

The Efficacy and Efficiency of Clear Aligners in Comparison to Traditional Fixed Appliances: A Systematic Review

Rachid Ait Addi^{1,2*}, Abdelhafid Benksim^{2,3} and Mohamed Cherkaoui²

¹Chirurgien dentiste, Expert Scientifique Certifié Invisalign, Marrakech Morocco

²Laboratory of Human Ecology, Department of Biology, School of Sciences Semlalia, Cadi Ayyad University, Marrakech, Morocco

³High Institute of Nursing and Technical Health, Marrakech, Morocco

*Corresponding author: Rachid Ait Addi, Chirurgien dentiste, Expert Scientifique Certifié Invisalign, Marrakech Morocco

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ABSTRACT

Backgrounds: The technology behind clear aligners has seen significant advancements in recent years. The objective of this systematic review was to examine and confirm whether the treatment effectiveness of clear aligners aligns with that of conventional fixed appliances.

Methods: We conducted an electronic search using various databases, including Pubmed, Medline, Embase, Google Scholar, and the Cochrane Central of Controlled Clinical Trials Register between January 1st, 2018, and January 1st, 2023. Included in this analysis were comparative clinical studies that evaluated the effectiveness of clear aligners in comparison to braces.

Results: Five papers were included in the systematic review: a retrospective study and four randomized clinical trials. Clear aligners reduce treatment duration, chairside time, number of nonscheduled, and finishing stage appointments in nonextraction Class I crowding cases. However, Conventional multibrackets appliance showed the highest incisal position variations over treatment.

Conclusion: Both clear aligners and braces demonstrated effectiveness in treating malocclusion. Clear aligners exhibited advantages in terms of segmented tooth movement and shorter treatment duration. However, they were found to be less effective than braces in achieving sufficient occlusal contacts, controlling teeth torque, and maintaining retention.

Keywords: Bracket; Clear Aligner; Orthodontics; Treatment Outcome; Systematic Review

Abbreviations: JBI: Joanna Briggs Institute; RCTs: Randomized Controlled Trials; MBT: McLaughlin Bennett Trevisi; CAT: Clear Aligner Therapy; MAAs: Modified Aligner Appliances with Nickel-Titanium Springs; OGS: Objective Grading System

Introduction

The technology behind clear aligners has seen significant advancements in recent years. Clear aligners have become a popular choice for many patients due to their enhanced comfort and aesthetics, although ongoing discussions remain regarding their efficacy [1]. The concept of clear orthodontic appliances was first introduced by Kesling in 1946 [2]. In 1998, Align Technology, Inc. introduced In-

visalign®, which revolutionized the field of orthodontics [3]. The utilization of clear aligners has become increasingly prevalent owing to advancements in material technology and computer-aided tooth movement design [4].

Several late investigations have revealed the efficacy of clear aligners in treatment of diverse types of malocclusions with good results [5,6]. However, there are concerns about clear aligners completely replacing traditional orthodontic approaches, as some patients prior-

itize aesthetically pleasing and comfortable treatment methods. It is important to acknowledge that fixed braces have served as the standard and most effective orthodontic option for more than a century [7]. The question of whether transparent aligners can be a suitable alternative to braces is still a subject of debate within the orthodontic community [8]. Due to the limited conclusive evidence regarding the efficacy of clear aligner treatments, practitioners have relied on their clinical expertise and existing evidence to develop treatment approaches [9]. Further research are fundamental to draw more decisive deductions in the comparison of the efficacy of clear aligners and conventional braces. This systematic review was conducted to furnish an updated comparison of the efficacy and efficiency of clear aligners and traditional braces.

Methods

Focused Question

In conducting this systematic review, strict adherence to the PRISMA 2020 guidelines for reporting items for systematic reviews was followed to ensure methodological rigor. The main research query directed in this review referred to the comparison of treatment efficacy and efficiency between clear aligners and conventional braces. To preserve uniformity and clearness all around the review operation, the definitions of population, intervention, comparison, outcome, and study design (PICOS) were established based on (Table 1), which furnished a setting for organizing the review and guarantying a complete exploration of the vacant documentation.

Table 1 : PICO's question.

Population	Patients without age restriction, patients with dental malocclusion.
Intervention	orthodontic treatment with clear aligners.
Comparison	orthodontic treatment with fixed appliances
Outcome	the primary outcome was treatment effectiveness: the outcome assessment of the treatment, included arch width, occlusal contacts, alignment, derotation and inclination of teeth; the secondary outcome was treatment duration
Study design	clinical comparative trials, Prospective studies Retrospective studies

Note: PICO's: Population, intervention, comparison, outcome and study design.

Search Strategies

We directed electronic research utilizing several databases, as well as Pubmed, Medline, Embase, Google Scholar, and the Cochrane Central of Controlled Clinical Trials Register. The search was performed without any restrictions on language or time. The aim was to capture a comprehensive range of relevant studies. For inclusion in our review, studies published between January 1st, 2018, and January 1st, 2023, were considered. This timeframe ensured that we included recent and up-to-date literature to inform our analysis.

The detailed search strategies were as follows:

- #1 (orthodont* OR clear OR removable) AND aligner*
- #2 Invisalign
- #3 #1 or #2
- #4 conventional orthodontic treatment OR traditional orthodontic treatment OR brace* OR bracket* OR fixed appliance*
- #5 #3 AND #4

Eligibility Criteria

The inclusion and exclusion criteria utilized to choose paper for investigation are summarized in (Table 2). This table provides a clear overview of the criteria employed to determine which studies were included in our review. By establishing these criteria, we aimed to ensure the relevance and quality of the articles included in our analysis while maintaining transparency in our methodology.

Table 2: Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
- Clinical studies on human with permanent dentition	- In vitro studies
- Studies involving treatments with clear aligners and fixed appliances	- Animal studies
- Studies providing data regarding the treatment effectiveness of orthodontics.	- Editorials
	- Author opinions, or reviews
	- Case reports

Study Selection and Data Extraction

To guarantee a strict and unbiased picking operation, two researchers separately tracked down the titles and abstracts of the recognized studies. If a study could not be definitively excluded based on the information provided in the titles and abstracts, it was further assessed through full-text analysis. If there were any discrepancies between the two researchers, a debate was kept with a third researcher to attain consensus. The inter-reviewer trustworthiness of study choice was evaluated by computing the percentage of accordance defining the value of Kappa. Data extraction was directed separately by the two researchers utilizing the PICO's method. Any discrepancies in the extracted data were resolved through discussions with a third investigator. The subsequent information was taken from every enclosed study: the first author's name, year of publication, country, study design, clinicians involved, inclusion criteria, gender distribution, number of participants, mean age of participants, description of intervention and comparison groups, primary outcomes (specifically treatment effectiveness), treatment duration, and the study's conclusion. This comprehensive data extraction process aimed to capture key information from each study to facilitate an in-depth analysis and synthesis of the findings.

Quality Assessment

To evaluate the goodness of the enclosed retrospective case-control studies, the Joanna Briggs Institute (JBI) tool was utilized. This tool provided a systematic approach to evaluating the methodological quality of these studies. Additionally, the quality assessment of randomized controlled trials (RCTs) was conducted following the recommendations provided by Cochrane, which sorted rankings founded on seven essential criteria: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other potential sources of bias [10]. The results of these quality assessments are exposed in Tables 3 & 4, providing a transparent overview of the strengths and limitations of the included studies in terms of their methodological rigor.

Table 3: Risk of bias assessment using the RoB2 tool.

	D1	D2	D3	D4	D5	Overall
Da Silva, VM et al. 2023	+	+	-	+	+	X
Lin, E et al. 2022	+	+	-	+	+	X
Jaber ST, et al. 2021	+	+	-	-	+	-
Alhafi ZM, et al. 2022	+	+	+	+	-	X

Note: Domains:

D1: Bias arising from the randomization process.

D2: Bias due to deviation from the intended interventions.

D3: Bias due to missing outcome data.

D4: Bias in measurement of the outcome.

D5: Bias in the selection of the reported result.

Judgment:

X - High

-- Some concerns

+ - Low

Table 4: The JBI critical appraisal for retrospective case control studies.

Checklist questions	1	2	3	4	5	6	7	8	9	10	%yes	Risk
Sfondrini MF, et al. (2018) (a)	✓	✓	✓	✓	✓	?	✓	✓	?	✓	80%	Low

Note: JBI: Joanna briggs institute.

Results

Literature Search

Initially, a total of 3299 primary references were identified through the literature search. Following the screening of titles and

abstracts, 32 references remained for full-text evaluation. Manual searching of the reference lists of these selected studies did not yield any additional pertinent manuscripts. After the examination of the full-text articles, a total of five papers met the inclusion criteria and were included in our systematic review. The flow diagram representing the literature search process is presented in (Figure 1), providing a visual description of the study selection and inclusion process. This comprehensive approach ensured that the final set of included studies was relevant and met the predetermined criteria for our review.

Study Characteristics and Rob

The studies included in our analysis encompassed a retrospective study conducted in Italy in 2018 and four randomized clinical trials published in 2021, 2022, and 2023, and conducted in India, USA, Syria and Brazil [11-15]. Specialized orthodontist was responsible for treatments and the entire explorations were executed in the universities. The retrospective study aimed to compare the buccolingual inclination of upper incisors in patients treated with clear aligners versus fixed appliances, using radiographic analysis [11]. One randomized clinical trial compared the efficacy and efficiency of clear aligners versus 2 x 4 fixed appliances in correcting irregularities in maxillary incisor position during the mixed dentition phase [12]. A second randomized clinical trial explored the treatment and posttreatment outcomes of traditional braces and compared them with Invisalign aligners associated to Smart Force features and attachments [13]. Another study compared the efficacy of the McLaughlin Bennett Trevisi (MBT) appliance and Clear Aligner Therapy (CAT) in nonextraction Class I crowding cases [14]. Lastly, a randomized clinical trial evaluated the effectiveness of modified aligner appliances with nickel-titanium springs (MAAs) for treating mild mandibular crowding, assessing treatment duration, alignment improvement percentage, and mandibular incisor proclination. [15].

In terms of risk of bias, the study of Jaber ST, et al. (2021) was considered to have a moderate risk of bias based on the RoB2 tool (Table 3). The retrospective case-control study was assessed using the JBI critical appraisal checklist, which had low risk of bias (Table 4). A total of 119 participants were treated with clear aligners, while another 120 participants were treated with fixed braces. The number of patients in each study ranged from 13 to 34. The gender ratio of all included studies was balanced between two groups except one study not reporting the gender of patients [11]. The mean age of patients ranged from 9.33 to 32 years. Four of the studies included non-extraction patients in the research [12-15] and one study included extraction patients [11]. The included patients in three studies were Class I malocclusion [11,12], while the remaining five studies did not mention the classification of malocclusion of patients [13-15]. A summary of the included articles and their key characteristics is provided in Table 5, offering a concise overview of the studies included in our systematic review.

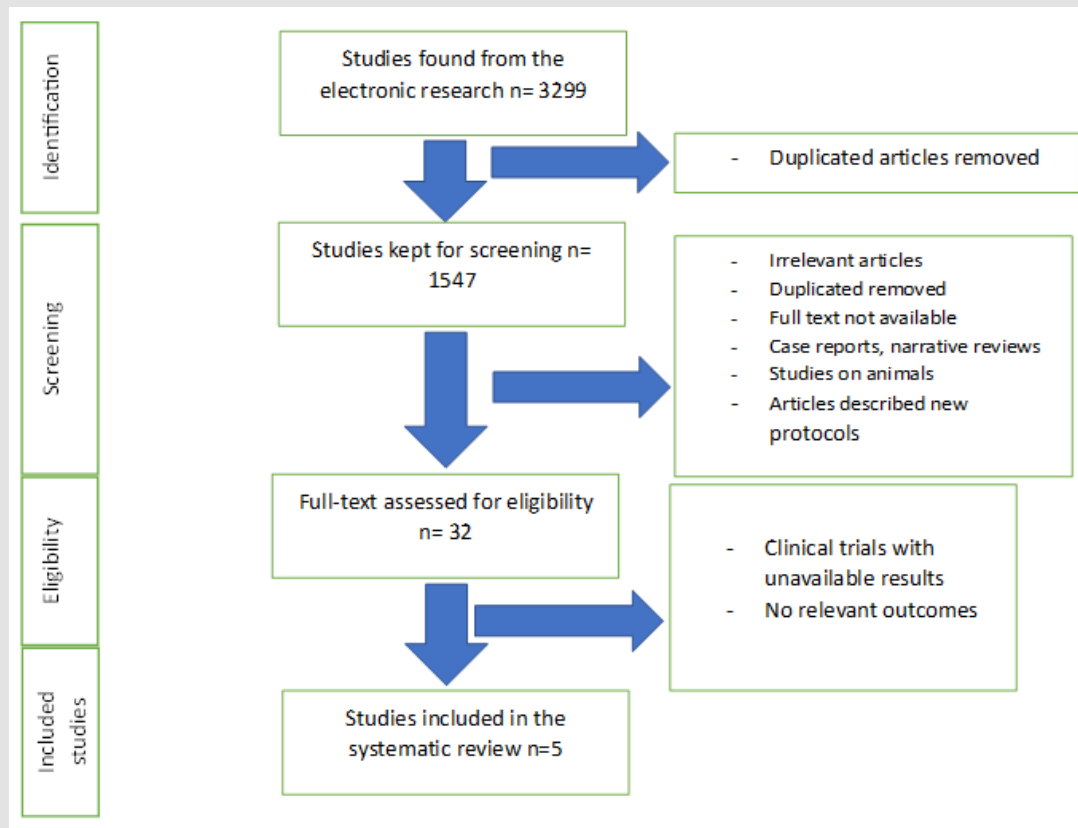


Figure 1.

Table 5: A summary of included studies.

Author/Year of publication and country	Population (Patients)	Intervention	Comparison	Outcome	Study	Study
Sfondrini MF, et al. (2018) Italy	50 patients: - 25 treated with aligners (Invisalign, Aligh Technology) - 25 treated with conventional brackets (Victory, 3M; Damon Q,Ormco) with similar skeletal and dental pretreatment parameters	Translation (VL); attachment implementation; upper incisors torque control	Predicted movements of crowns and roots of upper incisors and final result.	11^SnaSnp and 11^Ocl angles showed the highest numeric variation with conventional brackets. Lowest values were reported with aligners. Conventional multibrackets appliance showed the highest incisal position variations over treatment.	Retrospective study	Retrospective study
Da Silva VM, et al. (2023) Brazil	32 patients : - 14 treated with aligners - 13 treated with partial (2 x 4) fixed appliances	Incisor Irregularity Index, arch width perimeter, length, size and shape, incisor leveling, incisor mesiodistal angulation, plaque index, and white spot lesion formation (International Caries Detection and Assessment System index)	Expected and achieved amount of movement after treatment	Similar efficacy and efficiency for maxillary incisor position corrections in the mixed dentition. The choice of appliance should be guided by clinician and family preference.	Randomized clinical trial	Randomized clinical trial

Lin E, et al. (2022) USA	66 patients : - 32 treated with aligners - 34 treated with fixed appliances	Treatment of Class I molar and canine relationships With non-extraction treatment and mandibular crowding of 4 mm or less no missing teeth (from the second molar to the second molar)	Occlusion after treatment	The braces group finished treatment significantly (P , .001) earlier (0.4 years) than the aligner group. Patients with simple malocclusions require 4.8 months longer treatment times with aligners than traditional braces The treatment and 6-month posttreatment occlusal outcomes are similar	Randomized clinical trial	Randomized clinical trial
Agarwal SS, et al. (2021) India	60 patients: - 30 patients treated with 0.018" McLaughlin Bennett Trevisi (MBT) appliance - 30 treated with Clear Aligner Therapy (CAT) for correction of malocclusion	Treatment of nonextraction Class I crowding cases	Expected and achieved amount of movement after treatment	CAT significantly reduces treatment duration, chairside time, number of nonscheduled/emergency, and finishing stage appointments than MBT appliance	Randomized controlled trial	Randomized controlled trial
Alhafi ZM, et al. (2022) Syria	36 patients: - 18 treated with modified aligner appliances with nickel-titanium springs (MAAs) - 18 treated with conventional fixed brackets	Treatment of mild crowding of lower incisors	Expected and achieved amount of movement after treatment	No statistically significant difference was detected between the two groups in terms of alignment treatment duration (P = 0.097). Significant difference was observed in the alignment improvement percentage at T1 (P = 0.000), T2 (P = 0.001), and T3 (P = 0.022).	Randomized controlled trial	Randomized controlled trial

Treatment Effectiveness

Two included studies explored the treatment efficacy of clear aligners and braces [12,15]. The first study showed that compared to braces, modified aligner with nickel-titanium springs could be efficacious in lower incisor leveling, associated to lower incisor proclination. The second study discovered equivalent effectiveness in upper incisor rectifications in mixed dentition between 2 X 4 mechanics and clear aligners [12,15].

Treatment Efficiency

Three included studies evaluated the treatment efficiency between aligners and fixed appliances [12-14]. Similar treatment duration between clear aligners and 2 x 4 mechanics in the mixed dentition was found in the first study, while 4.8 months longer treatment times is needed with aligners than traditional braces in the second study with no statistically significant difference in posttreatment modifications of the total objective grading system (OGS) [12,13]. The third study found that Clear Aligner Therapy significantly reduces treatment duration, chairside time, number of nonscheduled/emergency, and finishing stage appointments in nonextraction Class I crowding

cases compared to McLaughlin Bennett Trevisi (MBT) preadjusted edgewise appliance [14].

Torque Control of Upper Central Incisors

In our systematic review, a study compared the radiographic buccolingual inclination of upper incisors in patients treated with conventional, self-legating braces and clear aligners. The study discovered that conventional braces showed the highest incisal situation changes during the treatment [11].

Discussion

This review examined five studies. The first study deduced that clear aligners are less efficacious in treating malocclusion than braces [13]. Another study discovered no statistically significant difference between clear aligners and 2 × 4 mechanics in the mixed dentition [12]. However, two studies showed that clear aligners are more effective and efficient than braces [14,15]. Similarly, in the study of Zheng et al. chair time and treatment duration were less with clear aligners than braces [6]. However, Li et al. discovered that treatment duration was forty-four percent less with braces than clear aligners in extraction cases [17]. The last study included in the review found

that conventional fixed appliances provide better torque control of the upper central incisor than clear aligners [11]. Actually Djeu, et al. explained in a study that included non-extraction cases that poor control of root torque is the main reason for statistically lower scores of clear aligners in 2005 [16]. Nevertheless, no statistically significant difference between clear aligners and braces was discovered in the Li's study with included extraction cases [17]. This difference could be related to the inclusion of the extraction cases because extraction space may be utilized to correct overjet [18]. In addition, Ke et al., discovered that braces are better in creating sufficient occlusal contacts and controlling posterior buccolingual inclination than clear aligners [18].

Furthermore, in non-extraction cases, clear aligners are more effective in preserving teeth inclination in the time of alignment [19]. Nonetheless, more relapse in tooth alignment occurred in the post-retention period amongst clear aligners patients. Braces, utilizing rectangular archwires, align and expand arches not only by tipping teeth but also by torquing roots [18]. Besides, the success of treatment is fully related to the wearing of clear aligners because they are removable, which makes demanding to have good results. Also, with braces tipping and proclination are done at the same time of alignment because they apply forces to the center of resistance of teeth. Clear aligners reduce the proclination of teeth during alignment which may indicate them more in thin gingival biotypes to prevent receding gums [18]. Likewise, it needs 7-14 days for alveolar bone resorption, and it needs the same duration for periodontal tissue regeneration which explain the need of three weeks to adjust orthodontic devices for repairing procedures. If the orthodontist doesn't allow sufficient time for this repairing procedures, bone resorptions and teeth harm will appear.

Further, clear aligners adjustments are at two-week intervals while they are at 4-6 weeks amongst braces. This may explain that because of the shortness of clear aligners adjustments for repairing procedures, more relapses may occur than with braces [19].

Nevertheless, clear aligners offer improved aesthetics, comfort, and oral hygiene for patients compared to conventional fixed appliances [19-22]. This systematic review is the first one conducted in Morocco to give an updated comparison of the efficacy and efficiency of clear aligners compared to traditional braces. Nevertheless, there are certain limitations to consider. Eliminating confounding factors present in the included studies proves to be challenging, potentially introducing bias. Additionally, thanks to digital dentistry technologies and Artificial Intelligence progresses, the clear aligners technique is unceasingly developing new methods and accessories to reduce their limitations. Recent research indicates more favorable outcomes with aligner treatment compared to earlier studies. Therefore, it is imperative to conduct additional relevant studies that include subgroup analyses to address confounding factors effectively. Furthermore, giv-

en the limited number of included studies (five), further randomized controlled trials are necessary to establish high-quality evidence.

Conclusion

Effectiveness in improving malocclusion in both aligners and braces were proved, but braces were more effective than aligners in establishment of sufficient occlusal contacts, improving transverse width and controlling posterior buccolingual inclination. Also, clear aligners demonstrated good control in maintaining teeth inclination and less treatment duration in nonextraction cases. Therefore, the orthodontist must consider the characteristics of these two orthodontic appliances and use them according to the cases to be treated when making a therapeutic decision.

Availability of Data and Materials

All data generated or analyzed during this study are included in this published article.

Authors' Contributions

RA: study selection, data extraction, data synthesis, quality assessment, and drafting the manuscript.

AB: research design, study selection, data extraction, and revision of the manuscript.

MC: research design and revision of the manuscript. All authors read and approved the final manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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