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# Clear Aligners for Orthodontic Correction of Class II Malocclusions in Adult Patients Without Tooth Extraction: A Systematic Review

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## ABSTRACT

**Objective(s):** This systematic review analyzed the use of clear aligners (CAs) in adult patients with Class II malocclusion who needed orthodontic treatment. The aim was to investigate the use, effectiveness, benefits, and limitations of the CAs in orthodontic treatment in adult patients.

**Materials and Methods:** This review was conducted according to the PRISMA statement, and the protocol was registered at PROSPERO. A comprehensive search on PubMed, Scopus, and Web of Science was conducted to identify relevant papers dated from January 1, 2014, to October 25, 2024. The electronic database search identified a total of 811 articles. After eligibility, 14 records were selected for qualitative analysis.

**Settings and Sample Population:** The relevant papers, randomized clinical trials, retrospective studies, case series, and case reports, in the English language, and with full text, involving adult patients, females and males, with Class II malocclusion treated with aligners.

**Results/Conclusion:** The findings suggest that the use of CAs in Class II malocclusion is achieved with the sequential distalization of the teeth and the application of intermaxillary elastics and miniscrews. The miniscrews allow treatment with precision, control, and greater anchorage, especially in cases requiring complex tooth movements, such as distalization. The results showed, in addition to the esthetics and comfort of aligners, adequate predictability of even the most complex movements leading to the resolution of Class II malocclusion.

## 1 | Introduction

Class II malocclusions are among the most common types of dental misalignment, and orthodontic repair presents substantial complications due to the anteroposterior disparity between the upper and lower arches. This difference frequently causes complications, such as overjet and misaligned molar connections, which have an impact on both function and appearance [1–4]. These difficult cases have traditionally been treated with fixed appliances, such as braces, as well as supplemental devices, such as Pendulum appliances, Herbst appliances, or headgear [5–11]. These traditional procedures attempt to achieve Class II

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correction by a variety of biomechanical measures, including molar distalization (MD), arch extension, and vertical control of tooth movement [12–16]. Fixed appliances, while successful, have limitations, such as esthetic downsides, pain, and increased difficulty maintaining oral hygiene, prompting many patients particularly adults to seek alternate treatment choices [17–26]. Clear aligners (CAs) have become an increasingly popular alternative for orthodontic treatment in recent years, providing a more cosmetic, pleasant, and practical choice for patients who want to maintain their privacy while still receiving effective treatment [27–33]. Advances in aligner technology, including digital treatment planning, predictive algorithms, and the incorporation of biomechanical aids, such as intermaxillary elastics and mini-implants, have broadened the potential applications of transparent aligners beyond cases previously addressed with fixed appliances [34–41]. The adaptability of CAs, combined with sophisticated software and strategic attachment placements, has sparked interest in their use in Class II malocclusion cases [42–45].

While preliminary studies show that CAs can accomplish regulated MD, arch stability, and tooth movement with minimal tipping or extrusion, there are still considerable uncertainties about their overall performance when compared to traditional braces [36, 46–54]. Specific limitations, such as difficulties achieving ideal anterior–posterior (AP) corrections and maintaining incisor proclination control, have been identified in the literature, implying that CAs may necessitate additional auxiliary mechanics or longer treatment times to achieve results comparable to fixed appliances [38, 55–60]. The heterogeneity in treatment outcomes associated with CAs, which is frequently influenced by factors, such as attachment design, the technique for staging tooth movements, patient adherence to wearing CAs, and specific anatomical considerations, highlights the need for additional systematic research. Furthermore, anchorage control, a critical factor in Class II corrections, showed variable results with CAs [61–66]. While studies have demonstrated effective distalization of molars, outcomes involving loss of anchorage, particularly in the anterior superior region, suggest that precise protocols, such as the application of intermaxillary elastics or miniscrews, may be critical to maintaining stability [37, 63, 67–75].

This review aims to evaluate the main therapeutic outcomes related to CAs, such as the effectiveness of MD, preservation of occlusal stability, control of arch width and incisor inclination, and the amount of anchorage loss. Furthermore, by exploring the role of auxiliary elements, such as intermaxillary elastics and miniscrews, in enhancing treatment with CAs, this review sought to identify best practices for the implementation of CAs in adult orthodontic care. By strengthening and investigating current evidence, this systematic review was intended to clarify the clinical indications for CAs in the successful management of Class II malocclusions, establish their efficacy, and offer insight into the conditions under which CAs may perform optimally.

## 2 | Materials and Methods

### 2.1 | Protocol and Registration

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [76]. The review protocol was registered at PROSPERO, ID 643040.

### 2.2 | Search Processing

A search on PubMed, Scopus, and Web of Science was performed to find papers that matched the topic of orthodontic treatment performed with CAs in adult patients with Class II malocclusion and the necessity of orthodontic treatment, dated from January 1, 2014, to October 25, 2024, in English. The search strategy used the Boolean keywords:

(aligners OR CAs OR transparent aligners OR Invisalign) AND (Class II malocclusion) (Table 1).

### 2.3 | Inclusion Criteria

The following inclusion criteria were considered: (1) studies that investigated orthodontic treatment performed with CAs in adult patients with the necessity of orthodontic treatment; (2) randomized clinical trials and retrospective studies; (3) English language; and (4) full text.

Papers that did not match the above criteria were excluded.

The PICOS criteria used:

- Participants: both male and female, adult, without pathologies or syndromes, with Class II malocclusion and the necessity of orthodontic treatment
- Interventions: orthodontic treatment performed with aligners
- Comparisons: patients treated and patients not treated
- Outcome: The main outcomes analyzed were as follows:
  - *MD:* evaluation of the effectiveness and efficiency of upper MD (measured in millimeters of displacement and tipping control).
  - *Maxillary incisor edges retraction:∗ extent of retroclination and retraction of upper incisors, assessed cephalometrically.
  - *Anchorage loss:* measured as mesial displacement of canines and premolars.
  - *Overjet reduction:* degree of improvement in sagittal relationships.
  - *Vertical control:* changes in anterior facial height, molar extrusion, and occlusal plane rotation.
  - *Arch width maintenance:* evaluation of transverse expansion or stability at premolar and molar levels.
- Study: randomized controlled trial (RCT) and CCT

### 2.4 | Exclusion Criteria

The exclusion criteria were as follows: (1) animal studies; (2) in vitro studies; (3) off-topic; (4) reviews, letters, or comments; (5) no English language; and (6) case reports and case series.

### 2.5 | Quality Assessment

The reviewers, M.C. and P.A., used "ROBINS," a tool developed to assess the risk of bias in the results of nonrandomized studies that compare the health effects of two or more interventions.

**TABLE 1** | Database search indicators.

| | |
|---|---|
| Articles screening strategy | Keywords: A: aligners; B: CAs; C: transparent aligners; D: Invisalign; E: class II malocclusion<br>Boolean Indicators: (A OR B OR C OR D) AND (E)<br>Timespan: January 1, 2014, to October 25, 2024<br>Electronic Databases: PubMed; Scopus; Web of Science |

"Seven points were evaluated and each was assigned a degree of bias."

The question in the domains evaluated in the ROBINS is the following:

- Bias due to confounding
- Bias arising from the measurement of exposure
- Bias in the selection of participants in the study
- Bias due to postexposure intervention
- Bias due to missing data
- Bias arising from the measurement of the outcome
- Bias in the selection of the reported results [75].

## 3 | Results

### 3.1 | Study Selection and Characteristics

The electronic database search identified a total of 811 articles (Scopus $N = 149$, PubMed $N = 544$, and Web of Science $N = 118$), and no articles were included through the hand search.

After the deletion of duplicates, 623 studies were screened by evaluating the title and abstract, focusing on orthodontic treatment performed with CAs in adult patients with Class II malocclusion. A total of 613 articles did not meet the inclusion criteria (603 off-topic, 6 reviews, and 4 case reports), leading to 10 records being selected for qualitative analysis.

The selection process and the summary of selected records are shown in Table 2 and Figure 1, respectively.

The selected studies encompassed both retrospective and prospective designs, including RCTs, with a combined sample of 367 patients. The studies primarily investigated the effects of CAs, often in combination with Class II elastics, on the correction of Class II malocclusion, particularly focusing on MD and associated dental changes.

The potential of CAs to produce measurable distal movement of the maxillary molars reported distal movements of 2.25 mm and 2.85 mm, respectively, confirming the capability of aligners to achieve bodily molar movement with minimal tipping. Additional studies explored other occlusal and dentoskeletal effects, highlighting that upper MD with aligners can serve as a viable alternative to nonextraction treatment strategies. The predictability of aligner-driven distalization reported lower-than-expected efficacy, with actual distalization rates of 36.48% and 41.94% for first and second molars, respectively, compared to software predictions.

In summary, while the use of CAs for Class II correction and MD shows promising clinical results in several studies, variability in outcomes suggests that success is influenced by multiple factors, including treatment planning accuracy, patient compliance, and anchorage control. Prospective and randomized studies tend to report more favorable and predictable results compared to retrospective designs. The main characteristics and results of the retrieved and included studies are shown in Table 3.

### 3.2 | Quality Assessment and Risk of Bias of Included Articles

RoB-2 domains (randomized studies) (Table 4).

- Bias arising from the randomization process
- Bias due to deviations from intended interventions
- Bias due to missing outcome data
- Bias in the measurement of the outcome
- Bias in the selection of the reported result

Each RCT was rated as having low risk, some concerns, or high risk of bias, based on the highest risk domain identified.

- Low-risk studies used appropriate randomization, maintained blinding when applicable, and reported outcomes completely and transparently.
- Studies with some concerns showed minor methodological limitations (e.g., missing data or limited blinding) but retained informative value.
- High-risk studies displayed clear problems in randomization, management of deviations, or outcome reporting, reducing internal validity.

Risk of bias for individual studies (Table 4):

- Loberto et al. (2023) [77]—Some Concerns: low risk in most domains, with minor issues in deviations from intended interventions (D2) and outcome measurement (D4).
- Patterson et al. (2021) [87]—Some Concerns: generally low risk, but some concerns for missing outcome data (D3).
- Rongo et al. (2022) [88]—Some Concerns: low risk across most domains, except for minor concerns in deviations from intended interventions (D2); overall judgment indicates some concerns.
- Taffarel et al. (2022) [89]—Low Risk: consistently low risk across domains, with only a minor issue for selection of reported results (D5) not affecting the overall low rating.
- Yan et al. (2023) [90]—Low Risk: low risk in all domains, supporting a robust trial design and reliable outcome assessment.
- Lione et al. (2022) [91]—Low Risk: low risk in randomization, deviations, and missing data, with isolated concerns

**TABLE 2** | Descriptive summary of item selection and results of the study.

| Authors | Study design | Number of patients | Average age/gender | Treatment and duration | Outcomes |
|---|---|---|---|---|---|
| Loberto et al., (2023) [77] | RCT | 49 | 14.9 ± 6 years; 27 women and 22 men | Change their CAs 16 h per day, with Class II elastics, (1/4″–4.5 oz) full-time. Every 7 days, the patient changes the aligner. After 5.5 months, MD was evaluated. | The treatment was effective in obtaining a MD movement. |
| Patterson et al., (2021) [78] | RCT | 80 | 35.25 ± 15.21 years; 11 men and 29 women | Patients with Class II malocclusion had finished treatment with the initial set of CAs and Class II elastics. | No significant Class II correction or overjet reduction was observed with elastics for an average of 7 months. |
| Rongo et al., (2022) [79] | RCT | 20 | 27.6 ± 6.3 years; 5 men and 15 women | Treatment with CAs and Class II elastics in adult patients with Class II malocclusion | After the treatment, there was a reduction of the overjet, a retroposition of the upper incisors, and an improvement of the molar relationship. |
| Taffarel et al., (2022) [80] | RCT | 32 | 35.47 ± 9.61 years; 7 men and 25 women | Treatment with CAs, exchange time for each CA between 7 and 14 days, and no refinement set was evaluated. | The standards for Class II correction were not achieved, contrary to what the ClinCheck Pro software predicted. |
| Yan et al., 2023 [81] | RCT | 51 | 25.1 ± 6.7 years; 13 men and 38 women | Patients with Class II division 2 malocclusion, with CA treatment. | Incisor proclamation and intrusion were 69.8% and 53.3%, respectively. |
| Lione et al., 2022 [82] | RCT | 20 | 17.2 ± 3.2 years; 7 men and 13 women | Evaluate the effects on vertical dentoskeletal dimension produced by Pendulum appliances and aligners in patients with Class II malocclusion. | Upper MD with aligners represents a valid alternative to nonextraction treatment. |
| Yurdakul et al., 2024 [83] | RCT | 12 | 22.9 ± 0.7 years; 5 men and 7 women | Evaluate the effect of CA treatment and differential sequence distalization of maxillary posterior teeth on anchorage loss in the upper incisors (U1s) in two groups in which there were 33% and 50% distalization, respectively. | The amount of distalization was 2.5 mm in both groups. |
| Chen et al., 2023 [84] | RCT | 40 | 28.5 ± 1.5 years; 20 men and 20 women | Evaluate the effectiveness of CA technology in MD and tooth movement. | The upper first molar was distalized by 2.85 mm without significant tilt or movement in the vertical plane. |
| Li et al., 2023 [85] | RCT | 43 | 28.15 6 6.94 years; 5 men and 38 women | Patients received maxillary MD with CAs. The movement obtained was compared to the predicted tooth movement in ClinCheck. | The rates of MD for the maxillary first and second molars were 36.48% and 41.94%, respectively. |
| Ravera et al., 2016 [86] | RCT | 20 | 29.73 years; 9 men and 11 women | Patients received maxillary MD with CAs, with a treatment time of 24.3 ± 4.2 months. | Aligner treatment with Class II elastics can distalize maxillary first molars by 2.25 mm. |

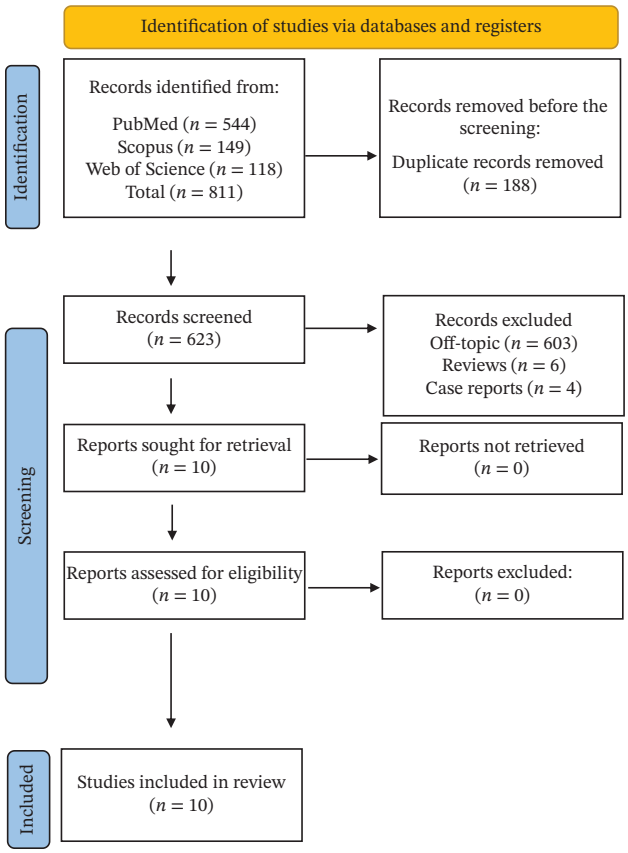


**FIGURE 1** | The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram and indicators of database search.

in outcome measurement (D4) and reported results (D5) not affecting the overall low rating.

- Yurdakul et al. (2024) [92]—Some Concerns: concerns in randomization (D1), deviations from intended interventions (D2) and selection of reported results (D5).
- Chen et al. (2023) [93]—Low Risk: low risk in most domains, with minor concern in outcome measurement (D4) and selection of reported results (D5) but overall low risk.
- Li et al. (2023) [94]—Low Risk: low risk in all domains except for a minor concern in the selection of reported results (D5).
- Ravera et al. (2016) [95]—Low Risk: low risk in all domains except for a minor concern in missing outcome data (D3) and selection of reported results (D5), maintaining an overall low-risk classification.

## 4 | Discussion

These studies evaluated the efficacy of treating adult patients with Class II malocclusions using CAs in conjunction with Class II intermaxillary elastics. The evaluation of how well CAs and braces worked for patients with mild to moderate crowding and Class II malocclusion in terms of MD and tooth mobility was very important. Compared to braces, which displayed some over-expansion, CAs maintained dental arch width better and accomplished faster, more controlled distalization with fewer unexpected shifts thanks to predictive algorithms and micro-implants [77]. Distalization of the upper molars had an efficiency of about 83% when vertical rectangular attachments were used.

Rongo et al. in their study analyzed adult patients with Class II malocclusion, and their dental structures were examined both before and after treatment to determine the precise impact on jaw alignment and tooth position. The outcomes demonstrated that this treatment strategy successfully improved the molar relationship, retropositioned the upper incisors, and decreased overjet. Crucially, the inclination of the upper and lower incisors stayed under control. This is important because the lower incisors' unwelcome forward tilt can cause periodontal problems, especially in patients with thin mandibular bones. Furthermore, without changing skeletal measures or substantially rotating the occlusal plane, the CAs consistently distalized the upper molars. This regulation of tooth movement maintained the grin [88].

Examining the anchoring loss of premolars and canines after maxillary MD in patients with Class II malocclusion receiving CAs treatment was the goal of this study. Using 3D digital dental casts to prevent extra X-rays, the study measured movement in tooth locations from the start of therapy until the conclusion of MD. Only the upper canines exhibited a statistically significant mesial shift (1.33 mm), suggesting anchoring loss, whereas the results revealed a considerable distal displacement of maxillary first molars (2.5 mm). Minimal, nonsignificant anchoring loss was observed in premolars. These results imply that anchoring loss in canines may occur even when transparent CAs are useful for MD. Compliance with Class II elastics helps mitigate this effect, reinforcing anterior anchorage and supporting the distalization process [88].

Lione et al. studied the effects of Pendulum appliances and CAs on vertical dimensions in the treatment of Class II malocclusion and compared the clinical outcomes. Lateral cephalograms recorded before and after treatment showed that Pendulum appliances caused significant vertical alterations, including increased anterior facial height, molar extrusion, and clockwise rotation of the occlusal plane, in a randomized experiment with the same number of patients per group [90]. CAs, however, minimized these effects and ensured more accurate molar movement without noticeable tilting or rotation by providing consistent vertical control. According to these findings, CAs are a better option for handling complicated orthodontic situations because they provide a more regulated method of MD, successfully establishing Class I molar relationships while maintaining occlusal and vertical stability [91].

The impact of CAs on anchorage loss in the upper incisors (U1) during maxillary posterior tooth distalization in Class II patients, using sequential distalization protocols of 33% (Group 1) and 50% (Group 2), found that both groups exhibited posterior tooth distal tipping and transverse expansion but varied in anchorage effects. Specifically, Group 1 (33% protocol) showed greater anterior anchorage loss, with U1s proclining and protruding more than in Group 2. Despite these movements, the vertical dimensions were well maintained. The findings suggest that the 50% protocol is more effective for anchorage control, while the 33% protocol might require Class II elastics for stabilization, particularly in cases with high overjet. Additionally, CAs caused slight distopalatal rotation in posterior teeth without altering the occlusal plane angle, underscoring CAs' utility in cases prone to crossbite.

**TABLE 3** | Case reports excluded studies.

| | | | | | |
|---|---|---|---|---|---|
| Lombardo et al., 2018 [87] | Case report | 1 | 18 years, men | Aligner treatment in an adult patient with Class II subdivision associated with crowding and dental crossbite. | Treatment was achieved in 12 months, with the functional and esthetic outcomes. |
| Wang et al., 2023 [37] | Case report | 1 | 19 years, men | Aligner treatment in an adult patient with Class II malocclusion using miniscrews. | Aligners with miniscrews could effectively achieve upper distal molar movement in 19 months of treatments. |
| Palone et al., 2023 [88] | Case report | 1 | 40 years | Orthodontic treatment without extractions and using CAs in combination with Class II elastics, in adult patients with Class II malocclusion. | The use of aligners and Class II elastics with good patient compliance provides satisfactory occlusal outcomes. |
| Sabouni et al., 2023 [89] | Case report | 1 | 25 years, women | The patient received maxillary MD with CAs. | Treatment was achieved in 10 months, with the functional and esthetic outcomes |

Overall, CAs facilitate controlled posterior distalization, making them a valuable option for managing complex malocclusion cases [91, 92].

CAs could move first and second molars distally by about 2–2.5 mm with minimal tipping or vertical movement, especially when combined with Class II elastics and attachments for stability. Li et al. assessed the effectiveness of maxillary MD using CAs in patients with and without anterior tooth retraction [93, 94]. Results showed that MD was significantly less effective when combined with anterior retraction (efficacy 32%–36%) compared to cases without retraction (48%–53%). Additionally, substantial arch width expansion occurred, especially at the molar and premolar levels, which exceeded predicted values [94]. Prior studies had reported higher distalization efficacy, but this study suggests that anchorage loss during retraction reduces overall effectiveness.

In Class II malocclusion cases, the efficacy of CAs in achieving the targeted upper incisor motions of proclination, intrusion, and labial shifting is very important. Analyzing patients' pre- and post-treatment models revealed that while labial movement frequently exceeded expectations, real proclination and intrusion were lower than anticipated. Movement prediction was limited to 69.8% for proclination and 53.3% for incursion, depending on factors, such as age, mini-implants, MD, and premolar extraction. The CAs have little control over some incisor movements, particularly root location [95–101].

**TABLE 4** | A tabular summary of the risk-of-bias assessment for the nine studies, evaluated across the five domains of RoB 2.0.

| Authors and year | D1 | D2 | D3 | D4 | D5 | D6 | D7 | Overall |
|---|---|---|---|---|---|---|---|---|
| Loberto et al. (2023) [77] | X | - | X | - | + | X | + | + |
| Patterson et al. (2021) [78] | - | + | X | + | - | + | + | + |
| Rongo et al. (2022) [79] | X | + | X | - | + | - | X | X |
| Taffarel et al. (2022) [80] | X | + | X | + | - | - | + | + |
| Yan et al. 2023 [81] | X | + | X | - | - | - | X | - |
| Lione et al. 2022 [82] | X | + | X | - | - | X | X | X |
| Yurdakul et al. 2024 [83] | X | + | X | - | + | - | X | - |
| Chen et al. 2023 [84] | X | + | X | + | - | - | - | + |
| Li et al. 2023 [85] | - | + | X | + | - | - | X | + |
| Ravera et al. 2016 [86] | - | + | X | - | - | - | X | - |

After completing an initial CA series, Patterson et al. examined the efficacy of using CAs to treat Class II malocclusions in adults. One set of 80 adults had Class I malocclusions, while the other group had Class II malocclusions. Class II patients demonstrated little overbite correction and only 6.8% of the projected AP correction, despite improvements in alignment and contact scores in both groups. Using Class II elastics throughout the average 7-month treatment period did not significantly enhance overjet reduction or AP correction, which was below the American Board of Orthodontics (ABO) guidelines. According to the study, even though transparent CAs can produce specific movements, AP correction may need more adjustments and longer treatment periods [87, 102–108].

A similar study conducted by Taffarell et al., at the end of the use of a set of CAs with sequential distalization, showed a significant difference between the predictions and results for alignment and rotation, buccolingual inclination, overjet, occlusal contact, occlusal relationship, molar relationship, and overbite [89].

## 5 | Conclusions

The findings of this systematic review indicate that CAs, particularly when used in combination with Class II intermaxillary elastics and optimized attachment strategies, may offer a viable therapeutic approach for managing Class II malocclusions in adult patients. Current evidence suggests that CAs are capable of producing controlled upper MD with relatively low anchorage loss and improved predictability. In specific clinical contexts, they may provide advantages over fixed appliances in maintaining arch width and achieving vertical control, potentially minimizing adverse effects, such as molar extrusion or occlusal plane rotation.

Nonetheless, these conclusions should be considered with caution due to the limited sample sizes, methodological heterogeneity, and overall moderate to high risk of bias in the included studies. Definitive comparisons with traditional fixed appliances are not yet supported by robust evidence, particularly with respect to AP correction and incisor inclination control.

Future investigations should prioritize RCTs with larger cohorts, longer follow-up periods, and standardized outcome measures to evaluate the long-term effectiveness and stability of Class II correction using CAs. Additionally, further research is needed to determine the optimal biomechanical protocols, including the role of auxiliary elements, to enhance treatment predictability and define the clinical scenarios in which CAs can be most effectively applied.

### Nomenclature

| | |
|---|---|
| AP | Anterior–posterior |
| CAs | Clear aligners |
| MD | Molar distalization |

### Author Contributions

Conceptualization, Gianna Dipalma and Alessio Danilo Inchingolo; methodology, Merigrazia Campanelli; software, Andrea Palermo and Angelo Michele Inchingolo; validation, Francesco Inchingolo, Pasquale Avantario, and Massimo Corsalini; formal analysis, Daniela Di Venere, Merigrazia Campanelli, and Gianna Dipalma; investigation, Pasquale Avantario, Francesco Inchingolo, and Massimo Corsalini; resources, Alessio Danilo Inchingolo, Andrea Palermo, and Angelo Michele Inchingolo; data curation, Daniela Di Venere, Merigrazia Campanelli, and Pasquale Avantario; writing–original draft preparation, Gianna Dipalma, Pasquale Avantario, and Andrea Palermo; writing–review and editing, Francesco Inchingolo, Alessio Danilo Inchingolo, and Merigrazia Campanelli; visualization, Daniela Di Venere and Massimo Corsalini; supervision, Angelo Michele Inchingolo and Francesco Inchingolo; and project administration, Gianna Dipalma and Angelo Michele Inchingolo.

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All authors have read and agreed to the published version of the manuscript.

### Conflicts of Interest

The authors declare no conflicts of interest.

### Data Availability Statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during this study.

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## Supporting Information

Additional supporting information can be found online in the Supporting Information section. *(Supporting Information)*

Supporting Information PRISMA 2020 checklist: This file contains the completed PRISMA 2020 checklist indicating where each recommended reporting item is addressed in the manuscript (with corresponding page/section references).