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Systematic Review

The Effectiveness of Aligners in the Treatment of Anterior Open Bite in Adult Patients: A Systematic Review and Critical Appraisal

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Abstract: An anterior open bite is a dental malocclusion, the diagnosis of which is fundamental for its treatment. With the evolution of artificial intelligence, it is possible to treat it through the Invisalign G4 protocol, depending on the degree of severity. The aim of this study was to perform a systematic review, based on the PICO strategy, to evaluate the effectiveness of aligners and accessory devices in adult patients with anterior open bites. The search was carried out in the following databases for publications over the last ten years: PubMed, Web of Science, Cochrane Library, and LILACS. The inclusion criteria were clinical studies evaluating adults with anterior open bites (overbites < 0 mm) and orthodontic studies with aligners. The exclusion criteria were studies of cases with dentofacial deformities, previous orthodontic treatment, history of surgery/trauma, or systemic diseases that affect craniofacial growth, as well as animal studies, reviews, and clinical cases. The selection was carried out separately by two researchers. In the four databases, 108 articles were obtained. By reviewing the titles and abstracts and applying the exclusion criteria, 91 articles were eliminated. The seven resulting articles were submitted to the inclusion criteria, two of which were excluded due to their lack of patients presenting an open bite and the absence of aligner treatment. According to the PRISMA method, five studies were selected. The collected data showed an increase in overbites with the use of aligners. The bias assessment was performed with the ROBINS-I tool, indicating a moderate risk of bias. The included studies demonstrated the effectiveness of aligners in the treatment of adults with mild or moderate open bites; however, due to the lack of scientific evidence, it is necessary to carry out randomized studies with the same standardized variables.

Keywords: anterior open bite; aligners; orthodontic treatment

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1. Introduction

Anterior open bites (AOBs), characterized by the absence of contact between the anterior teeth, represent a complex treatment challenge [1,2]. Consequently, a precise diagnosis is imperative for formulating a treatment plan. A study with a specific differential diagnosis model to identify an anterior open bite early may be a tool of great value [3]. Alhammad et al. reported a global prevalence of 4.83% for anterior open bites in individuals with permanent dentition [4].

The etiology of an AOB can be classified as hereditary or non-hereditary. In hereditary cases, it may be purely inherited from one of the parents. Non-hereditary causes encompass non-nutritive sucking (such as finger or pacifier habits), abnormal tongue function, neurological disorders, mandibular condyle pathology, and iatrogenic factors [5]. Identifying the etiological factors at the outset of treatment and managing them, from diagnosis until orthodontic retention, is crucial.

While the etiology of an anterior open bite is multifactorial, tongue interposition and atypical swallowing are prominently relevant factors, given their direct association with this malocclusion [5]. Failure to interrupt these habits poses a significant risk of recurrence of the condition even post-treatment [6].

This condition can be categorized as alveolo-dental (generally influenced by environmental factors) or a skeletal open bite (predominantly having hereditary components, with genetic factors influencing its morphology) [6].

Treatment options for correcting anterior open bites in permanent dentition include conventional fixed appliances or orthodontic surgical orthognathic treatment. Relapse is a common issue in both of these treatment modalities [7].

With technological advancements, an alternative therapeutic option emerged in the 1990s: invisible aligners [8,9]. These aligners are designed using computer technology to correct dental positions and have gained popularity among adult patients due to their aesthetics and comfort [10]. Studies suggest potential molar intrusion attributed to the coverage provided by the aligner material, which can enhance control over the vertical dimension, making it a viable option for anterior open bite treatment [11,12].

Aligners are composed of a plastic material, potentially consisting of polyethylene terephthalate glycol, polyvinyl chloride, or polyethylene terephthalate, among other materials. Orthodontic materials are subject to continual evolution, thereby enhancing mechanical properties and consequently impacting treatment outcomes [9]. This treatment promotes three-dimensional force distribution across the entire contact surface. Dental movement is realized by a disparity between the device and the geometric configuration of the teeth, as predetermined in the treatment plan [8].

Presently, aligner treatment is executed utilizing software that simulates tooth movement and fabricates the devices via CAD-CAM (computer-aided design-computer-aided manufacturing) technology [8]. This system integrates interactive planning using 3D computational technology, 3D movement within CAD-CAM, and the digital design/manufacturing of the device. Additionally, it defines the positioning of attachments, affixed with composite resin, tailored for intricate tasks across all spatial planes. With such precision, it becomes feasible to delineate a treatment plan aimed at correcting complex issues like an anterior open bite [12].

This systematic review aimed to assess the effectiveness of aligner therapy and its associated devices in adults with anterior open bites. To achieve this objective, the PICO methodology (Population, Intervention, Control, Outcome) [13] was used. The proposed inquiry was as follows: Does aligner therapy demonstrate effectiveness in adult patients presenting with an anterior open bite?—Table 1.

Table 1. PICO strategy.

Parameter	Description
Population (P)	Adults diagnosed with anterior open bites
Intervention (I)	Clear aligner therapy
Control (C)	Conventional fixed orthodontic appliances
Outcome (O)	Evaluation of the efficacy in reducing anterior open bites

2. Materials and Methods

This systematic review was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [14]. This systematic review was registered in the International Prospective Register of Systematic Reviews (PROSPERO) platform (ID: CRD42024529194).

2.1. Search Strategy

An electronic search was conducted in the following databases: Cochrane Library (www.cochranelibrary.com, accessed on 16 April 2024), PubMed (www.ncbi.nlm.nih.gov/pubmed, accessed on 16 April 2024), Web of Science (www.webofscience.com, accessed on 16 April 2024), and LILACS (www.lilacs.bvsalud.org, accessed on 16 April 2024). The search covered articles published in the last ten years, including September 2023. The search keys employed in the respective databases are outlined in Table 2.

Table 2. Search keys.

Database	Search Keys
PubMed	((open bite [MeSH Terms]) OR (open bite [Title/Abstract])) AND ((Invisalign [Title/Abstract]) OR ("clear aligners" [Title/Abstract]))
Cochrane Library	#1 open bite AND treatment #2 clear aligner OR Invisalign #3 #1 AND #2
Web of Science	(open bite [title]) AND (Invisalign [all fields] OR clear aligner [all fields])
LILACS	mordida aberta [Palavras] AND alinhadores [Palavras]

2.2. Inclusion and Exclusion Criteria

Clinical studies assessing the efficacy of aligner treatment in adults with open bites were incorporated into the review. The inclusion and exclusion criteria are outlined in Table 3.

Table 3. Inclusion and exclusion criteria.

Inclusion criteria	Clinical studies evaluating adults presenting an anterior open bite (overbite < 0 mm).
	Studies involving orthodontic treatment with aligners.
Exclusion criteria	Studies including cases with dentofacial deformities, previous orthodontic treatment, history of surgery, trauma, or systemic diseases that have impacted craniofacial growth.
	Animal studies, reviews, and clinical cases.

2.3. Study Selection

Following the retrieval of articles from the databases, duplicate studies were removed. All titles and abstracts were reviewed and the exclusion criteria were applied. Language was not a limiting factor, as it was not considered as an exclusion criterion. Subsequently, the full contents of the articles were examined, and the inclusion criteria were applied. The article selection process was independently conducted by two researchers. Any discrepancies were settled through discussion, and when necessary, the input of a third reviewer was requested.

2.4. Data Extraction

For data extraction, both reviewers independently reviewed all the chosen articles. A Microsoft® Excel table (Microsoft, Washington, WA, USA) was generated to incorporate pertinent details, including authors, year of publication, study type, patient count, age, gender distribution, treatment duration, and bite-related variables (such as overbite, SN-GoMe, LAFH, L1-MP, L6-MP, U1-PP, and U6-PP).

2.5. Quality Assessment

The methodological quality assessment of the included clinical studies was conducted by two independent reviewers. The clinical studies underwent evaluation using the Revised Cochrane risk-of-bias tool in accordance with the Methodological Index for Non-Randomized Studies (ROBINS-I) [15]. The seven following domains were subjected to evaluation:

1. Bias due to confounding (D1).
2. Bias due to the selection of participants (D2).
3. Bias in the classification of interventions (D3).
4. Bias due to deviations from intended interventions (D4).
5. Bias due to missing data (D5).
6. Bias in the measurement of outcomes (D6).
7. Bias in the selection of the reported result (D7).

Following this assessment, the studies were categorized based on their risk of bias, and they were classified as either "low", "moderate", "serious", or "critical".

2.6. Statistical Analysis

The Analysis of Variance (ANOVA) was used to assess the mean overbite values obtained from each of the included studies and to determine if there was a statistically significant difference between at least one of the groups in comparison to the others.

3. Results

The initial screening of electronic databases resulted in a total of 108 articles (51 from PubMed, 6 from Cochrane Library, 41 from Web of Science, and 10 from LILACS). Following the removal of duplicate studies, 91 titles and abstracts were assessed. Ultimately, after a comprehensive review of titles and abstracts, seven potentially relevant articles were identified. The full texts of these articles were obtained and subjected to a thorough evaluation. Of these, five met the inclusion criteria and were subsequently incorporated into the systematic review [12,16–19]. The flowchart of the data selection process can be seen in Figure 1.

This scientific analysis comprises a collection of studies conducted between 2017 and 2022, including research by Khoshavi (2017), Moshiri (2017), Garnett (2019), Harris (2020), and Suh (2022) [12,16–19]. Two specific investigations [12,18] spotlight the application of aligners in conjunction with the Invisalign G4 protocol for all patients, offering an updated approach for those with open bite conditions.

The sample sizes for these studies varied significantly, with a study [16] involving 12 participants and research [12] featuring a larger cohort of 69 adult patients. The mean age of the participants ranged from 28 years [17] to 35 years [18], with a predominance of female subjects. Notably, only the study conducted by Garnett [18] et al. incorporated a control group within its sample. The average treatment duration ranged from 1 year and 2 months [19] to 1 year and 7 months [17]. Detailed results are presented in Table 4 for reference and comparison.

Furthermore, it is noteworthy that the studies indicated an increase in overbite measurements, ranging from 1.3 mm [16] to 3.4 mm [17]. The ANOVA test yielded a p-value below than 0.01 concerning the mean overbite values, signifying substantial variation among the included samples, as presented in Table 5.

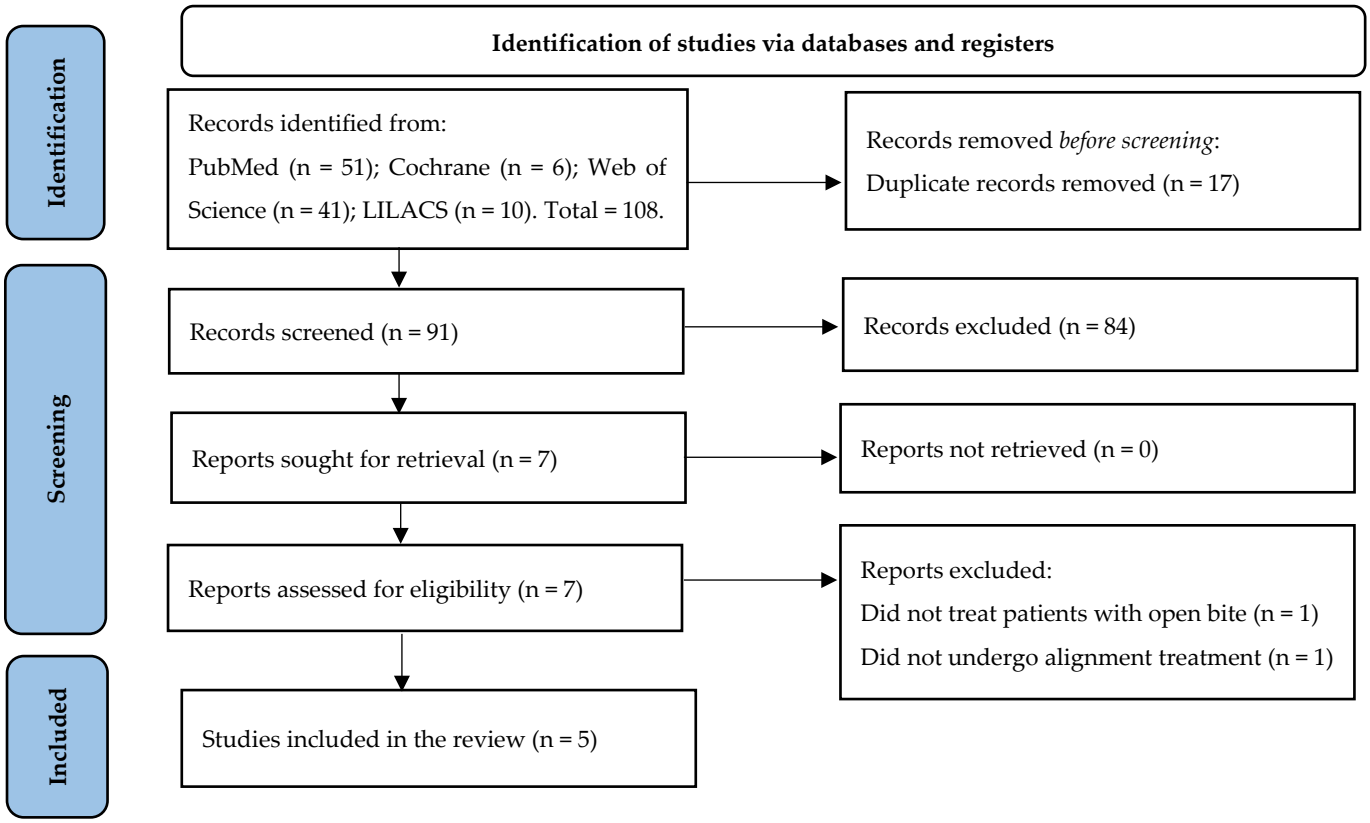

Figure 1. PRISMA flowchart.

The results of the quality assessment of the studies are presented in Figure 2.

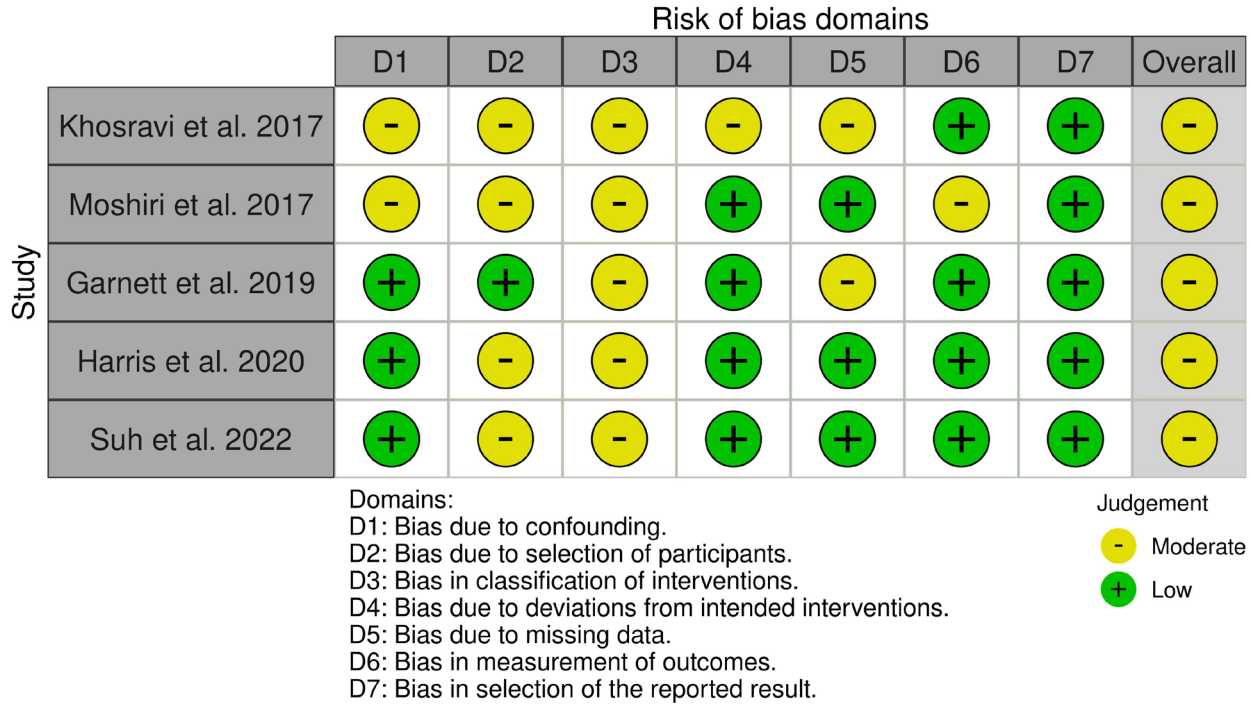

Figure 2. Risk of bias domains—ROBINS-I [12,16–19].

Table 4. Results of the articles.

Author/Year	Khosravi et al., 2017 [16]		Moshiri et al., 2017 [17]		Garnett et al., 2019 [18]		Harris et al., 2020 [19]		Suh et al., 2022 [12]	
Type of study	Retrospective study		Retrospective study		Retrospective study		Retrospective study		Retrospective study	
Group (n)	G1: 12		G1: 30		G1: Fixed appliance—17 G2: Aligners—36		G1: 45		G1: 69	
Age—years (mean)	34		28.8		G1: 32.8/G2: 35.3		30.7		33	
Gender (%)	♀—44% ♂—66%		♀—73.3% ♂—26.6%		G1: ♀—47% G2: ♀—75%		♀—91% ♂—9%		♀—77% ♂—23%	
T1/T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
Overbite (mm)	−1.1 ± 1.0	0.2 ± 0.9 *	−1.8 ± 1.2	1.5 ± 0.9 *	G1: −1.3 ± 1.2 G2: −1.5 ± 1.2	G1: 0.4 ± 0.9 G2: 0.7 ± 0.9	−1.21 ± 1.1	2.1 ± 0.7 *	−2.2 ± 1.3	1.0 ± 0.8 *
LAFH (mm)	71.6 ± 6.9	71.6 ± 7.4	74.3 ± 5.3	72.8 ± 5.2 *	G1: 70.2 ± 5.0 G2: 68.8 ± 6.4	G1: 70.0 ± 5.2 G2: 69.0 ± 6.2	115.9 ± 7.2	114.8 ± 7.3 *	72.6 ± 5.4	72.0 ± 5.6 *
L1-MP (mm)	42.8 ± 3.6 *	43.5 ± 4.1 *	38.3 ± 2.8	39.1 ± 3.1 *	G1: 41.5 ± 3.6 G2: 40.7 ± 3.7	G1: 41.4 ± 3.6 G2: 41.5 ± 3.6	41.0 ± 3.5	41.5 ± 3.6 *	37.3 ± 3.3	38.7 ± 3.8 *
L6-MP (mm)	33.1 ± 2.9	33.3 ± 3.7	31.3 ± 2.5	30.7 ± 2.4 *	G1: 32.3 ± 3.5 G2: 31.4 ± 3.5	G1: 32.5 ± 4.0 G2: 31.3 ± 3.6	33.2 ± 3.1	32.8 ± 3.0 *	33.8 ± 2.7	33.7 ± 2.8 *
U1-PP (mm)	29.6 ± 3.7	30.3 ± 3.8	30.7 ± 2.8	31.2 ± 2.6	G1: 30.9 ± 2.3 G2: 31.0 ± 3.2	G1: 31.4 ± 2.6 G2: 32.0 ± 3.0	69.0 ± 4.7	70.5 ± 4.6 *	29.8 ± 2.8	31.0 ± 2.9 *
U6-PP (mm)	23.5 ± 3.4	23.6 ± 3.6	25.4 ± 2.2	25.0 ± 2.3	G1: 25.2 ± 1.8 G2: 24.8 ± 2.7	G1: 24.9 ± 2.2 G2: 24.8 ± 2.7	63.8 ± 3.6	63.3 ± 3.75 *	24.9 ± 2.3	24.6 ± 2.4 *
Accessory Devices	Attachments		IPR, elastic		G1: TAD, TPA, TLA, BB, extraction G2: IPR, expansion		Attachments, IPR, elastic, Acceledent devices		IPR, expansion, elastic	
Duration (years)	-		1.75		1.6		1.2		1.4	

G1: group 1; G2: group 2; ♀: female; ♂: male; ; T1: time 1; T2: time 2; LAFH: lower anterior facial heights; L1-MP: distance from L1 to the mandibular plane; L6-MP: distance from L6 to the mandibular plane; U1-PP: distance from U1 to the palatal plane; U6-PP: distance from U6 to the palatal plane; IPR: interproximal reduction; TAD: temporary anchorage devices; TPA: transpalatal arches; BB: bite block; *: p-value < 0.05.

Table 5. ANOVA.

	Sample (N)	Overbite (Mean)	SD	Inferior Limit	Upper Limit
Khosravi et al., 2017 [16]	12	1.3	0.6	0.918776	1.68122
Moshiri et al., 2017 [17]	30	3.4	1.4	2.87723	3.92277
Garnett et al., 2019 [18]	36	2.2	1.5	1.69248	2.70752
Harris et al., 2020 [19]	45	3.2	1	2.89957	3.50043
Suh et al., 2022 [12]	69	3.3	1.4	2.96368	3.63632

ANOVA: p-value < 0.01.

All studies presented a moderate result in the assessment of bias. The two oldest studies [16,17], carried out in 2017, performed worse in assessing bias because they had a small sample size and were carried out in more than one location. Although the three most recent studies [12,18,19] had a better assessment, only the study by Garnett et al. [18] received a low risk of bias assessment in domain 2, referring to participant selection. This is attributed to the fact that only this study provided a comprehensive overview of the participant selection process and incorporated a control group within the sample.

4. Discussion

To strategize an effective treatment plan and ascertain the most suitable therapeutic course, the early identification of an anterior open bite stands as a crucial factor. Such a diagnosis not only expedites decision processes but also broadens the spectrum of available treatment modalities, enabling a more comprehensive exploration of potential solutions [20,21]. This systematic review aimed to evaluate the effectiveness of aligner treatment for adult patients with open bites. All studies included adult patients with an overbite less than zero who received treatment with aligners.

4.1. Mechanism and Effectiveness of Aligners

The findings from the five included studies demonstrated a reduction in anterior open bites, thereby confirming the hypothesis of the proposed objective. Nevertheless, discrepancies exist among the studies regarding how this outcome was achieved. Khosravi et al. [16] indicated in their research that incisor extrusion is the primary mechanism for closing an anterior open bite, whereas the studies by Moshiri and Harris [17,19] illustrated that the cause of an increased overbite is not solely attributed to incisor extrusion but also involves molar intrusion. Suh's investigation [12] revealed a correlation between the extrusion of upper incisors and the closure of dentally originated open bites, whereas the extrusion of lower incisors, the reduction in the mandibular plane angle, and the decrease in lower facial height exhibited a moderate correlation with patients having skeletal open bites. Garnett et al. reported that key factors for correcting an open bite involve incisor retroclination, effective vertical control, and the prevention of posterior molar extrusion [18].

The results from Khosravi's and Suh's studies [12,16] demonstrated success in patients with mild to moderate anterior open bites. Garnett et al. extended these findings, concluding that aligners are effective even in the treatment of anterior open bites in hyperdivergent adults, without the need for adjunctive devices. In this study, both the control group with fixed appliances and the group receiving aligner treatment showed a positive change in overbite of 2.3 mm in the aligners group and 1.8 mm in the control group. With the G4 protocol, attachments were utilized for incisor extrusion in the lower incisors, contributing to leveling the occlusal plane and achieving a flat Spee curve. This was particularly relevant as many patients presented with an inverted Spee curve, attributed in part to habits such as tongue protrusion against the incisors [12,18].

Moshiri et al. emphasized a reduction in the mandibular occlusal plane angle and an increase in the maxillary occlusal plane, confirming bite closure achieved through aligners involving molar intrusion and incisor extrusion. Additionally, there was a counterclockwise rotation of the mandibular plane and a decrease in anterior facial height. Consequently, the

overbite value increased significantly, reaching a mean positive difference of 3.4 mm [17]. Similar to Moshiri, Harris et al. found a pre-treatment to post-treatment difference in anterior open bite overbite values of 3.27 mm. The authors stated that dental changes are more pronounced when compared to skeletal changes, involving both incisor extrusion and molar intrusion in both the upper and lower arches [19].

Suh et al. demonstrated an overbite difference comparable to that of Moshiri and Harris, with an average change of 3.3 mm [12,17,19]. A positive overbite value was achieved in 94% of the treated cases, resulting from a 1 mm intrusion of the maxillary molars, leading to an increase in overbite by 1.2 mm. This outcome is slightly lower than the predictions of earlier studies cited in the literature, where each 1 mm of intrusion was associated with a 2–3 mm increase in overbite [22–25]. When evaluating patients across Angle's Class I, II, and III groups, Suh et al. highlighted differences in the treatment mechanism [19]. The Class I and II groups showed positive outcomes in terms of maxillary incisor retroclination and maxillary molar intrusion. Patients in Class III achieved closure through the extrusion and retroclination of the lower incisors, along with vertical dimension control.

4.2. Fixed Device and Vertical Dimension

In the literature, there is evidence of the difficulty of maintaining the vertical dimension with the use of fixed appliances, especially in patients with long faces and hyperdivergent profiles [12,17,18,26–28]. According to Moshiri et al., treating patients with anterior open bites represents a challenge due to the typically high angle of the mandibular plane [17]. This concern is noteworthy in such treatments as there is a need to avoid an increase in facial height and molar extrusion [12,19]. In contrast to descriptions in the literature, Garnett revealed in their study that there were no significant differences in the mandibular plane angle between patients treated with fixed appliances or aligners, thus preserving control over the vertical dimension in both groups [18].

4.3. Aligners and Vertical Dimension

An open bite can be closed with aligners without losing control over the vertical dimension [18]. This is attributed to the interposition of aligner material on the dental occlusion, generating a response of intrusive muscular forces, particularly in the first molar region, thereby causing a counterclockwise rotation of the mandibular plane [18,19,29]. Moshiri asserted that achieving a substantial reduction in occlusal plane values requires premeditated planning, specifically with the placement of accessories designed for this purpose [17]. On the other hand, Harris et al. reported that all aligners induce an intrusive effect due to the coverage of posterior teeth. Thus, in addition to not losing control over the vertical dimension, aligners can lead to a decrease in the vertical dimension. This reduction is justified by the hardness of the aligner material, which provides complete coverage of the teeth. Therefore, if this effect is not intended, measures need to be taken to prevent such movement, such as in patients with deep bites [19].

4.4. Accessory Devices

A relevant observation concerns the difference in tooth movement when interproximal reduction (IPR) is applied [17,18]. In one of the studies, the lower teeth experienced vertical changes similar to the upper teeth; however, the lower teeth showed statistically significant results [17]. This could possibly be justified by a greater interproximal reduction (IPR) in the lower teeth, leading to increased conditions of extrusion. Garnett et al. also emphasized the benefit of space gain in the group treated with aligners, induced using IPR, facilitating dental movement [18].

Another device that can promote dental movement is the use of anterior elastics. With elastics, it is possible to achieve a positive overbite and correct the inclination of the occlusal plane [17]. This technique, using elastics, is referred to as Multiloop Edgewise Archwire (MEAW), where bite closure occurs mainly due to the extrusion of anterior teeth [30–32].

However, there is no evidence that these elastics affect anterior facial height or the angle of the mandibular plane [17].

Some authors emphasize the importance of skeletal anchorage using temporary anchorage devices (TAD) concurrently with fixed appliances to achieve molar intrusion in adult patients with anterior open bites [33,34]. Therefore, the alternative use of mini-implants/mini-screws is suggested to provide anchorage support and facilitate dental movement. Garnett et al. achieved positive outcomes by opting to utilize devices to maintain control over the vertical dimension in fixed-appliance treatment, such as TAD, bite elevators, and planned extractions. Conversely, in the same study, the group undergoing aligner treatment did not require TAD or extractions due to the inherent control exerted by the aligner material, even with the use of Class II or Class III elastics [18].

4.5. Other Factors Influencing Treatment

A factor to be considered in aligner treatment is the clinician's experience with adult patients with anterior open bites. The studies conducted by Khosravi et al. and Garnett et al. involved three and five professionals, respectively, with expertise in aligner technology and experience in treating patients with this type of malocclusion. In their research, the authors agreed that this expertise may have influenced the positive treatment outcomes [16,18].

On the other hand, Suh et al. involved only one clinician assessing and performing all treatments, which may have limited the study but reduced heterogeneity in terms of professional experience [12]. Difficulty also exists in tooth movement because there is the expected tooth position, the position programmed in the protocol, and the current tooth position. In other words, the planned movement and the actual movement do not always coincide. Additionally, overcorrections or undercorrections may be incorporated to achieve a better outcome. Therefore, it is within the field of clinical practice to determine the intended positions and potential movements that may occur throughout the treatment.

Evaluations conducted through cephalometric examinations are susceptible to subjectivity, which can be considered a factor contributing to imprecisions in the results [12,16]. This type of examination may involve errors in reading and interpretation, attributable to the patient's head positioning, movement during radiation exposure, challenges in identifying structures, and image magnification. To reduce errors in identifying landmarks, the use of software can be employed, in which the calculations of linear and angular measurements are performed automatically. Additionally, using the same cephalometric radiography machine for both pre-treatment and post-treatment examinations also enhances result accuracy. At present, technologies such as cone-beam computed tomography (CBCT) have been employed to enhance precision in the obtained results [16].

4.6. Statistical Evaluation and Bias Analysis

The review employed an Analysis of Variance (ANOVA), allowing for the assessment of comparisons among three or more groups [35]. Thus, the analysis focused on the mean differences in overbite obtained from the included studies. Significance in the p-value indicates a statistical distinction between at least two of the examined studies [36]. This study verified the presence of such statistical differences, thereby representing a limitation in conducting a more specific evaluation of result comparisons. Consequently, a lack of standardization among the studies was identified, restricting more precise assessments.

The bias assessment, conducted using the Cochrane tool for non-randomized studies (ROBINS-I) [15], evaluated seven classification domains and revealed a moderate risk in all five included studies. In one study, nearly 50% of the initially selected individuals had to be excluded due to the need for surgical treatments or the absence of post-treatment cephalometric analysis, creating the potential for selection bias (Khosravi 2017 [16]). This categorization arises from the observational and retrospective nature of these studies, leading to data loss and a reduction in sample size over time.

4.7. Limitations and Expectations for Future Work

While all studies included in the research demonstrated positive outcomes using aligners to treat previous open bites, there are some limitations that should be mentioned. Only five studies met the predefined criteria for inclusion in the review, and the sample sizes in these studies were small, potentially affecting the robustness of the results. The difficulty of collecting a large number of adult patients with anterior open bites was noted [17].

Only one of the included studies incorporated a control group [18], providing a unique reference for comparing clinical values between aligner and fixed-appliance treatments for patients with anterior open bites. All studies were of observational and retrospective nature. Retrospective studies are limited in their ability to control all variables [12,17,19]. Despite this limitation, these studies can produce valid scientific evidence when conducted in a standardized and controlled format, offering a cost-effective option compared to other study types [16].

This current review highlights a scientific evidence gap on the proposed subject. Therefore, there is a need for further studies such as prospective, randomized, controlled clinical trials with standardized variables and the inclusion of a control group. This would enable subsequent statistical analyses to demonstrate the efficacy of aligner treatment more robustly for adult patients with anterior open bites. Additionally, given the advancements in aligner technology since the studies mentioned in the literature were published, improvements in protocols may impact the outcomes of this treatment approach.

In addition to including a control group with other types of treatment, it would be effective for future studies to separate groups based on the severity level of open bites (mild, moderate, and severe), the origin of the problem (dental or skeletal), and Angle's classification (Class I, II, and III), as the treatment mechanism differs in each situation. Evaluating the stability in treatments with aligners is also of great importance in future studies, as well as considering the use of alternative examinations (CBCT and intraoral scanners), as these may reduce analysis errors and provide more accurate data, potentially improving the precision of assessments in future research.

5. Conclusions

The research indicated that despite the absence of robust scientific evidence, the reviewed studies suggest the efficacy of aligner treatment for adults with mild or moderate anterior open bites. Nevertheless, there is a need for randomized clinical trials incorporating standardized variables and using a control group. Conducting such trials would enhance the reliability of findings and provide more concrete evidence regarding the effectiveness of aligner therapy for this specific condition.

This study highlights new therapeutic possibilities for the treatment of anterior open bites. This encourages researchers to carry out further research on aligners and their effectiveness, as well as promoting continuous technological improvements to enhance reliability in this clinical approach. Finally, for future studies, it is concluded that more clinical research is needed on aligners in the treatment of anterior open bites in adult patients.

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References

1. Ingervall, B.; Helkimo, E. Masticatory Muscle Force and Facial Morphology in Man. *Arch. Oral Biol.* **1978**, *23*, 203–206. [CrossRef] [PubMed]
2. Proffit, W.R.; Fields, H.W.; Nixon, W.L. Occlusal Forces in Normal- and Long-Face Adults. *J. Dent. Res.* **1983**, *62*, 566–570. [CrossRef] [PubMed]

3. Urzal, V.; Braga, A.C.; Ferreira, A.P. Diagnostic Model of Anterior Open Bite—A New Way to Predict Skeletal Type: A Cross-Sectional Study. *Int. Orthod.* **2014**, *12*, 358–370. [CrossRef] [PubMed]
4. Alhammadi, M.S.; Halboub, E.; Fayed, M.S.; Labib, A.; El-Saaidi, C. Global Distribution of Malocclusion Traits: A Systematic Review. *Dent. Press J. Orthod.* **2018**, *23*, e1–e10. [CrossRef] [PubMed]
5. Mizrahi, E. A Review of Anterior Open Bite. *Br. J. Orthod.* **1978**, *5*, 21–27. [CrossRef]
6. Ngan, P.; Fields, H.W. Open Bite: A Review of Etiology and Management. *Pediatr. Dent.* **1997**, *19*, 91–98. [PubMed]
7. Greenlee, G.M.; Huang, G.J.; Chen, S.S.H.; Chen, J.; Koepsell, T.; Hujoel, P. Stability of Treatment for Anterior Open-Bite Malocclusion: A Meta-Analysis. *Am. J. Orthod. Dentofac.* **2011**, *139*, 154–169. [CrossRef] [PubMed]
8. Wong, B.H.; Scholz, R.P.; Turpin, D.L. Invisalign A to Z. *Am. J. Orthod. Dentofac.* **2002**, *121*, 540–541. [CrossRef]
9. Urzal, V.; Ferreira, A.P. Analysis of the Invisalign System in What Concerns It's Advantages and Limitations. *Rev. Ortod.* **2011**, *13*, 28–39.
10. Azaripour, A.; Weusmann, J.; Mahmoodi, B.; Peppas, D.; Gerhold-Ay, A.; Van Noorden, C.J.F.; Willershausen, B. Braces versus Invisalign®: Gingival Parameters and Patients' Satisfaction during Treatment: A Cross-Sectional Study. *BMC Oral Health* **2015**, *15*, 69. [CrossRef]
11. Talens-Cogollos, L.; Vela-Hernández, A.; Peiró-Guijarro, M.A.; García-Sanz, V.; Montiel-Company, J.M.; Gandía-Franco, J.L.; Bellot-Arcís, C.; Paredes-Gallardo, V. Unplanned Molar Intrusion after Invisalign Treatment. *Am. J. Orthod. Dentofac.* **2022**, *162*, 451–458. [CrossRef] [PubMed]
12. Suh, H.; Garnett, B.S.; Mahood, K.; Mahjoub, N.; Boyd, R.L.; Oh, H. Treatment of Anterior Open Bites Using Non-Extraction Clear Aligner Therapy in Adult Patients. *Korean J. Orthod.* **2022**, *52*, 210–219. [CrossRef] [PubMed]
13. Eriksen, M.B.; Frandsen, T.F. The Impact of Patient, Intervention, Comparison, Outcome (Pico) as a Search Strategy Tool on Literature Search Quality: A Systematic Review. *J. Med. Libr. Assoc.* **2018**, *106*, 420–431. [CrossRef] [PubMed]
14. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *BMJ* **2021**, *372*, 71. [CrossRef]
15. Sterne, J.A.; Hernán, M.A.; Reeves, B.C.; Savović, J.; Berkman, N.D.; Viswanathan, M.; Henry, D.; Altman, D.G.; Ansari, M.T.; Boutron, I.; et al. ROBINS-I: A Tool for Assessing Risk of Bias in Non-Randomised Studies of Interventions. *BMJ* **2016**, *355*, i4919. [CrossRef] [PubMed]
16. Khosravi, R.; Cohanim, B.; Hujoel, P.; Daher, S.; Neal, M.; Liu, W.; Huang, G. Management of Overbite with the Invisalign Appliance. *Am. J. Orthod. Dentofac.* **2017**, *151*, 691–699. [CrossRef]
17. Moshiri, S.; Araújo, E.A.; McCray, J.F.; Thiesen, G.; Kim, K.B. Cephalometric Evaluation of Adult Anterior Open Bite Non-Extraction Treatment with Invisalign. *Dent. Press J. Orthod.* **2017**, *22*, 30–38. [CrossRef] [PubMed]
18. Garnett, B.S.; Mahood, K.; Nguyen, M.; Al-Khateeb, A.; Liu, S.; Boyd, R.; Oh, H. Cephalometric Comparison of Adult Anterior Open Bite Treatment Using Clear Aligners and Fixed Appliances. *Angle Orthod.* **2019**, *89*, 3–9. [CrossRef] [PubMed]
19. Harris, K.; Ojima, K.; Dan, C.; Upadhyay, M.; Alshehri, A.; Kuo, C.L.; Mu, J.; Uribe, F.; Nanda, R. Evaluation of Open Bite Closure Using Clear Aligners: A Retrospective Study. *Prog. Orthod.* **2020**, *21*, 1–9. [CrossRef] [PubMed]
20. Arat, Z.M.; Akcam, M.O.; Esenlik, E.; Arat, F.E. Inconsistencies in the Differential Diagnosis of Open Bite. *Angle Orthod.* **2008**, *78*, 415–420. [CrossRef]
21. Matsumoto, M.A.; Romano, F.L.; Ferreira, J.T.; Valério, R.A. Open bite: Diagnosis, treatment and stability. *Braz. Dent. J.* **2012**, *23*, 768–778. [CrossRef] [PubMed]
22. Kuhn, R.J. Control of anterior vertical dimension and proper selection of extraoral anchorage. *Angle Orthod.* **1968**, *38*, 340–349. [PubMed]
23. Schudy, F.F. The control of vertical overbite in clinical orthodontics. *Angle Orthod.* **1968**, *38*, 19–39. [PubMed]
24. Kassem, H.E.; Marzouk, E.S. Prediction of changes due to mandibular autorotation following miniplate anchored intrusion of maxillary posterior teeth in open bite cases. *Prog. Orthod.* **2018**, *19*, 1–7. [CrossRef] [PubMed]
25. Kim, K.; Choy, K.; Park, Y.C.; Han, S.Y.; Jung, H.; Choi, Y.J. Prediction of mandibular movement and its center of rotation for nonsurgical correction of anterior open bite via maxillary molar intrusion. *Angle Orthod.* **2018**, *88*, 538–544. [CrossRef]
26. Sassouni, V.; Nanda, S. Analysis of dentofacial vertical: Proportions. *Am. J. Orthod.* **1964**, *50*, 801–823. [CrossRef]
27. Subtelny, J.D. Oral respiration: Facial maldevelopment and corrective dentofacial orthopedics. *Angle Orthod.* **1980**, *50*, 147–164. [PubMed]
28. Taibah, S.M.; Feteih, R.M. Cephalometric features of anterior open bite. *World J. Orthod.* **2007**, *8*, 145–152. [PubMed]
29. Iscan, H.N.; Sarisoy, L. Comparison of the effects of passive posterior bite-blocks with different construction bites on the craniofacial and dentoalveolar structures. *Am. J. Orthod. Dentofac. Orthop.* **1997**, *112*, 171–178. [CrossRef]
30. Kim, Y.H. Anterior openbite and its treatment with multiloop edgewise archwire. *Angle Orthod.* **1987**, *57*, 290–321.
31. Chua, A.L.; Lim, J.Y.; Lubit, E.C. The effects of extraction versus nonextraction orthodontic treatment on the growth of the lower anterior face height. *Am. J. Orthod. Dentofac. Orthop.* **1993**, *104*, 361–368. [CrossRef] [PubMed]
32. Endo, T.; Kojima, K.; Kobayashi, Y.; Shimooka, S. Cephalometric evaluation of anterior open-bite nonextraction treatment, using multiloop edgewise archwire therapy. *Odontology* **2006**, *94*, 51–58. [CrossRef] [PubMed]

33. Kuroda, S.; Sakai, Y.; Tamamura, N.; Deguchi, T.; Takano-Yamamoto, T. Treatment of severe anterior open bite with skeletal anchorage in adults: Comparison with orthognathic surgery outcomes. *Am. J. Orthod. Dentofac. Orthop.* **2007**, *132*, 599–605. [CrossRef] [PubMed]
34. Deguchi, T.; Kurosaka, H.; Oikawa, H.; Kuroda, S.; Takahashi, I.; Yamashiro, T.; Takano-Yamamoto, T. Comparison of orthodontic treatment outcomes in adults with skeletal open bite between conventional edgewise treatment and implant-anchored orthodontics. *Am. J. Orthod. Dentofac. Orthop.* **2011**, *139*, S60–S68. [CrossRef] [PubMed]
35. Mishra, P.; Singh, U.; Pandey, C.; Mishra, P.; Pandey, G. Application of Student's t-Test, Analysis of Variance, and Covariance. *Ann. Card. Anaesth.* **2019**, *22*, 407–411. [CrossRef]
36. Kao, L.S.; Green, C.E. Analysis of Variance: Is There a Difference in Means and What Does It Mean? *J. Surg. Res.* **2008**, *144*, 158–170. [CrossRef]