






Review

Predictability of ClinCheck in Overbite Correction with Aligners: A Systematic Review

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Abstract

Background: The use of aligner therapy for open bite and deep bite correction has increased in contemporary society. There is no evidence that unify the results present the in literature regarding a real comparison between clinical outcomes and the results predicted by the ClinCheck software 3.0 (Align Technology, Santa Clara, CA, USA). Furthermore, the literature shows conflicting data about the protocols and not all authors compare the programmed movements and the clinical results obtained for the overbite correction. Therefore, the aim of this systematic review is to assess the predictability of ClinCheck in the correction of vertical discrepancies by comparing the planned outcomes with the actual clinical results performed with clear aligners. **Methods:** The research question focused on the effectiveness of ClinCheck in predicting the actual correction of deep bite AND open bite in adult patients. Five electronic databases (PubMed, Scopus, Embase, Web of Science and Cochrane Library) were investigated, with the following keywords: overbite AND aligners. A quality assessment was performed using the Newcastle-Ottawa scale, while the risk of bias was evaluated using the ROBINS-I tool 2.0. PROSPERO ID: CRD420251078610. **Results:** Out of a total of 838 records initially screened, seven studies fulfilled the inclusion criteria and were ultimately selected for this systematic review. The analysis focused on assessing the divergence between the overbite correction predicted by ClinCheck and the outcomes observed in clinical practice. **Conclusions:** ClinCheck demonstrated a predictability of 62.1% for overbite correction in open bite cases and 41.5% in deep bite cases. However, not all studies report the planned tooth movements. Among the studies that addressed this aspect, the majority reported no significant association between the overbite correction predicted during treatment planning and the results ultimately achieved—except for one study, which demonstrated significant accuracy in achieving absolute extrusion in the correction of open bite.



Academic Editor: Iole Vozza

Received: 11 May 2025

Revised: 23 June 2025

Accepted: 24 June 2025

Published: 27 June 2025

Citation: Boccuzzi, M.; Cosola, S.; Butera, A.; Genovesi, A.; Laborante, T.; Castaldo, A.; Zizza, A.; Oldoini, G.; Nota, A.; Tecco, S. Predictability of ClinCheck in Overbite Correction with Aligners: A Systematic Review. *Appl. Sci.* **2025**, *15*, 7268. <https://doi.org/10.3390/app15137268>

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Keywords: systematic review; overbite; aligner

1. Introduction

Clear aligners have become a widely accepted tool for orthodontic tooth movement and are now routinely employed in clinical practice worldwide [1]. Although initially intended for the treatment of mild to moderate orthodontic problems, the increasing aesthetic demand from patients has driven both companies and clinicians to refine the treatment protocols and the quality of aligner therapies, thereby expanding their use for the correction of more complex and less predictable malocclusions [2]. Achieving vertical control of the occlusion remains one of the most demanding aspects of orthodontic treatment, as it includes the complex management of both open bite and deep bite malocclusions. The term “overbite” is defined as the superimposition of upper and lower incisal edges in vertical dimension, and it is considered within normal limits when varying by approximately ± 2 mm [3]. An overbite is classified as deep when it exceeds 30%, while an anterior open bite is defined as a lack of incisal contact between the upper and lower anterior teeth when posterior occlusion is present [4,5]. Both conditions can arise from dental or skeletal origin [6–8].

The integration of CAD/CAM systems with advanced 3D planning software has enabled orthodontists to digitally simulate tooth movements, customize treatment staging, and select attachments based on case-specific biomechanical requirements, leading to the fabrication of fully customized aligners [9]. Invisalign (Align Technology, Santa Clara, CA, USA) was the first clear aligner system to incorporate 3D digital technology for orthodontic treatment and it is supported by ClinCheck, the company proprietary software for virtual treatment planning and tooth movement simulation.

Since its initial development in 1997, the Invisalign system has been continuously refined, particularly following the introduction of the SmartTrack material in 2013, which replaced the earlier EX30 and contributed to the progressive optimization of clinical protocols [10–14].

The correction of deep bite and anterior open bite primarily involves a combination of intrusive and extrusive tooth movements.

In deep bite cases, overbite reduction is typically accomplished through a combination of anterior tooth intrusion and/or posterior tooth extrusion. Intrusion can be classified as either absolute or relative, with the latter generally associated with anterior proclination [15]. Kravitz et al. proposed a biomechanical strategy aimed at generating an inverse Curve of Spee by promoting extrusion of the lower premolars and molars in conjunction with the intrusion of mandibular incisors and canines, thereby effectively mimicking the dental configuration observed in anterior open bite cases. Their study reported an average intrusion of 45.3% of the lower incisors in adults, whereas Houili et al. observed an intrusion rate of 35.3% [12,16,17]. Furthermore, they reported an improvement in overbite of 1.5 mm with an average intrusion of the upper incisors of 0.72 mm [18].

A growing clinical approach suggests removing the occlusal coverage on second molars to promote vertical control by enhancing posterior disocclusion. In this context, Align Technology has incorporated bite ramps—elevated structures on the lingual surface of the upper aligner—aimed at minimizing occlusal contact in the posterior region and reducing vertical forces. Despite this innovation, several studies have indicated that the effectiveness of this strategy in correcting deep bite remains limited, even when the G5 protocol is implemented [19,20].

Conversely, the anterior open bite strategies provided anterior extrusion and/or posterior intrusion. The planning of anterior extrusion may involve either absolute vertical movement or relative extrusion resulting from incisor retraction [21]. Khosravi et al. reported that anterior open bite correction primarily results from incisor extrusion, whereas other studies have concluded that molar intrusion combined with mandibular counter-

clockwise rotation plays a significant role in overbite correction, with molar intrusion measurements of approximately 1 mm [18,22,23]. Rask et al. suggested that the inherent thickness of the aligner contributes to promoting intrusion in the posterior region [24]. Based on these findings, some authors have recommended incorporating thickened areas on the chewing surfaces of posterior teeth—commonly described as “occlusal posterior bite blocks”—into the ClinCheck digital treatment plan [25].

Current evidence indicates that the average accuracy of extrusion is approximately 29.6%, whereas Nguyen et al. reported a higher accuracy of 56% [26]. According to Suh et al., only 38% of the programmed posterior intrusion was successfully achieved [27].

In clinical practice, for both anterior open bite and deep bite cases, the Invisalign system offers clinicians various tools for vertical control, including the option to select attachment designs (optimized or conventional), adjust treatment staging, and apply overcorrection of tooth movements according to the clinician’s biomechanical strategy. The accuracy of the biomechanical mechanisms underlying overbite correction with aligners has not been extensively investigated in the literature. Furthermore, most studies tend to evaluate overbite correction only after the initial series of aligners or following the first refinement phase. The heterogeneous data available in the literature on vertical control suggests that the accuracy of dental movements does not necessarily equate to clinical effectiveness. As with conventional orthodontic treatment, clear aligner therapy does not ensure outcomes that precisely replicate the initial virtual treatment plan.

A variety of factors may influence the effectiveness of orthodontic treatment, including the interindividual biological variability, patient adherence to prescribed protocol, the clinician’s level of expertise and the technical limitations associated with the precise execution of planned dental movement [28,29].

The ClinCheck software 3.0 simulates dental biomechanics and generates a digital preview of the anticipated final outcome. Therefore, this systematic review investigates how accurately overbite correction predicted by ClinCheck aligns with clinically achieved results following planned aligner therapy.

2. Materials and Methods

This systematic review was carried out following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and registered within the PROSPERO International Prospective Register of Systematic Reviews with the ID number CRD420251078610 [30]. The research question was formulated following the PICO strategy: Participant, Intervention, Comparison, Outcome. The population included adult patients with either deep or open bite malocclusions treated with clear aligners (intervention). The purpose of the comparison was to evaluate the predictability of the ClinCheck software and the actual clinical outcomes. The outcome was the overbite value assessed pre-, during and post-treatment.

2.1. Eligibility Criteria

Studies were considered eligible based on the following conditions:

1. Studies published in English;
2. Patients aged ≥ 18 years;
3. Patients treated with aligners;
4. Patients without systemic diseases;
5. Presence of permanent teeth, with involvement of the second molars;
6. Patients with overbite measurements ≤ 2 mm or ≥ 2 mm;
7. Orthodontic treatments involving both the maxillary and mandibular arches;
8. Inclusion of a digital prediction of overbite correction generated by the software.

The following exclusion criteria were applied:

1. Growing patients;
2. Extractions;
3. Temporomandibular disorders;
4. Patients with bone metabolism disorders;
5. Patients treated with orthognathic surgery;
6. Loss of specimen.

2.2. Search Strategy and Selection Process

Five electronic databases (PubMed, Scopus, Embase, Web of Science and Cochrane Library) were investigated from November to January 2025 by two independent examiners (M.B, T.L.). The research strategy was carried out with the following key words coupled with Boolean operators and organized as the following algorithm for the database research: “Overbite” AND “Aligners”. The publication year was not used as an exclusion criterion. The different steps of the search and selection process are outlined in the PRISMA flow chart (Figure 1).

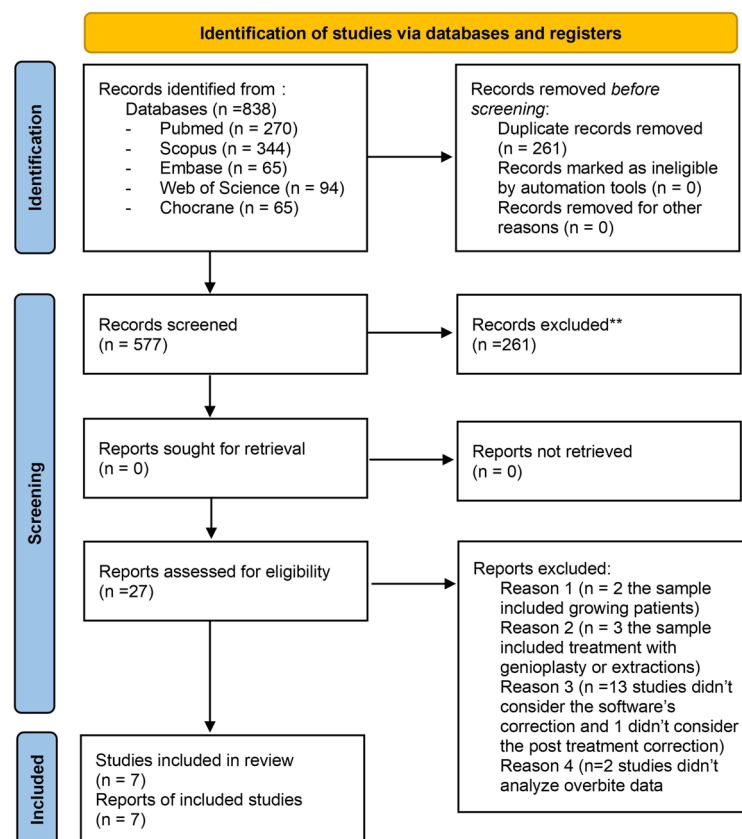


Figure 1. PRISMA flow diagram [30], **: in Table 1 there is the list of excluded articles.

The initial database search produced 838 results. Following the elimination of duplicate records, a total of 577 articles underwent screening based on their titles and abstracts. Following this first assessment, 261 records were excluded as not relevant to the subject, and 27 papers were selected for full-text analysis. Finally, 7 studies were selected for this systematic review (Figure 1).

A summary of the excluded articles, along with the corresponding reasons for their exclusion, is provided in the table below (Table 1).

Table 1. Articles and reason for exclusion.

Articles	Reason of Exclusion
[31]	The authors analyze overbite in a heterogeneous sample considering patients who underwent extraction and genioplasty
[32]	The authors analyze extraction cases
[33]	Two of the 24 patients included in the sample underwent extraction of four premolars
[34]	Patients <18 years old are also analysed from a cephalometric perspective between T1 and T2, without considering the data provided by ClinCheck
[35]	Patients <18 years old and evaluation of deep bite in terms of the IMPA value
[16]	The authors consider only the value of intrusion and do not report overbite values
[36]	The authors evaluate the leveling of the Spee curve, but the overbite data is not analyzed
[37]	There is a loss of the sample at T3. At T1, 36 patients are analyzed, and at T3, only 14 remain. Additionally, there is no evaluation of overbite through ClinCheck (T2)
[38]	The study compares two groups, but it does not analyze the correction of overbite through the ClinCheck software (T2)
[39]	Cephalometric evaluation between two groups of patients treated with two different devices in hyperdivergent patients, without considering the correction of overbite through software (T2) in patients treated with aligners
[14]	The correction of overbite at T2 through ClinCheck is not considered
[13]	The correction of overbite at T2 through ClinCheck is not considered
[40]	The correction of overbite at T2 through ClinCheck is not considered
[41]	The correction of overbite at T2 through ClinCheck is not considered
[18]	The correction of overbite at T2 through ClinCheck is not considered
[42]	The authors compare whether there are differences between the ClinCheck software and Geomagic Control X software in predicting the correction of overbite in open-bite subjects. However, they do not analyze the actual correction after treatment (T3)
[43]	The correction of overbite at T2 through ClinCheck is not considered
[24]	The correction of overbite at T2 through ClinCheck is not considered in the comparison between a group of patients treated with fixed appliances and a group treated with aligners
[27]	The correction of overbite at T2 through ClinCheck is not considered
[44]	The correction of overbite at T2 through ClinCheck is not considered

2.3. Data Collection and Data Items

Two calibrated reviewers (M.B. and T.L.) removed duplicate records from the database using Rayyan software (Qatar Computing Research Institute, Doha Qatar, <https://www.rayyan.ai>). Then, they screened the records, first by title and then by abstract, excluding those that did not meet the eligibility criteria. For papers where the reviewers were uncertain, the full text was reviewed.

All disagreements were discussed between the two primary reviewers (M.B. and T.L.). If consensus was not achieved, a third reviewer was consulted as arbitrator (A.N.)

A structured data extraction table was developed to systematically record and analyze the key characteristics of each included study. The items reviewed were the following: authors and year of publication, study design, sample size, sex, age, aligner system, number of aligners, material, presence of second molars, presence of bite block, bite ramp and type of attachments, use of elastics or TADs, type of software used by the authors to extract the data, overbite, clinical references adopted by the author to measure the overbite, type of

overbite, measure of overbite, skeletal pattern, treatment duration, aligners, and change regime (Table 2).

Table 2. Included articles and data extraction sheet.

Parameter	Blundell et al., 2022 [10]	Blundell et al., 2021 [20]	Blundell et al., 2023 [45]	Bowman et al., 2023 [46]	Burashed et al., 2023 [47]	Burashed et al., 2023 [48]	Fiorillo et al., 2024 [49]
Study design	Retrospective	Retrospective	Retrospective	Retrospective	Retrospective cohort	Retrospective cohort	Retrospective
Sample size	68	42	76	33	86	78	25
Sex	/	/	53 F 23 M	21 F 12 M	57 F 29 M	29 M 49 F	12 M 13 F
Age	≥18 y	≥18 y	35 ± 2 y	32.7 y	31.8 ± 10.1 y	34.9 ± 14.3 y	32.28 y
CA system	Invisalign	Invisalign	Invisalign	Invisalign	Invisalign	Invisalign	Invisalign
No. of CA	≥14	≥14	≥14	/	25.0 ± 10.8	29.8 ± 12.9	≥14
Material	N = 29 Smart track + bite ramp N = 39 EX30	Smart track	Smart track	Smart track	Smart track	Smart track	Smart track
Presence of second molars	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Biteramp, biteblock and attachments	(N = 29) bite ramp	/	POBBs	/	A (n = 42) Conventional attachments B (n = 44) Optimized attachments	A (n = 42) Conventional attachments B (n = 36) Optimized attachments (G5)	Conventional attachment (3 mm, 1.5 mm) 0.20 ± 0.05 mm vertical jump
Elastics	/	/	/	/	/	/	/
TADs	/	/	/	/	/	/	/
Software	Geomagic Control X software (3DSystem Rock Hill SC) version 2017.0.3	Geomagic Control X software (3DSystem Rock Hill SC) version 2017.0.3	Geomagic Control X software (3DSystem Rock Hill SC) version 2017.0.3	Geomagic Control X software (3DSystem Rock Hill SC) version 2017.0.3	ClinCheck software version 2023	ClinCheck software version 2023	Geomagic Control X software (3DSystem Rock Hill SC) version 2017.0.3
Measure	Vertical distance between the mid-point of the incisal edge of the upper left central incisor and the mid-point between the incisal edges of the lower left central and lateral incisors	Vertical distance between the midpoint of the incisal edge of the upper left central incisor and the midpoint between the incisal edges of the lower left central and lateral incisors	Vertical distance between the midpoint of the incisal edge of the upper left central incisor and the midpoint between the incisal edges of the lower left central and lateral incisors	Vertical distance between the midpoint of the incisal edge of the upper left central incisor and the midpoint between the incisal edges of the lower left central and lateral incisors	/	/	Distance between the marginal edges of the upper and lower incisors
Type of malocclusion	Deep bite	Deep bite	Open bite	Deep bite	Open bite	Deep bite	Deep bite
Skeletal pattern	/	/	/	/	/	/	/
Treatment duration	/	/	16.4 months	/	/	/	/
CA change regime	2 weeks	2 weeks	2 weeks	2 weeks	10 days	10 days	/

2.4. Quality Assessment in Individual Studies

Two calibrated reviewers (M.B., T.L.) assessed the methodology and quality of the included studies using the Newcastle-Ottawa scale [50]. The scale evaluated three areas:

- Selection of study groups
- Comparability between groups
- Assessment of exposure/outcome

The analysis revealed that three studies showed moderate quality, while four studies were rated as high quality (Figure 2).

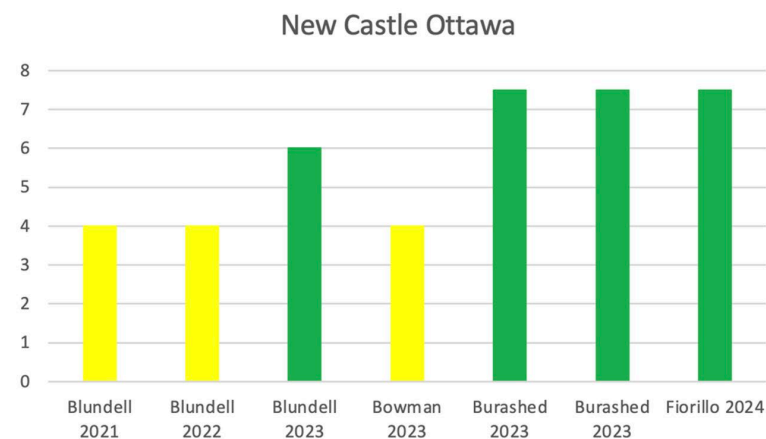


Figure 2. The Newcastle-Ottawa scale was employed to evaluate the quality assessment of the included studies. Bar colors reflect the methodological quality of the included studies: green bars indicate high-quality studies, while yellow bars correspond to studies assessed as having moderate quality [10,20,45–49].

2.5. Risk of Bias Assessment

The quality of the included studies was independently assessed by two authors (M.B. and T.L.). Any disagreements and uncertainties were resolved through mutual discussion. Risk of bias was evaluated using the ROBINS-I framework, tailored for non-randomized studies of interventions, which evaluates the following domains [51]:

- D1: Bias due to confounding factors
- D2: Bias due to participant selection
- D3: Bias in intervention classification
- D4: Bias due to deviations from the planned interventions
- D5: Bias due to missing data
- D6: Bias in data measurement
- D7: Bias in selection of reported outcomes

All included articles demonstrate a low risk of bias, with the exception of the first domain, where all studies exhibited a moderate risk value due to their retrospective design. Furthermore, only three studies adhere to the blind selection of patients as specified in D2.

The absence of skeletal pattern data in the study groups analyzed may represent a confounding factor, potentially related to both the exposure and the outcome. Additionally, within D3 (bias in intervention classification), four articles could have provided a more detailed specification of the protocol for overbite correction (Figure 3).

Articles	D1	D2	D3	D4	D5	D6	D7	Overall
Blundell 2021	●	●	●	●	●	●	●	●
Blundell 2022	●	●	●	●	●	●	●	●
Blundell 2023	●	●	●	●	●	●	●	●
Bowman 2023	●	●	●	●	●	●	●	●
Burashed 2023	●	●	●	●	●	●	●	●
Burashed 2023	●	●	●	●	●	●	●	●
Fiorillo 2024	●	●	●	●	●	●	●	●

Figure 3. Risk of bias of the included studies [10,20,45–49].

3. Results

All the included studies adopted the Invisalign as Clear Aligner System with treatment protocols involving at least ≥ 14 aligners.

Overbite measurements were conducted using Geomagic Control X software (3DSys-tem Rock Hill SC) in five studies, while two studies employed the ClinCheck software for this purpose [10,20,45–49].

Five studies measured the vertical linear distance between the midpoint of the incisal edges of the mandibular left central and lateral incisors and the midpoint of the incisal edge of the maxillary left central incisor to measure overbite, except for one study, which evaluated the vertical distance between the edges of the upper and lower incisors (central or lateral) [10,20,45,46,49]. Two studies did not specify the overbite measurement by ClinCheck software [47,48]. The aligners being changed once every two weeks were adopted by four studies, whereas two studies employed a ten-day period, while one study did not specify this parameter [10,20,45–49]. In all studies, second molars were present and no elastics or TADS were employed to implement arch levelling.

Overall, the studies were grouped into two categories according to the initial overbite to be corrected with Invisalign treatment. The two categories were as follows:

- Studies analyzing the correction of the open bite [45,47];
- Studies analyzing the correction of the deep bite [10,20,46,48,49].

The overbite data were reported in two tables to appreciate and analyze the differences of the ClinCheck estimation between the open bite group and the deep bite group.

Overbite values from the included studies were extracted and pooled at three standardized time points: T1 (pre-treatment), T2(CC) (planned outcome as predicted by the software) and T3(R) (post-treatment outcome). The real expression of planned overbite correction was calculated as the difference between the predicted and the achieved values (T2(CC)-T3(R)) (Figures 4 and 5).

Authors	T1(pre-treatment)	T2 (CC) (software)	T3 (R) (post-treatment)	The real expression of the Invisalign overbite (T2(CC)-T3(R))
Blundell 2023	-1.48 ± 1.09 mm	1.66 ± 0.81 mm	0.60 ± 1.21mm	66.7% (N=76)
Burashed 2023	-1.1 ± 1.1 mm	1.5 ± 0.7 mm	0.4 ± 1.1 mm	62.1 ± 33.4% - 58.4 ± 36.9% (N=42) (GroupA) - 54.6 ± 40.3%. (N=44) (GroupB)

Figure 4. The overbite values in open bite studies [45,47].

Authors	T1(pre-treatment)	T2 (CC) (software)	T3 (R) (post-treatment)	The real expression of the Invisalign overbite (T2(CC)-T3(R))
Blundell 2021	3.9 ± 1.4 mm	1.9 ± 0.7 mm	3.3 ± 1.3 mm	39.2% (N=42)
Blundell 2022	4.55 ± 1.08 mm	1.30 ± 0.80 mm	3.14 ± 1.18 mm	43.4% (bite ramp) (N=29) 55.1% (EX30) (N=39)
Bowman 2023	3.91 ± 1.61 mm	1.74 ± 0.87 mm	2.94 ± 1.17 mm	45% (N=33)
Burashed 2023	4.8 ± 1.1 mm	1.6 ± 0.8 mm	3.5 ± 1.0 mm	36.6% ± 35.4% - 36.1 ± 34.8%. (N=44) (anterior intrusion) - 37.4% ± 37.2% (N=34) - (anterior intrusion/premolars extrusion)
Fiorillo 2024	4.66 ± 0.86 mm	1.91 ± 0.71 mm	3.34 ± 0.85 mm	48.61% - 51.35% moderate deepbite(N=18) - 41.56% severe deepbite(N=7)

Figure 5. The overbite values in deep bite studies [10,20,46,48,49].

Two studies analyze open bite correction and one of these evaluates the efficiency of posterior occlusal bite blocks (POBBs) in overbite correction, while one study compares the use of optimized attachments with conventional attachments [45,49].

No statistically significant differences were found in overbite correction efficiency among POBBs, optimized attachments and conventional attachments.

Only one study specified the protocol adopted to correct the open bite and the author revealed a statistically significant difference between the absolute and the relative extrusion demonstrating greater efficiency in the overbite correction through the mechanism of absolute extrusion [47].

Five studies investigated deep bite correction [10,20,46,48,49]. One study compared patients treated with EX30 material to those treated with SmartTrack combined with bite ramp material [10]. Two studies focused on overbite correction in patients treated with SmartTrack material, one study analyzed the differences in deep bite correction between patients treated with optimized versus conventional attachments and, in one study, traditional attachments were applied to all patients [20,46,48,49]. None of the included studies reported significant difference or improvements in treatment outcomes associated with the use of the EX30 material, the bite ramp, conventional attachments, or optimized attachments.

Only two studies described the specific correction mechanism for deep bite [48,49]. One study adopted the incisor intrusion combined with the incisor intrusion and premolar extrusion [48]. One study recorded anterior intrusion, posterior extrusion, and relative extrusion [49]. Both studies reported no statistically significant differences; however, one study noted greater extrusion in the molar region compared to incisor intrusion.

3.1. Meta-Analysis

We quantified the difference between the virtual plan (T2(CC)) and the clinical outcome (T3(R)) in terms of overbite correction. To assess the discrepancy across studies, separate random effects meta-analyses were conducted for each group to account for inter-study heterogeneity across the studies and to obtain estimates with 95% confidence intervals.

In the deep bite group (N = 246), the mean difference between T2(CC) and T3(R) was -1.61 mm [95% CI: $-1.87, -1.35$], which indicates an overestimation of treatment efficacy by the software. τ^2 was 0.022 and the I^2 was 26.2%. These data suggest a low-moderate variability among the five studies [10,20,46,48,49].

In the open bite group (N = 162), a mean difference of 1.08 mm was observed [95% CI: 1.00, 1.16], indicating that the overbite predicted by the software was greater than the clinically achieved overbite. Notably, heterogeneity was negligible ($I^2 = 0\%$, $\tau^2 = 0.000$), reflecting highly consistent result across the two included studies [45,47]. Figure 6 summarizes these results graphically.

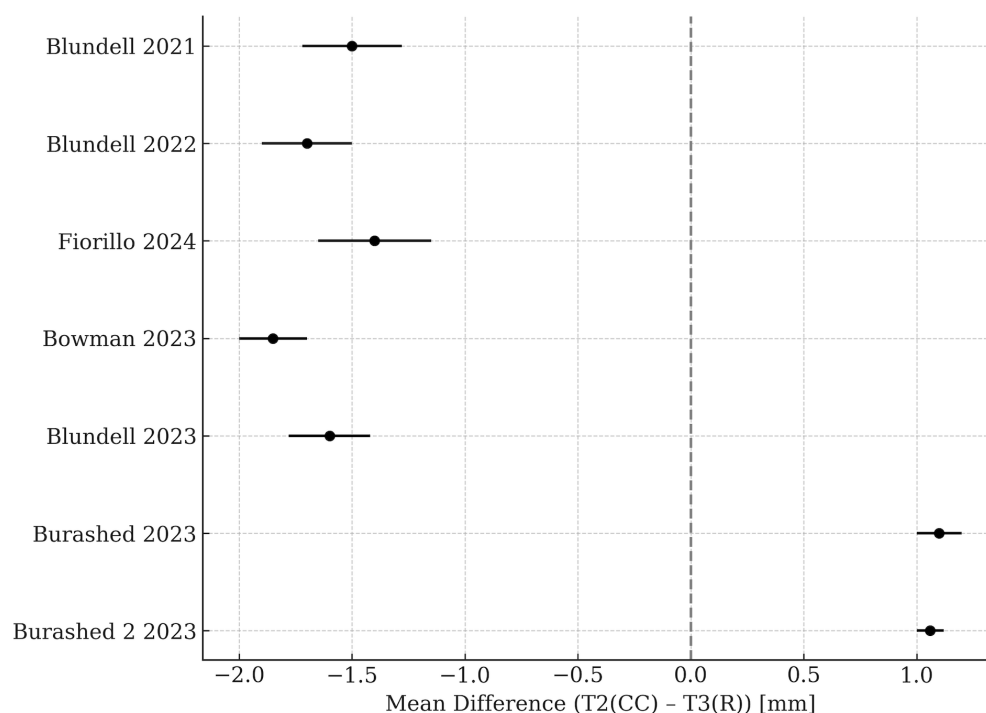


Figure 6. Forest plot showing the differences between T2(CC)-T3(R) for each study (open bite and deep bite). The black dot represents the mean difference expressed in mm between T2(CC) and T3(R); the horizontal bars indicate 95% confidence intervals [10,20,45–49].

3.2. Quantitative Assessment of Overbite Correction

For each study, the mean overbite was analyzed at three timepoints: T1, T2(CC) and T3(R) [10,20,46,48,49]. The weighted mean overbite measurements were as follows:

- T1: 4.39 mm (SD: 0.37; 95% CI: 4.34–4.44 mm);
- T2(CC): 1.62 mm (SD: 0.25; 95% CI: 1.59–1.65 mm);
- T3(R): 3.24 mm (SD: 0.18; 95% CI: 3.21–3.26 mm).

The actual correction obtained T1-T3(R) was 1.15 mm, while the planned correction (T1-T2(CC)) was 2.77 mm, resulting in an effective correction rate of the overbite of 41.5% [45,47].

The weighted mean overbite for open bite studies was as follows:

- T1: −1.28 mm (SD: 0.19; 95% CI: −1.31, −1.25 mm)
- T2(CC): 1.58 mm (SD: 0.08; 95% CI: 1.56–1.59 mm)
- T3 (R): 0.49 mm (SD: 0.10; 95% CI: 0.48–0.51 mm).

The actual correction obtained was 1.77 mm compared to a planned correction of 1.86 mm, yielding a correction rate of 62.1% [45,47].

Figures 7 and 8 show the mean overbite data at T1, T2(CC) and T3(R), both in open bite and deep bite groups.

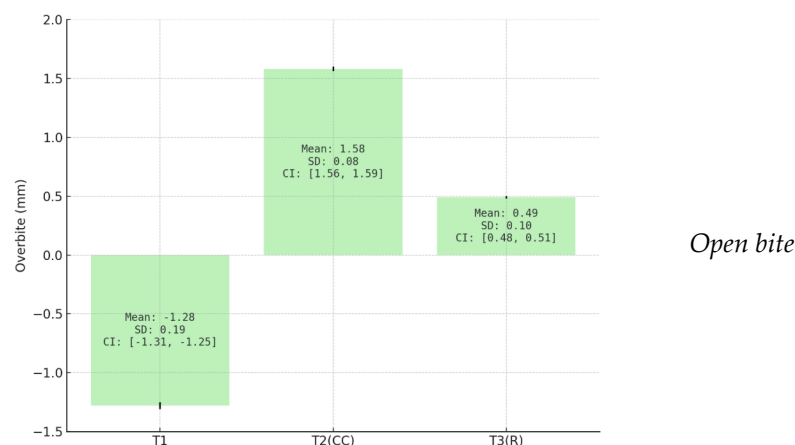


Figure 7. The bar charts report the mean overbite values in open bite patients at three time points: T1, T2(CC), T3(R). At T1, patients presented a negative mean overbite (−1.28 mm). At T2, the software predicted a positive correction (1.58 mm), whereas the actual outcome recorded at T3 was 0.49 mm. These findings indicate that the software tends to overestimate the extent of overbite correction, despite the relatively high consistency across the included studies ($I^2 = 0\%$).

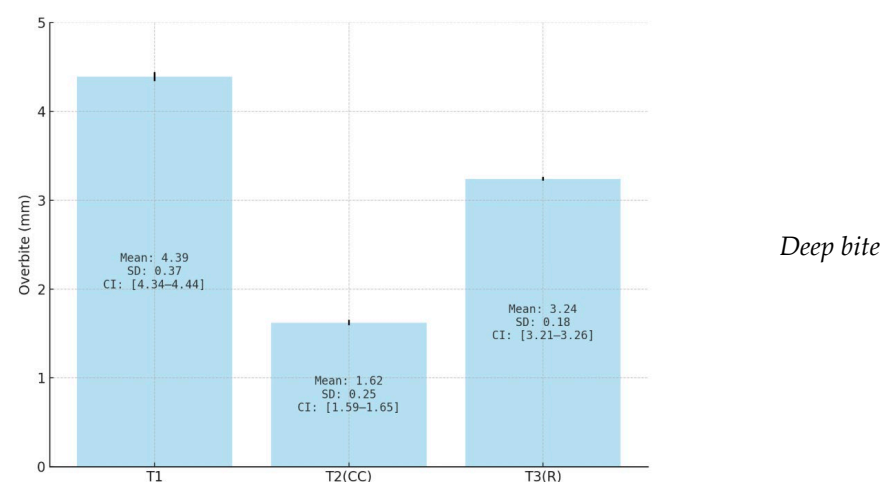


Figure 8. The bar charts illustrate the evolution of the mean overbite in deep bite patients across T1, T2(CC) and T3(R). Bars indicate mean values. At T1 the mean overbite was 4.49 mm, at T2 the software programmed a final overbite of 1.62 mm and at T3(R) the overbite achieved was 3.24 mm. Despite this, heterogeneity among studies was low–moderate ($I^2 = 26.2\%$), indicating partially consistent outcomes.

4. Discussion

Aligners offer several advantages, including in esthetics and oral hygiene, in comparison to conventional fixed appliances. In response to increased requests by patients,

orthodontists have increasingly used aligners in clinical practice. As aligners grow in popularity, it is prudent to understand how ClinCheck can predict and provide reliable data.

This systematic review aims to assess the reliability of virtual planning in managing vertical discrepancies with clear aligners, with particular emphasis on the divergence between the overbite correction predicted by ClinCheck at T2(CC) and the clinical outcomes observed at T3(R). Five out of seven studies analyzed and measured overbite values using the Geomagic 3D System software, while two studies utilized ClinCheck software. Both ClinCheck and Geomagic 3D System software are representations of the force system used by the Invisalign appliance. Meade et al. found that the discrepancy values for overbite and overjet measured at baseline and those predicted by ClinCheck showed high agreement with the measurement obtained using the Geomagic 3D software system [42]. This supports the utility of Invisalign predictability data in guiding clinicians to recognize potential limitations of the system and apply overcorrections when necessary to achieve the desired treatment outcomes [52].

All studies included in this systematic review focused on overbite correction in adult patients, eliminating the potential confounding factors related to craniofacial growth. Furthermore, all studies involved experienced orthodontists, ruling out clinician experience as a source of variability. Two studies did not specify the gender distribution on their sample, whereas four studies showed a predominance of female participants, in line with the demographic profile commonly observed among patients undergoing aligner therapy [53]. A concordance between T2(CC) and T3(R) was observed for open bite correction. The Invisalign system was found to be both effective and predictable for open bite and one study reported that anterior extrusion is the main mechanism of correction [47]. The findings reported by Burashed et al. contrast with those of other authors, who have indicated that anterior extrusion is the primary mechanism responsible for open bite closure [18,39,54]. Conversely, other studies have observed greater posterior intrusion, documenting approximately 0.4 mm of upper molar intrusion and 0.6 mm of lower molar intrusion [34]. Intrusion of the molars may contribute to bite closure by promoting mandibular autorotation. When this biomechanical effect is paired with the extrusion of anterior teeth, it frequently facilitates effective resolution of bite discrepancies in numerous clinical cases. According to Blundell et al., there is no scientific evidence confirming the efficacy of posterior occlusal bite blocks (POBBs) in promoting posterior dental intrusion [55]. Deep bite correction, on the other hand, is less predictable and there is a lack of consensus regarding clinical strategies involving posterior extrusion and anterior intrusion. Consequently, this systematic review is intended to investigate the reliability of the bite opening mechanism. The results revealed a low concordance between T2(CC) and T3(R).

Only two authors clearly outlined the specific role of each mechanism; however, a comprehensive description of the intrusion and extrusion movements was not provided. Only Fiorillo et al. reported greater accuracy in the extrusion of lower molars compared to the anterior intrusion, although this difference was not statistically significant [49]. Similar findings have been reported by other studies, with a mean intrusion accuracy of 45%. Furthermore, Grunheid et al. also concluded that the anterior intrusion predicted by the aligner treatment plan was not fully realized in clinical outcomes [19,25,56]. The relative intrusion is evaluated in only one study, which confirmed that the overbite correction accuracy improves when incisor proclination is planned. The use of bite ramps did not improve the overbite correction, a finding that contrasts with the overbite correction of 1.3 mm achieved by Heinick et al. [13].

For both open bite and deep bite correction, current evidence does not demonstrate the superior effectiveness of either optimized or traditional attachments. Only two studies specify the type, the sizes and the position of attachments on teeth whereas one study

merely stated the use of traditional attachments without further detail [47–49]. Two studies found no significant differences between conventional and optimized attachments [47,48].

Bates et al. reported that most orthodontists prefer traditional attachments and, as previously documented, the use of attachments may enhance vertical tooth movement [57,58]. A recent systematic review concluded that the attachments could improve aligner biomechanics, and they should therefore be considered important auxiliary elements of aligner therapy [59].

No study has investigated the influence of skeletal pattern, although the literature suggests that brachyfacial patients are more resistant to deep bite correction, just as dolichofacial patients are in open bite cases [60].

Additionally, various biomechanical strategies can impact treatment efficiency. One such method, commonly referred to as “frog staging”, involves sequencing the intrusion of anterior teeth to enhance predictability. In this protocol, the intrusion is performed in alternating phases, initially targeting the lower canines, followed by the incisors, then returning to the canines and incisors in a staggered manner depending on the clinical scenario. While this approach increases the total number of aligners and prolongs treatment duration, it enhances control by allowing one group of teeth to serve as anchorage while the other undergoes movement.

Several clinicians recommend using 4-mm rectangular horizontal attachments at the premolar level and 5 mm attachments at the canine level. When extrusion is planned at the premolar level, the attachments are beveled gingivally [61,62]. Similarly, factors such as proclination, class II elastics or anchorage design and overengineering the final set up might influence predictability [63,64].

To our knowledge, this is the first systematic review and meta-analysis providing a quantitative assessment of ClinCheck software accuracy in overbite correction, stratified by open and deep bite groups. These results may offer valuable insights for clinicians in planning and adjusting aligner treatments for improved overbite control.

5. Conclusions

- The correction of deep bite predicted by the ClinCheck software overestimates the correction achieved clinically.
- There is a concordance between the ClinCheck prediction and the actual outcomes for open bite correction.
- The application of posterior occlusal bite blocks and traditional attachments appears to exert minimal influence on the success of open bite closure.
- The lack of standardized protocols for staging and biomechanics likely contributes to the variability observed in deep bite treatment outcomes. Overengineering the final set up and incorporating planned overcorrections may be necessary to reduce the discrepancy between the virtual plans and the clinical results.

6. Limitations

This review is limited by the retrospective design of the included studies and the lack of long-term follow-up data. All authors concluded their investigations at the initial refinement stage without assessing the stability of the corrections achieved. Furthermore, heterogeneity in the software used (ClinCheck and Geomagic 3D), type of attachments and variability in reporting quality limited the comparability of results. Finally, important patient-level variables such as compliance, gender and skeletal patterns were not reported.

Author Contributions: Conceptualization, M.B. and S.T.; methodology, S.C. and A.N.; software, T.L., G.O. and A.C.; formal analysis, A.B., A.G. and A.Z.; investigation, M.B. and S.C.; resources, M.B. and T.L.; data curation, M.B. and T.L.; writing—original draft preparation, M.B., T.L. and A.N.; writing—review and editing, A.N. and M.B.; visualization, S.T.; supervision, S.T.; project administration, S.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: The authors have reviewed and edited the output and take full responsibility for the content of this publication.

Conflicts of Interest: The authors declare no conflicts of interest.

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