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Clinical efficacy of aligners with mandibular advancement in treatment of Class II malocclusions compared to conventional functional appliances: A systematic review

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SUMMARY

Background and objectives. Clear aligners were initially limited to the treatment of mild malocclusions. Recent advancements have expanded their use to skeletal Class II correction through mandibular advancement features designed to mimic conventional functional appliances. However, evidence regarding their clinical effectiveness, particularly compared with traditional functional appliances, remains limited. The aim of this systematic review is to evaluate the clinical effectiveness of clear aligners with mandibular advancement in the management of Class II malocclusion, in comparison with conventional functional orthopedic appliances.

Material and methods. The protocol of the systematic review is in line with the PRISMA requirements, papers published in English language between 2020 and 2025 were searched in PubMed, ScienceDirect, The Cochrane Library and Google Scholar databases using the PICO framework. The ROBINS-I tool was used to assess the risk of bias.

Results. A total of 726 articles were identified. After eliminating duplicates and applying eligibility criteria, nine studies involving 412 patients were included, primarily using cephalometric analyses to evaluate skeletal and dental changes before and after treatment. Despite variability in the parameters assessed and methodologies used, both aligners with mandibular advancement and conventional functional appliances showed similar skeletal and dental correction. Consistent reductions in overbite and overjet, increases in SNB as well as decreases in ANB and Wits appraisal.

Conclusion. Aligners with mandibular advancement appear to be an effective option for treating Class II malocclusions in growing patients, demonstrating similar dentoalveolar and skeletal effects to conventional functional appliances. However, methodological limitations and heterogeneity among studies restrict the strength of the evidence.

Keywords: mandibular advancement, functional appliances, invisalign mandibular advancement, Class II malocclusion, mandibular skeletal retrusion.

INTRODUCTION

Class II malocclusion is one of the most common orthodontic problems, with a reported prevalence of approximately 20-25% globally (1). Individuals presenting with this condition may demonstrate skeletal and dentoalveolar discrepancies with mandibular retrognathism present in most of the cases (1-4). Malocclusion can have a substantial impact on an individual's quality of life by impairing orofacial functions such as mastication and speech while also exerting psychological and social effects due to its effect on appearance (5-6).

A range of functional appliances has historically been used for the treatment of Class II malocclusion, aiming to promote mandibular growth by maintaining the mandible in an advanced position. Among these appliances, the Twin Block and Herbst are the most commonly used removable and fixed options, respectively (6).

A major limitation of removable functional appliances is patient compliance (7-8). These ap-

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pliances are often bulky and difficult to tolerate because they can interfere with speech and normal oral function, leading some patients to discontinue their use. In addition, they have high production costs and must be worn for extended periods—typically 9 to 18 months—to achieve correction of Class II malocclusions (9-10).

Fixed Class II correctors, such as the Herbst appliance, are less dependent on patient compliance. However mandibular mobility may be restricted, they are susceptible to breakage, and frequently lead to undesirable dental compensations, most notably excessive flaring of mandibular incisors (11-12).

In 2017, Invisalign introduced a mandibular advancement (MA) feature incorporated into its clear aligners to assist in the correction of Class II malocclusions in growing patients. The MA feature mimics the twin-block appliance and is similarly composed of inclined planes positioned buccally in the posterior region of the aligners to posture the mandible forward. Mandibular advancement aligners offer several advantages, including enhanced aesthetics, increased patient comfort and the ability to simultaneously address orthodontic and orthopedic treatment goals. These benefits are critical for promoting patient compliance, which is essential for optimizing treatment outcomes and reducing overall treatment duration (13-16).

Despite these proposed benefits, evidence supporting its effectiveness has remained limited, largely due to the extended treatment duration required in growing patients and the lack of long-term follow-up studies. Consequently, the clinical efficacy of mandibular advancement aligners compared with conventional functional orthopedic appliances remains unclear. Therefore, this systematic review aimed to evaluate the effectiveness of clear aligners incorporating mandibular advancement in the treatment of growing patients with Class II malocclusion, compared with traditional functional appliances.

MATERIAL AND METHODS

Study protocol

The current systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (17).

Focus question

The objective of this review was to address the focus questions: How effective are mandibular advancement aligners in treatment of Class II malocclusion compared to conventional orthopedic appliances? The focus question was developed based on the Population, Intervention, Comparison, and Outcomes (PICO) design (18).

Population: Growing pediatric patients diagnosed with Class II malocclusion requiring functional appliance therapy.

Intervention: Treatment of skeletal Class II malocclusion with mandibular advancement aligners.

Comparison: Class II orthopedic functional appliances.

Outcomes: Efficiency and clinical outcomes of mandibular advancement aligners compared with conventional functional appliances in Class II malocclusion treatment.

Search Strategy

A comprehensive search was performed in PubMed, Science Direct, Google Scholar and Cochrane Library electronic databases to identify records published from 2020 to 2025. The search strategy used a combination of keywords and MeSH terms to ensure a comprehensive retrieval of studies. The syntax included terms such as: (”Class II malocclusion” OR ‘’Mandibular retrusion’’) (“clear aligner” OR “mandibular advancement”[MeSH Terms] OR ”functional aligners”) (“functional appliance” OR “Twin-Block” OR “Herbst”) NOT (‘’orthognathic surgery’’[MeSH Terms] OR ‘’surgery’’ OR ‘’osteotomy’’[MeSH Terms]).The search syntax was adapted for each database to align with its respective indexing system and search requirements.

Selection of studies

Two authors independently conducted the study selection in a two-stage process. In the first stage, titles and abstracts of all retrieved records were screened for relevance. In the second stage, the full texts of potentially eligible articles were assessed using inclusion and exclusion criteria. Any disagreements between the two reviewers were resolved through discussion.

Eligibility criteria:

1. Studies using mandibular advancement aligners and any other functional appliance in treatment of Class II malocclusion;
2. Studies with appropriate and sufficient data;
3. Articles with full text availability;
4. Studies written in the English language;
5. Articles published between 2020 and 2025.

Exclusion criteria:

1. Case series, case reports, systematic reviews, conference abstracts, and opinion articles;
2. Studies not published in the English language;

3. Studies with surgical or syndromic cases;
4. Trials with missing information or unclear data.

Data extraction

Data extraction was performed independently by two reviewers. For each included study, the following information was recorded: study characteristics (authors, year of publication), study design, participant demographics (sample size, gendre distribution and mean age), treatment methods, methods of outcome assessment, treatment duration, and key findings.

Risk of bias assessment

The methodological quality of the included studies was independently evaluated by two reviewers using the ROBINS-I tool (19).

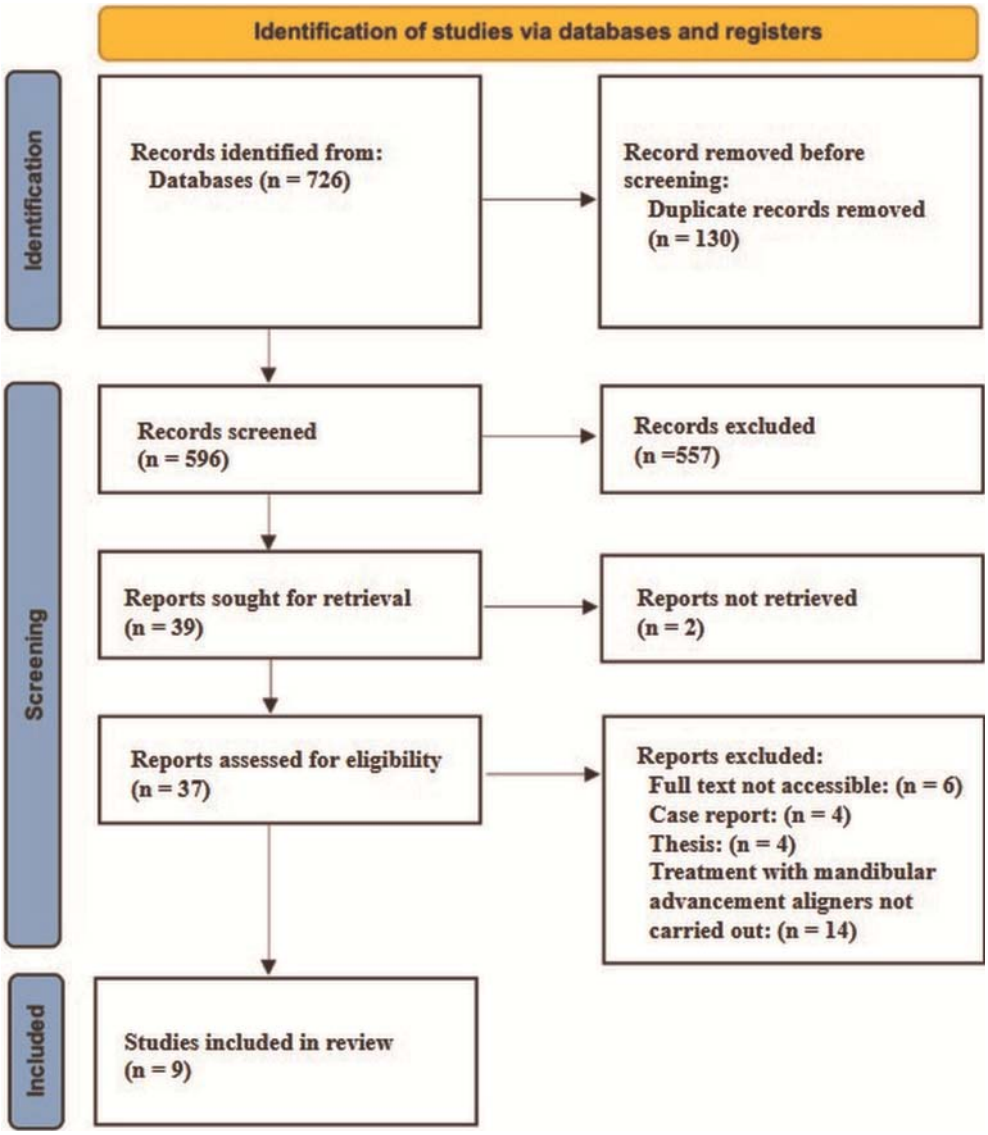

Fig. 1. PRISMA flow chart

RESULTS

Study selection

Following the initial database search, 726 records were identified. After duplicate removal, 596 unique records remained. Titles and abstracts were independently screened, resulting in articles selected for full-text assessment. Of these, 9 studies met the predefined inclusion criteria and were incorporated into the systematic review. The study selection process is illustrated in the PRISMA flow diagram (Figure 1).

Study characteristics

Nine studies that were conducted between 2021 and 2025 were included in this systematic review. All nine of them adopted a retrospective study design. Table presents data on the characteristics and outcomes of the included studies.

A total of 412 patients (males and females) were included in the studies (20-28). Mean participant age across studies ranged from 10 (23) to 15 years (27), depending on the treatment group. The included studies predominantly focused on growing patients presenting with skeletal Class II malocclusion. The majority compared mandibular advancement aligners with the Twin Block appliance (20-23, 25-27), while one study evaluated mandibular advancement aligners relative to the Herbst appliance (28), and one mandibular advancement aligners compared to twin block, herbst appliance and Vanbeek activator (24). Some studies also included an untreated control group (21, 23, 24, 26). Treatment durations varied among studies, although some did not disclose it (21-23). Outcomes were primarily assessed by analysing cephalometric radiographs (20-28), while one study also analysed 3D models (28).

Quality assessment

The ROBINS-I tool (Risk of Bias in Non-randomized Studies of Interventions) is designed to assess the quality of studies that compare interventions in situations where randomization was

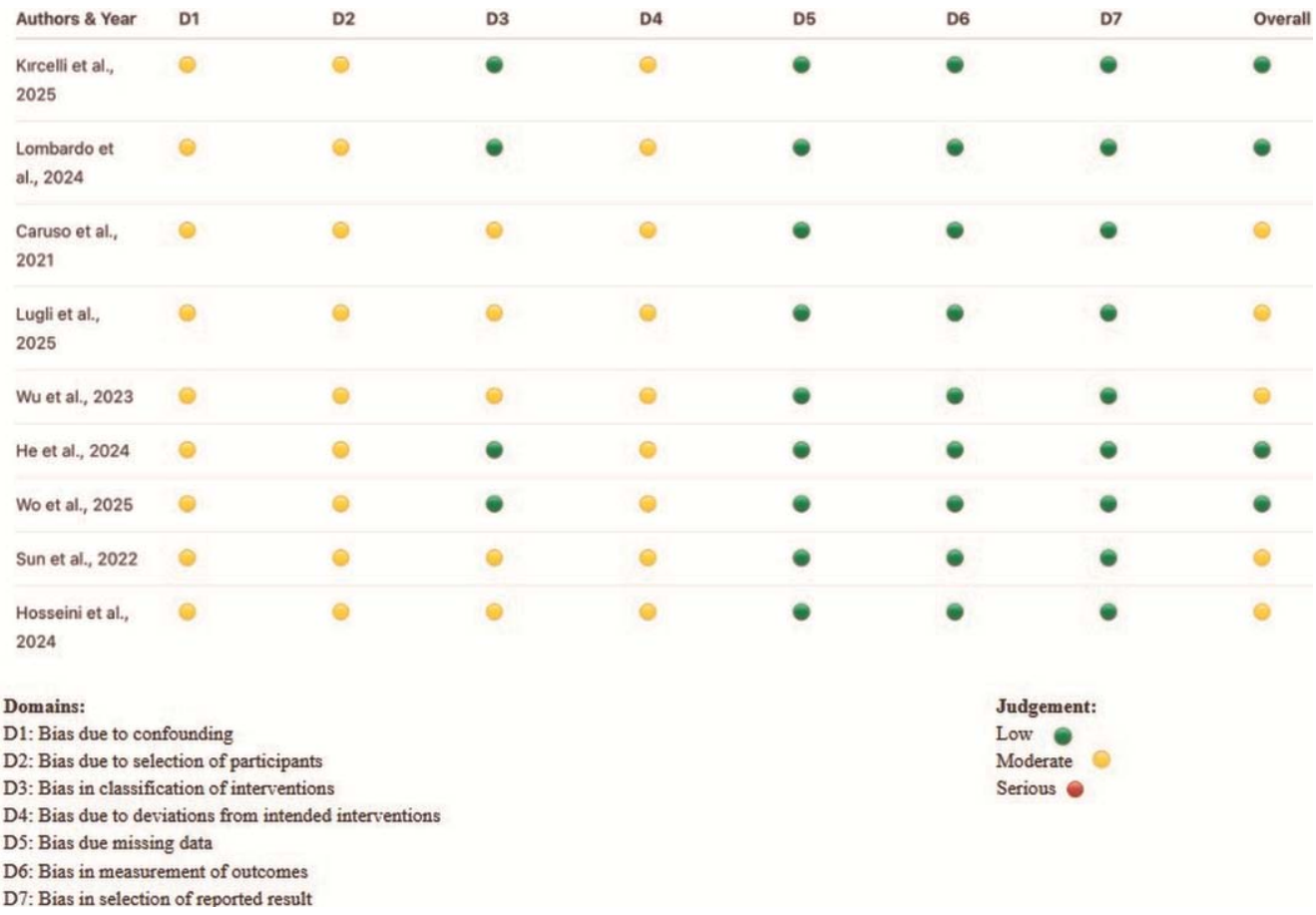

Fig. 2. Risk of bias evaluation

not used. It evaluates the risk of bias across several domains and provides a systematic framework for appraising non-randomized controlled trials with the results presented in Figure 2. Main sources of bias were related to confounding, participant selection and deviations from intended interventions as none of the included studies employed randomization and key confounding variables, patient compliance and environmental influences, were insufficiently controlled. The predominance of retrospective study designs further heightened the risk of selection bias, as inclusion may have favored patients with favorable treatment outcomes. This lack of transparency resulted in a moderate risk of bias in 5 studies (22-24, 27, 28) whilst four studies resulted in low risk of bias (20, 21, 25, 26).

Results of individual studies and main findings

Studies comparing treatments with Mandibular Advancement aligners and Twin-Block, both groups showed a significant reduction in the ANB angle (20-23, 25-27) and Wits appraisal values (20, 25, 26) post-treatment, with no significant difference between them. Except in one research where Wits appraisal reduction was more significant in the TB group (26). The SNB angle increased in both groups (20, 22, 25, 26) except in the study by Sun *et al.*, favoring TB group (27). Mandibular length Co-Gn (21, 23, 27) also showed significant increases in both groups. Both appliances improved soft tissue profile with significant increase in the Z-angle (25-27), reduction in the H-angle (26,27). A decrease in the UL-E-line distance was also observed, indicating that the two appliances had a significant effect on improving the protrusion of the upper lip (26, 27). Dentoalveolar effects varied, some studies reported that upper incisors retraction was greater in the MA (20, 27), with 2 studies also reporting a good control of the position of the lower incisors in the MA group in 2 studies (20, 22).

Kircelli *et al.* assessed transverse changes from digital models and reported significant increases in maxillary intercanine width in both groups, with greater expansion in MA. Mandibular intercanine width and molar expansion in both arches increased significantly only in the MA group.

Wu *et al.* reported that all appliance groups (MA, Twin-Block, Herbst, and Van Beek) showed increased SNB and decreased ANB compared with controls. Supplementary mandibular elongation (Co-Go, Co-Pog) was observed in MA and Twin-Block, and Co-Pog in Herbst. Dental changes varied, but MA showed better incisor control.

Table. General characteristics of the selected studies

Authors and Year	Study Design	Treatment Methods	Sample Size	Gender Distribution	Mean age (Years)	Average treatment duration	Assessment method	Outcomes
Kırcelli *et al.*, 2025	Retrospective study	TB and MA	32 patients (TB-18, MA-14)	MA (Male 8, Female 6) TB (Male 8, Female 10)	TB (12±1.34) MA(13.21±1.42)	MA (19.36±5.68) TB (12±6.39)	Cephalometric radiographs and scanned models (intercanine and intermolar widths)	MA showed greater transverse expansion and better maintenance of lower incisor inclination. In both groups increased SNB, decreased SNA, ANB and Wits appraisal.
Lombardo *et al.*, 2024	Retrospective study	TB and MA	71 patients (TB-35, MA-21, Control group- 15)	MA (Male 9, Female 12) TB (Male 17, Female 18) Control group (Male 4, Female 11)	TB (12±1.3), MA (11.2±1.1), Control group(10.9±1.1)	Not disclosed	Cephalometric radiographs	TB and MA reduced ANB, increased Co-Gn value. Increase in Pg to TVL distance was greater in the TB group. Both groups improved overjet and overbite.
Caruso *et al.*, 2021	Retrospective study	TB and MA	20 patient (TB-10, MA-10)	MA (Male 5, Female 5) TB (Male 5, Female 5)	TB (10 ±1.05), MA (10 ±1.05),	Not disclosed	Cephalometric radiographs	SNB increased in both groups. SNA remained unchanged in the MA group but decreased in the TB group. Both TB and MA groups showed a decrease in the ANB angle, which was significantly greater in the TB group, overjet decreased in both groups.
Lugli *et al.*, 2025	Retrospective study	TB and MA	69 patients (TB-22, MA-23, Control group- 24)	MA (Male 11, Female 12) TB (Male 14, Female 8) Control group (Male 12, Female 12)	TB (11.3±1.4 years), MA (11.2±1.3), Control group(11.2±1.1)	Not disclosed	Cephalometric radiographs	Both the TB and MA groups showed a significant increase in the profile facial angle (G'-SubNPg') and mandibular sulcus parameter. TB and MA reduced ANB and increased Co-Gn value. Increase in Pg to TVL distance was greater in the TB group. Both groups improved overjet and overbite.
Wu *et al.*, 2023	Retrospective study	TB, MA, Herbst appliance, Vanbeek Activator	63 patients (TB-12, MA-14, Vanbeek Activator-14, Herbst appliance-11, Control group- 12	MA (Male 8, Female 11) TB (Male 7, Female 5) Vanbeek Activator (Male 7, Female 7) Herbst appliance (Female 7, Male 4) Control group (Male 7, Female 5)	TB (11.00±1.04), MA (12.11±1.16), Vanbeek Activator (10.71±1.44), Herbst appliance (11.55±0.69), Control group (10.41±0.90)	TB (10.16±5.46), MA (22.84±8.98), Vanbeek Activator (7.28±2.30), Herbst appliance (10.18±3.06), Control group (10.25±3.74)	Cephalometric radiographs	SNB, FH-NP, and lower facial height ratio increased, while NA-PA and ANB decreased in all groups. Co-Go increased in Twin-Block and MA groups, and Co-Pog increased in Herbst. Dental changes varied: U1-PP changed most in MA and TB, U6-PP decreased in Herbst but increased in other groups, L1-MP increased most in Herbst, and U1-L1 increased in VanBeek and MA.
He *et al.*, 2024	Retrospective study	TB and MA	24 patients (TB-12, MA-12)	Not disclosed	TB (11.87±0.34) MA(11.73± 0.33)	MA (~12 months) TB (~12 months)	Cephalometric radiographs	Both MA and TB effectively reduced overjet, ANB, and Wits appraisal, while increasing SNB and Z-angle.
Wo *et al.*, 2025	Retrospective study	TB and MA	47 patients (TB-15, MA-19, Control group- 13)	MA (Male 8, Female 11) TB (Male 9, Female 6) Control group (Male 6, Female 7)	TB (11.86±1.92), MA (11.19±1.31), Control group(11.62±1.85)	MA (~13 months) TB (~10 months) Control group (~12 months)	Cephalometric radiographs	Both MA and TB showed reduced ANB and Wits appraisal, with greater Wits improvement in TB. Both MA and TB caused upper incisors lingual and lower incisors labial tipping, reducing overjet and overbite. Both TB and MA retracted the upper lip, improved facial convexity, and reduced H angle, with greater changes in TB.
Sun *et al.*, 2022	Retrospective study	TB and MA	46 patients (TB-23, MA-23)	MA (Male 11, Female 12) TB (Male 12, Female 11	TB (15.25±4.93) MA(12.07±2.63)	MA (10.23±3.27) TB (9.40±4.23)	Cephalometric radiographs	Both groups reduced ANB and increased facial height (ANS-Me, N-Me, S-Go). Both appliances increased Co-Gn value. After treatment with MA and TB overjet and overbite was reduced. MA caused greater maxillary incisor adduction. Both TB and MA reduced the Ul-E-line, increased Z-angle and enhanced chin prominence.
Hosseini *et al.*, 2024	Retrospective study	TB and Herbst	N=40 (20 Invisalign, 20 Herbst)	MA (Male 9, Female 11) Herbst (Male 9, Female 11)	MA (13.1±1.5) Herbst (12.7 ±1.8)	MA(~ 32.3 months) Herbst (~36.8 months)	Cephalometric radiographs	Both the Herbst and MA appliances reduced overjet, overbite, ANB, and Wits appraisal, with greater changes observed in the Herbst group. Greater mandibular incisor proclination was also noted with the Herbst appliance.

Similarly, Hosseini *et al.* found reductions in SNA and ANB and increases in SNB with both MA and Herbst. Greater improvements in overjet, molar relationship, Wits appraisal, and overbite were observed in the Herbst group, whereas MA provided better control of mandibular incisor inclination and showed a less pronounced increase in lower anterior facial height.

DISCUSSION

The effectiveness of functional appliances in the management of Class II malocclusion remains a subject of ongoing debate. While several controlled clinical trials have evaluated the skeletal and dentoalveolar effects of conventional functional appliances, evidence specifically addressing mandibular advancement aligner systems is still limited and inconsistent.

This systematic review included nine (20-28) retrospective studies evaluating the skeletal and dental effects of aligners with mandibular advancement in comparison with conventional functional appliances. The included studies analysed a wide range of cephalometric parameters, including anteroposterior skeletal relationships, vertical facial height, overbite and overjet. However, considerable heterogeneity was observed in both outcome measures and methodological approaches. Despite this variability, the overall evidence suggests that aligners with mandibular advancement and conventional functional appliances produce comparable skeletal and dentoalveolar corrections.

In studies comparing MA and TB, both the Twin Block and Mandibular Advancement aligners function via similar mechanisms, employing inclined planes to guide the mandible anteriorly (32). Increases in SNB and mandibular length (Co-Gn), as well as decreases in ANB and Wits appraisal were noticed in the included studies, reflecting the orthopedic impact of both appliance types. Regarding maxillary growth, neither treatment demonstrated a marked inhibitory effect.

In comparison TB appliances seemed to be more efficient in the advancement of the chin and consequently in the improvement of the facial profile. This could be related to the one step protrusion of the mandible performed if using the TB compared to the gradual advancement realized with the MA (26).

In terms of dentoalveolar effects, mandibular advancement aligners demonstrated control over the angulation of both upper and lower incisors, which is a crucial factor in achieving long-term stability and may also be beneficial in cases of Class II, Division 2 malocclusion, where normalization of overjet is required to allow proper mandibular advancement.

Regarding the expansion achieved with TB and MA, Kircelli *et al.* reported that MA appliance can facilitate simultaneous mandibular advancement and lower-arch expansion when indicated, highlighting their potential for combined sagittal and transverse correction in selected cases (20). However, evidence suggests that maxillary expansion achieved with clear aligners occurs predominantly through dentoalveolar tipping and is supported by limited long-term stability data. Additionally, mandibular intercanine expansion has been shown to be prone to relapse. Therefore, expansion achieved primarily through tipping should be interpreted with caution (29,30).

When evaluated against the Herbst appliance, mandibular advancement aligners were more effective in limiting lower incisor proclination, as reported by Wu *et al.* and Hosseini *et al.* Conversely, treatment with the Herbst appliance was associated with greater improvements in overjet, molar relationship, Wits appraisal, and overbite (24,28). According to Hosseini *et al.*, this is likely due to the stepwise mandibular advancement protocol, which includes overcorrection toward a Class III canine relationship – a strategy that may reduce the risk of relapse. In contrast, treatment with the MA appliance is generally limited to correction of overjet to an ideal value (28).

Patient compliance is a critical consideration in Class II treatment with removable functional appliances (31). Conventional devices, such as the Twin Block, may be associated with functional limitations affecting speech, sleep, schooling, and social interactions, which can negatively impact adherence over time (32). Furthermore, patients with a history of prior orthodontic treatment often exhibit reduced compliance, particularly when therapy involves multiple appliances or extended treatment durations (33).

In this context, the MA appliance may provide a more integrated treatment approach by simultaneously advancing the mandible while also achieving dental alignment and controlling anterior tooth inclination. In contrast, conventional functional appliances primarily focus on mandibular repositioning and frequently require a two-stage protocol followed by comprehensive fixed orthodontic therapy. This combined functionality of the MA system may reduce overall treatment duration, which could enhance patient compliance and improve treatment efficiency.

An important limitation of the included studies is their retrospective design, which increases the risk of

bias, particularly due to the exclusion of patients based on predefined selection criteria. Such exclusions may have influenced the reported outcomes. Another limitation is that changes in the transverse dimension were not adequately assessed, as three-dimensional imaging was not utilized, potentially limiting measurement accuracy. Additionally, patient compliance with removable MA appliances was not evaluated, which is a relevant factor since variations in cooperation can affect both skeletal and dental treatment outcomes when comparing fixed and removable appliances. Finally, treatment efficiency was not addressed, as outcomes such as the number of required office visits and emergency appointments were not reported. These considerations may influence appliance selection in clinical practice and should be accounted for in future research.

CONCLUSION

Based on the available evidence, it is not possible to identify a superior orthopedic appliance for the management of Class II malocclusion. The overall strength of the evidence is limited due to methodological weaknesses, including baseline dentoskeletal discrepancies between groups, heterogeneous analytical approaches, retrospective designs, and short follow-up periods. This heterogeneity limited direct comparisons and precluded definitive conclusions.

Despite these limitations, both functional appliances showed a clinically meaningful effect on mandibular growth and were associated with favorable reductions in overjet and overbite, supporting their effectiveness in Class II correction without a clear advantage of one over the other. Future research should focus on well-designed, randomized longitudinal studies with adequate sample sizes and long-term follow-up.

STATEMENT OF CONFLICTS OF INTEREST

The authors state no conflict of interest.

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