soft tissue changes.
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Search Strategy and Data Sources - A comprehensive literature search was conducted across the following electronic databases: PubMed, ScienceDirect, Google Scholar, and the Cochrane Library. Articles published from January 2000 to March 2024 were included. The search was restricted to studies published in English.

Search terms used - Twin Block OR Herbst Appliance AND Skeletal, Dental, and Soft Tissue changes. **(Table II)**

Database Search Details

Table II: Search Strategy		
Database	Search Keywords	Limits
PubMed	(Twin Block OR Herbst Appliance) AND (Skeletal, Dental and Soft tissue changes)	English; 2000–2024; Systematic Reviews, RCTs
Google Scholar	Same as above	English; 2000–2024
ScienceDirect	Same as above	English; 2000–2024; Only original research articles (excluding reviews, editorials)
Cochrane Library	Same as above	English; 2000–2024; Only original studies (excluding abstracts, meetings, letters)

Selection Criteria –

Inclusion Criteria :

- Randomized Controlled Trials (RCTs), Controlled Clinical Trials (CCTs), Retrospective Studies, Systematic Reviews, and Meta-Analyses
- Studies published between January 2000 and March 2024
- Articles written in English
- Full-text availability

Exclusion Criteria :

- Case reports, case series, laboratory studies, descriptive or epidemiological studies
- Editorials, expert opinions, books, and conference abstracts
- Studies unrelated to treatment outcomes in Class II malocclusion
- Research focusing solely on treatment duration or adverse effects in lingual orthodontics or clear aligner therapy

The quality of the studies is considered as follows: The quality of each article was scored by using following characteristics were evaluated: Study design, Sample size, Sample description, Error analysis, and Statistical Analysis. Each characteristic received a score according to the criteria described in Table III. The quality of each study was categorized as High (7-9 points), Medium (4-6 points), or Low (0-3 points). **(Table III)**

Table III: Methodologic quality scoring protocol (maximum score: 9 points)	
Study design	3 points: randomized clinical trial 2 points: if randomization process is not well described, onf it was a controlled prospective study 1 point: uncontrolled prospective study 0 point: retrospective study or not mentioned
Sample size	1 point: larger than or equal to 15 subjects or prioestimate of sample size 0 point: less than 15 subjects and no prior estimate of sample size
Sample description	2 points: description of all 3 items (age, sex, appliance)l point: only 2 items described 0 point: only 1 item described
Error analysis	1 point: error analysis value cited 0 point: error analysis value not cited, or error analysis notPerformed
Statistical analysis	2 points: adequate 1 point: partially adequate 0 point: no statistical tests conducted

III. RESULT

After the electronic database search, 230 studies were retrieved from PubMed, 818 from Science Direct, 2807 from Google Scholar and 251 from chochrane library. After application of the initial inclusion and exclusion criteria and elimination of studies indexed in more than 1 database, 216 were retrieved. The full texts were accessed, studies not relevant to this systematic review were excluded. Therefore, 14 studies fulfilling all inclusion and exclusion criteria were included in this systematic review. **(Chart - I)**

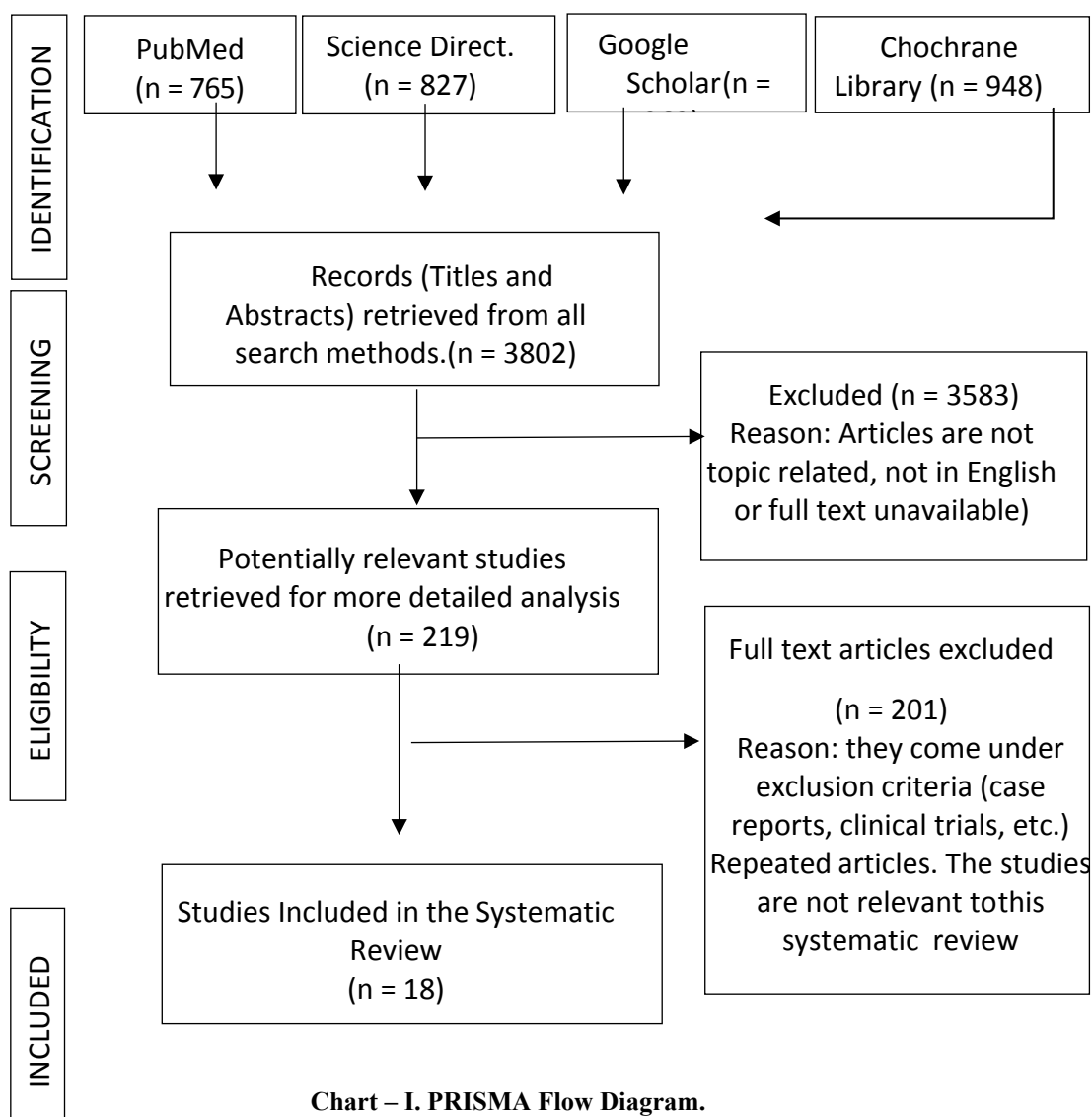


Table IV. Characteristics of Included Studies						
No.	Study	Appliance	Sample Size	Age	Skeletal & Dental Changes	Soft Tissue Changes
1.	Feifei Xu et. al. (2024) ²¹	Twin Block & Herbst Appliance	17	12.6	Achieve Mandibular Advancement and Molar Relationship	Improve Facial Esthetics
2.	Aslı Baysal and Tancan Uysal et. al. (2014) ²²	Twin Block & Herbst Appliance	20	13.3	Achieve Mandibular Advancement and Molar Relationship	N/A
3.	Moaiyad M. Pacha et. al. (2024) ²³	Twin Block & Herbst Appliance	14	14.8	Overjet reduction and molar relationship correction.	N/A
4.	Kevin O'Brien et. al. (2013) ²⁴	Twin Block & Herbst Appliance	15	12.1	Achieve Mandibular Advancement and Molar	Improve Facial Esthetics

			18		Relationship	
5.	Annapurna Kannan et. al. (2022) ²⁵	Twin Block & Herbst Appliance	15	12.6	N/A	profile enhancement
6.	Pancherz H. et. al. (2011) ²⁶	Herbst Appliance	50	14.4	Achieve Mandibular Advancement and Molar Relationship	N/A
7.	Bondevik O. et. al. (2014) ²⁷	Twin Block & Herbst Appliance	35	14.9	overjet reduction and molar relationship correction.	profile enhancement
8.	Sayeh Ehsani et. al. (2014) ²⁸	Twin Block Appliance	40	13.6	Achieve Mandibular Advancement and Molar Relationship	Improve Facial Esthetics
9.	Abbie T. Schaefer. Et. al (2004) ²⁹	Twin Block & Herbst Appliance	20	12.9	Increase Mandibular Ramal Height and Achieve Molar Relationship	N/A
10.	Muhammed Hilmi Buyukcavus. Et. al. (2021) ³⁰	Twin Block Appliance	50	12.3	Overjet and Overbite reduction	N/A
11.	Stjepan Spalj. Et. al. (2017) ³¹	Twin Block Appliance	70	13	Increase Mandibular Ramal Height and Achieve Molar Relationship	N/A
12.	H. Pancherz et. al. (2014) ³²	Herbst Appliance	35	15	Achieve Mandibular Advancement	Improve Facial Profile
13.	H. Pancherz et. al. (2012) ³³	Herbst Appliance	40	14.5	Increase Mandibular Ramal Height and Achieve Molar Relationship	profile enhancement
14.	Tulika Tripathi et. al. (2020) ³⁴	Twin Block Appliance	25	13.4	Achieve Molar Relationship	Improve Facial Profile
15.	Flores-Mir C. et. al. (2020) ³⁵	Twin Block Appliance	48	12.4	N/A	Improvement of the facial convexity
16.	Ashok Kumar Jena et. al. (2005) ³⁶	Twin Block Appliance	33	13.3	Achieve molar relation and reduction of overjet.	N/A
17.	Dr Khurram Shahzad. Et. al. (2018) ³⁷	Twin Block & Herbst Appliance	50	14.7	Increase Mandibular Ramal Height and Achieve Molar Relationship	Improvement of the facial convexity
18.	Mahasen A Taha. Et. al. (2011) ³⁸	Twin Block & Herbst Appliance	45	15.5	Achieve Molar Relationship	profile enhancement

Quality Assessment - After quality assessment, 9 studies were classified as high quality and 9 studies were classified as medium quality. (**Table V**)

Table V. Assessment of the Quality of the Studies

No.	Study	Study Design (0-3)	Sample Size (0-1)	Selection Description (0-2)	Method Error Analysis (0-1)	Adequacy of Statistical Analysis (0-2)	Quality Score (0-9)	Judged Quality Standard
1.	Feifei Xu et. al. (2024) ²¹	2	1	2	0	2	7	High
2.	Aslı Baysal and Tancan Uysal et. al. (2014) ²²	3	1	2	0	2	8	High
3.	Moaiyad M. Pacha et. al. (2024) ²³	2	1	2	0	2	7	High
4.	Kevin O'Brien et. al. (2013) ²⁴	3	1	2	1	2	9	High
5.	Annapurna Kannan et. al. (2022) ²⁵	2	1	1	0	2	6	Medium
6.	Pancherz H. et. al. (2011) ²⁶	2	1	0	1	2	6	Medium
7.	Bondevik O. et. al. (2014) ²⁷	3	1	2	1	2	9	High
8.	Sayeh Ehsani et. al. (2014) ²⁸	3	1	1	0	1	6	Medium
9.	Abbie T. Schaefer. Et. al (2004) ²⁹	2	1	1	0	2	6	High
10.	Muhammed Hilmi Buyukcavus. Et. al. (2021) ³⁰	3	1	1	0	1	6	Medium
11.	Stjepan Spalj. Et. al. (2017) ³¹	2	1	1	0	2	6	Medium
12.	H. Pancherz et. al. (2014) ³²	3	1	1	0	1	6	Medium
13.	H. Pancherz et. al. (2012) ³³	2	1	1	0	2	6	Medium

14.	Tulika Tripathi et. al. (2020) ³⁴	2	1	1	0	2	6	Medium
15.	Flores-Mir C. et. al. (2020) ³⁵	2	1	1	0	2	6	Medium
16.	Ashok Kumar Jena et. al. (2005) ³⁶	3	1	1	0	1	6	Medium
17.	Dr Khurram Shahzad. Et. al. (2018) ³⁷	3	1	2	1	2	9	High
18.	Mahasen A Taha. Et. al. (2011) ³⁸	2	1	2	0	2	7	High

It was observed that there isn't enough evidence available to compare the various parameters regarding Twin Block appliances and Herbst Appliance. Most of the studies performed have considered only one of the appliances and assessed the skeletal, dental and soft tissue effects. The most common skeletal and dental effects of Twin block appliance include Achieve Mandibular Advancement and Molar Relationship, while for Herbst Appliance, the most common skeletal and dental effects of Increase Mandibular Ramal Height and Achieve Molar Relationship. Different studies showed different effects required for treatment with twin block appliances and those with Herbst appliance. Most of them concluded that it depended on the severity of malocclusions and patient cooperation. According to each criterion for quality analysis, the following results were obtained:

- **Study design:** Only 8 studies were randomized clinical trials with the randomization process described in detail.
- **Sample size:** The authors of all the 18 studies performed sample-size calculation or had sample sizes larger than or equal to 15 patients.
- **Selection description:** 7 studies gave proper sample description including age, sex, appliance used, etc.
- **Error analysis:** the authors of 4 studies performed and described the method error results. Some studies stated that the error of the method was performed but did not present the results
- **Statistical analyses:** the authors of 4 studies performed only a descriptive analysis.

IV. DISCUSSION

Class II malocclusion, primarily resulting from mandibular retrusion, poses significant aesthetics and functional concerns in growing patients. Functional appliances play a pivotal role in modifying jaw growth during the developmental period, and the Twin Block and Herbst appliances have been extensively investigated for their effectiveness in orthopaedic and dentoalveolar correction. This discussion evaluates and interprets the clinical and cephalometric outcomes of both appliances, with a focus on skeletal, dental, and soft tissue adaptations, as reported in contemporary literature.

Skeletal Modifications - Both the Twin Block and Herbst appliances are effective in stimulating mandibular advancement; however, the mode and magnitude of skeletal response differ due to their biomechanical characteristics. The **Herbst appliance**, being a fixed device, maintains the mandible in a forward position consistently, resulting in more predictable and significant skeletal effects. It promotes condylar remodelling, anterior positioning of the glenoid fossa, and an increase in mandibular length. These skeletal adaptations were consistently supported by multiple randomized controlled trials and meta-analyses (Xu et al., Pacha et al., Panchez)²¹, indicating that the Herbst appliance produces a greater magnitude of true skeletal correction when compared to the Twin Block. Conversely, the **Twin Block**, a removable appliance, relies heavily on patient compliance. Despite this limitation, it facilitates mandibular advancement through intermittent yet sufficient functional stimulation. Studies have shown that it can produce moderate skeletal effects primarily via condylar adaptation and repositioning. While the skeletal effects may be less pronounced than those of the Herbst appliance, they are nonetheless clinically meaningful, especially in compliant patients (Jena et al., Ehsani et al., Shahzad et al.).³⁶

Dentoalveolar Effects - The dental changes associated with both appliances are considerable and often contribute significantly to Class II correction. **Lower incisor proclination** and **upper incisor retroclination** are commonly observed outcomes, with a more pronounced effect noted in patients treated with the Herbst appliance due to its continuous force application (Schaefer et al., Baysal and Uysal)²². The molar relationship is corrected through mesialization of the mandibular molars and distalization of the maxillary molars in both treatment modalities. Notably, while these dental compensations assist in achieving occlusal goals, they may also mask true skeletal correction, thereby necessitating further post-functional orthodontic management to refine the occlusion and ensure long term stability. These findings highlight the importance of understanding the interplay between skeletal and dentoalveolar contributions during treatment planning.

Soft Tissue Adaptations - Soft tissue improvement, particularly in the lower facial profile, is a key objective in Class II correction. Both appliances have demonstrated favourable changes in facial convexity and lip

competence. The **Herbst appliance** typically yields more immediate improvements in chin projection and lip posture due to its fixed nature, which imposes consistent mandibular advancement (Pancherz & Anehus-Pancherz, Kannan and Padmanabhan).²⁵ However, this may initially result in temporary soft tissue strain that typically resolves with adaptation. In contrast, the **Twin Block** induces more gradual changes, which may be perceived as more natural and harmonious, especially in patients undergoing treatment during early or peak pubertal growth (Flores-Mir & Major).³⁵ The aesthetic outcomes, while subtle, contribute significantly to treatment acceptance and satisfaction.

Treatment Efficiency and Compliance Considerations - Treatment efficiency and patient cooperation are critical in determining the success of functional appliance therapy. The **Herbst appliance**, being patient-independent, offers a distinct advantage in cases where compliance is questionable. Its fixed nature ensures consistent orthopaedic force application and reduces variability in treatment outcomes (O'Brien et al., Pacha et al.).²⁴ However, initial discomfort, potential soft tissue irritation, and the need for appliance maintenance are considerations that may affect patient experience. On the other hand, the **Twin Block**, though highly effective in motivated individuals, presents a compliance-dependent model that may compromise treatment outcomes if wear time is inadequate.⁴¹ Nevertheless, it offers advantages in terms of comfort, ease of hygiene, and customizability. The development of aesthetically modified Twin Block appliances has shown promise in enhancing patient compliance and satisfaction (Tripathi et al.).³⁴

Long-Term Stability and Retention - Long-term stability remains a key consideration in functional orthopaedic treatment. Although both appliances demonstrate effective short-term outcomes, the extent of skeletal versus dental contribution plays a role in post-treatment stability. The **Herbst appliance**, with its higher reliance on dentoalveolar changes, may exhibit greater post-treatment relapse if not followed by comprehensive fixed appliance therapy and proper retention (Pancherz).³² In contrast, the **Twin Block**, when used in conjunction with fixed appliances, has been associated with comparable or even superior long-term stability, particularly when skeletal corrections are achieved during active growth phases (Jena et al.).³⁶

Comparative Insights and Clinical Implications - Synthesizing data from recent meta-analyses and clinical trials reveals that while both appliances are effective in managing Class II malocclusion, the **Herbst appliance** may be better suited for non-compliant patients or cases requiring rapid skeletal correction. In contrast, the **Twin Block appliance**, with its favourable impact on soft tissue profile and customizable wear protocol, may be more appropriate for cooperative patients with high aesthetic concerns or mild-to-moderate skeletal discrepancies. The study by Shahzad et al. and the meta-analysis by Xu et al.²¹ underline the importance of individualized appliance selection based on patient-specific growth patterns, compliance potential, and treatment goals. Moreover, the incorporation of subjective measures such as perceptual aesthetic assessment, as seen in Kannan and Padmanabhan study,²⁵ underscores the multidimensional impact of functional therapy, extending beyond cephalometric correction to patient satisfaction and psychosocial outcomes.

V. CONCLUSION

Both the Herbst and Twin Block appliances effectively correct Class II malocclusion by improving skeletal, dental, and soft tissue structures.

- The Herbst appliance induces greater mandibular advancement due to its fixed nature, while the Twin Block enhances molar relationship correction and facial aesthetics. Overjet reduction and skeletal improvements are achieved with both, though incisor proclination is more pronounced with the Herbst, whereas the Twin Block shows greater skeletal changes.
- Patient compliance is superior with the Herbst, ensuring more predictable results, whereas the Twin Block relies on adherence for optimal outcomes. Although initial correction is faster with the Herbst, overall treatment duration remains similar.
- The Herbst appliance, however, is more prone to breakage and requires maintenance.
- No significant differences were found between the Twin Block and Hybrid-Herbst in skeletal and dental effects, though the latter may exert greater influence on mandibular dentition.
- Gender differences indicate that female patients respond better to treatment. While both appliances normalize dentoskeletal parameters, long-term stability and retention strategies require further research.

REFERENCE

- [1] Marsico G, Gatto E, Burrascano M, Matarese G, Cordasco G. Effectiveness of orthodontic treatment with functional appliances on mandibular growth in the short term. *Am J Orthod Dentofacial Orthop.* 2011;139(1):24-36.
- [2] Bock NC, Ruf S. Occlusal and cephalometric evaluation of Class II treatment with the Twin Block appliance followed by fixed appliances. *Am J Orthod Dentofacial Orthop.* 2012;141(5):627-635.
- [3] Elsharaby FA, Elshazly T. A systematic review on the dentoskeletal effects of Twin Block and Herbst appliances in Class II malocclusion treatment. *Eur J Orthod.* 2022;44(4):412-423.

- [4] Ehsani S, Nebbe B, Normando D, Flores-Mir C. Short-term treatment effects of the Twin Block appliance versus Herbst-like appliances in Class II division 1 malocclusion. *Eur J Orthod*. 2015;37(3):275-281.
- [5] Toth LR, McNamara JA. Treatment effects produced by the Twin-block appliance and the FR-2 appliance of Frankel compared with an untreated Class II sample. *Am J Orthod Dentofacial Orthop*. 1999;116(6):597-609.
- [6] Pancherz H, Hansen K. Occlusal changes during and after Herbst treatment: A cephalometric study. *Eur J Orthod*. 1986;8(4):215-228.
- [7] O'Brien K, Wright J, Conboy F, et al. Effectiveness of treatment for Class II malocclusion with the Twin Block appliance: A randomized, controlled trial. *Am J Orthod Dentofacial Orthop*. 2003;124(2):128-137.
- [8] Ruf S, Pancherz H. Dentoskeletal effects of Herbst appliance treatment in the early and late growth period: A retrospective cephalometric analysis. *Am J Orthod Dentofacial Orthop*. 2006;129(4):491-498.
- [9] Jena AK, Duggal R. Treatment effects of twin-block and mandibular protraction appliance-IV in subjects with Class II Division 1 malocclusion. *Angle Orthod*. 2006;76(4):566-572.
- [10] Bacetti T, Franchi L, McNamara JA. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. *Semin Orthod*. 2005;11(3):119-129.
- [11] Kilic N, Erkan M, Oktay H. Soft tissue changes following Twin Block and Herbst appliance therapy: A systematic review. *Am J Orthod Dentofacial Orthop*. 2013;144(5):654-662.
- [12] Mills CM, McCulloch KJ. Treatment effects of the twin block appliance: A cephalometric study. *Am J Orthod Dentofacial Orthop*. 1998;114(1):15-24.
- [13] Batista KBS, Thiruvengkatachari B, Harrison JE, O'Brien KD. Orthodontic treatment for prominent upper front teeth in children and adolescents. *Cochrane Database Syst Rev*. 2018;3(3):CD003452.
- [14] Pacha MM, Fleming PS, Johal A. A comparison of Twin Block and Herbst effects on condylar position: A systematic review. *Angle Orthod*. 2016;86(4):686-692.
- [15] Keeling SD, Wheeler TT, King GJ, Garvan CW, Cohen DA. Anteroposterior and vertical changes after early Class II treatment with bionators and headgear. *Am J Orthod Dentofacial Orthop*. 1998;113(1):40-50.
- [16] Woodside DG, Linder-Aronson S. Mandibular growth after changed oral respiration patterns. *Am J Orthod Dentofacial Orthop*. 1991;100(1):1-18.
- [17] Filipović N, Toljan I, Brakus D, et al. Cephalometric effects of functional appliances in Class II malocclusion: A systematic review. *J Orthod Sci*. 2020;9(1):2-9.
- [18] Atik E, Taner T, Darendeliler N. The effects of fixed and removable functional appliances on Class II malocclusion. *Eur J Orthod*. 2007;29(2):139-145.
- [19] Singh GD, McNamara JA, Lozanoff S. Finite element analysis of Twin Block appliance therapy. *Am J Orthod Dentofacial Orthop*. 2000;118(3):325-332.
- [20] Trenouth MJ. Proportional changes in cephalometric distances during Twin Block appliance therapy. *Eur J Orthod*. 2002;24(5):485-491.
- [21] Xu F, Fang Y, Sui X, Yao Y. Comparison of Twin Block appliance and Herbst appliance in the treatment of Class II malocclusion among children: a meta-analysis. *BMC Oral Health*. 2024 Feb 26;24(1):278.
- [22] Baysal A, Uysal T. Dentoskeletal effects of Twin Block and Herbst appliances in patients with Class II division 1 mandibular retrognathia. *Eur J Orthod*. 2014 Apr;36(2):164-72.
- [23] Pacha MM, Fleming PS, Shagmani M, Johal A. The skeletal and dental effects of Hanks Herbst versus twin block appliances for class II correction in growing patients: a randomized clinical trial. *Eur J Orthod*. 2024 Jan 1;46(1):cjad065.
- [24] O'Brien K, Wright J, Conboy F, Sanjie Y, Mandall N, Chadwick S, Connolly I, Cook P, Birnie D, Hammond M, Harradine N, Lewis D, McDade C, Mitchell L, Murray A, O'Neill J, Read M, Robinson S, Roberts-Harry D, Sandler J, Shaw I. Effectiveness of treatment for Class II malocclusion with the Herbst or twin-block appliances: a randomized, controlled trial. *Am J Orthod Dentofacial Orthop*. 2003 Aug;124(2):128-37.
- [25] Kannan A, Padmanabhan S. Comparative evaluation of soft tissue profile changes with herbst and twin block appliances in class II malocclusion patients: A perception study. *Turk J Orthod*. 2022;35(3):173-179.
- [26] Pancherz H. The effects, limitations, and long-term dentofacial adaptations to treatment with the Herbst appliance. *Semin Orthod*. 1997 Dec;3(4):232-43.
- [27] Bondevik O, Espeland L, Stenvik A. Dental arch changes from 22 to 43 years of age: are they different in individuals with high versus low mandibular plane angle? *Eur J Orthod*. 2015 Aug;37(4):367-72.
- [28] Ehsani S, Nebbe B, Normando D, Lagraverre MO, Flores-Mir C. Short-term treatment effects produced by the Twin-block appliance: a systematic review and meta-analysis. *Eur J Orthod*. 2015 Apr;37(2):170-6.
- [29] Schaefer AT, McNamara JA Jr, Franchi L, Bacetti T. A cephalometric comparison of treatment with the Twin-block and stainless-steel crown Herbst appliances followed by fixed appliance therapy. *Am J Orthod Dentofacial Orthop*. 2004 Jul;126(1):7-15.
- [30] Buyukcavus MH, Kale B. Skeletal and dental effects of twin-block appliances in patients treated with or without expansion. *Turk J Orthod*. 2021; 34(3): 155-162.
- [31] Spalj S, Mroz Tranesen K, Birkeland K, Katic V, Pavlic A, Vandevska-Radunovic V. Comparison of Activator-Headgear and Twin Block Treatment Approaches in Class II Division 1 Malocclusion. *Biomed Res Int*. 2017;2017:4861924.
- [32] Pancherz H, Anehus-Pancherz M. Facial profile changes during and after Herbst appliance treatment. *Eur J Orthod*. 1994 Aug;16(4):275-86.
- [33] Pancherz H. The effects, limitations, and long-term dentofacial adaptations to treatment with the Herbst appliance. *Semin Orthod*. 1997 Dec;3(4):232-43.
- [34] Tripathi T, Singh N, Rai P, Gupta P. Comparison of Dentoskeletal Changes, Esthetic, and Functional Efficacy of Conventional and Novel Esthetic Twin Block Appliances among Class II Growing Patients: A Pilot Study. *Turk J Orthod* 2020; 33(2): 77-84.
- [35] Flores-Mir C, Major PW. Cephalometric facial soft tissue changes with the twin block appliance in Class II division 1 malocclusion patients. A systematic review. *Angle Orthod*. 2006 Sep;76(5):876-81.
- [36] Jena AK, Duggal R, Parkash H. Orthopedic and orthodontic effects of Twin-block appliance. *J Clin Pediatr Dent*. 2005 Spring;29(3):225-30.
- [37] Shahzad, Khurram & Cheema, Javeeria & Azeem, Muhammad & Hamid, Waheed. (2018). Dentoskeletal Changes in Class II Subjects following Treatment with Twin Block and Herbst Appliance. *Orthodontic Journal of Nepal*. 8. 18. 10.3126/ojn.v8i1.21341.
- [38] Taha, Mahasen & Hammad, Shaza. (2011). A radiographic comparison of apical root resorption between Herbst and Jumper twin block bite appliances. *Egyptian Orthodontic Journal*. 39. 15-28.