



GRADUATION PROJECT

Degree in Dentistry

PREDICTABILITY IN OVERBITE CORRECTION WITH CLEAR ALIGNERS

Madrid, academic year 2025/2026

RESUMEN

Introducción: La sobremordida profunda es una maloclusión común que puede tener consecuencias funcionales y estéticas. Los alineadores transparentes como Invisalign se han convertido en una opción de tratamiento cada vez mas popular debido a su comodidad y estética, sin embargo, persisten dudas sobre la predictibilidad de los movimientos dentarios verticales necesarios para la corrección de la sobremordida; **Objetivos:** El objetivo de la investigación documental fue evaluar la predictibilidad de la corrección de la sobremordida con alineadores transparentes comparando los movimientos digitales planificados con los resultados clínicamente obtenidos. Los objetivos secundarios fueron comparar la corrección de la sobremordida planificada y la obtenida, identificar los factores que influyen en la predictibilidad y evaluar los movimientos dentarios necesarios en la corrección de la sobremordida; **Métodos:** Se realizó una revisión de literatura disponible en las siguientes bases de datos: Medline complete, PubMed, AJO-DO, incluyendo estudios que evaluaban la predictibilidad de la sobremordida con alineadores, el aplanamiento de la curva de Spee y los movimientos dentarios verticales con alineadores; **Resultados:** Se incluyeron en total de 12 estudios. La predictibilidad de la corrección de la sobremordida osciló aproximadamente entre el 33,35% y el 61% en 7 de los estudios incluidos, siendo la reducción de la sobremordida obtenida consistentemente menor que la planificada en el set up digital. Se observaron mayores discrepancias en casos con mayor sobremordida inicial y en casos de extracciones. Los estudios que evaluaron los movimientos dentarios verticales mostraron que la intrusión anterior es un componente importante de la corrección de la sobremordida, mientras que la extrusión posterior menor predictibilidad; **Conclusiones:** La corrección de la sobremordida profunda con alineadores es posible, pero su predictibilidad sigue siendo moderada. La planificación digital del tratamiento, generalmente mediante Clincheck, tiende a sobreestimar la cantidad de reducción que puede lograrse clínicamente. Factores como la severidad inicial de la sobremordida y la complejidad del tratamiento influyen en el resultado. Es necesario una planificación cuidadosa del tratamiento, incluyendo estrategias de sobre corrección y la expectativa de fases de refinamiento.

PALABRAS CLAVES

Odontología, Sobremordida, Invisalign/alineadores, Curva de Spee, Predictibilidad.

ABSTRACT

Introduction: Deep overbite is a common malocclusion that can have functional and aesthetic consequences. Clear aligner such as Invisalign has become an increasingly popular treatment option due to the comfort and aesthetics however, concerns remain regarding the predictability of vertical tooth movements needed in overbite corrections; **Objectives:** The aim of this documental research was to evaluate the predictability of overbite correction with clear aligner by comparing the predicted digital movements with the clinically achieved outcomes. Secondary objectives were to compare planned and achieved overbite correction, to identify factors influencing predictability and to evaluate the tooth movements needed in overbite correction; **Methods:** A review of the available literature was done on the following databases: Medline complete, PubMed, AJO-DO, including studies that evaluated overbite predictability with aligner, curve of Spee levelling and vertical tooth movements with aligners; **Results:** A total of 12 studies were included. The predictability of overbite correction ranged from approximately 33.35%-61% in 7 of the included studies with the achieved overbite reduction consistently lower than the amount planned in the digital setup. Greater discrepancies were observed in cases of increased initial overbite and in extraction cases. Studies evaluating vertical tooth movements showed that anterior intrusion is an important component of overbite correction, whereas posterior extrusion demonstrated lower predictability; **Conclusions:** Deep bite correction with aligners is possible, but its predictability remains moderate. Digital treatment planning usually through Clincheck tends to overestimate the amount of reduction that can be clinically expressed. Factors such as initial overbite severity and treatment complexity influence the outcome. A careful treatment planning, including overcorrection strategies and the expectations of refinement stages is often required.

KEYWORDS

Dentistry, Deepbite, Invisalign/aligner, Curve of Spee, Predictability.

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1. INTRODUCTION

Overbite is a common term used within dental professionals and specially orthodontist's referring to the vertical distance between the incisal tips of the maxillary incisors respective to the mandibular incisors (1). An excessive overbite or a deep overbite could occur based on dental factors, skeletal factor or a mixture of these two (2). It is important to note that deep overbite isn't a disease, but rather a clinical manifestation of the underlying dental or skeletal disorder (3). However, it is very important to identify these underlying factors for a better treatment plan and hence better treatment outcome.

An untreated deep overbite can cause temporomandibular joint disorder, abnormal mandibular function, attrition of the lower incisors and ulceration of the gingival tissue (4). In severe deep overbite a loss of the maxillary tooth can also occur due to the harm against the periodontium (5). Furthermore, malocclusions could possibly affect dentofacial aesthetics and psychosocial self-confidence, which may negatively influence quality of life (6). These are some consequences of why malocclusions shouldn't be left untreated.

Over the past few decades clear aligners has gained a significant popularity as a response to the increasing aesthetic and comfort demands of adult wanting orthodontic treatment (7). Clear aligners are based on a sequential and digitally guided approach, in a way where the needed orthodontic tooth movements are virtually planned on a three-dimensional model of the patient's malocclusion. As a next phase, a series of custom-made thermoplastic aligners is manufactured to progressively achieve the desired dental movements (8).

Although the popularity of clear aligners continues to grow, its efficacy has been questioned. As studies have shown a significant discrepancy between the predicted and achieved results (9,10).

1.1 Vertical relationship

Overbite as itself isn't something pathological as the normal values should be between 1-2mm (1). A non-pathological or normal overbite is also defined when the upper incisor crowns overlap not more than one third of the lower incisors crowns (11). However, an increased overbite of more than 4mm would be a serious malocclusion called deep bite or deep overbite (12). Moreover, overbite can be measured in a percentage and a proportion related to how much of the inferior crown's height is covered, and deep overbite is diagnosed when we have a

coverage beyond 40%. The values between 25-40% can be normal if the temporomandibular joint presents no functional problems (3). Deep bite is associated with sagittal molar relationship, and it has been found more recurrent in the class II population (13). The deep bite associated with class II division 2, also known as “cover bite”, it is considered one of the worst manifestations of the condition (5).

inclination of the maxillary and the mandibular incisors have a direct influence on the overbite severity. Greater incisor proclination is generally associated with a reduced overbite, whereas an increased retroclination of the incisors tends to produce a deeper overbite and thus a more severe malocclusion (9).

On the other hand, open bite is another malocclusion related to the vertical relationship. It is identified when we have values of less than 0mm or explained in other words when the upper incisors don't overlap the lower incisors and thus having an open bite in maximal intercuspation (6,12).

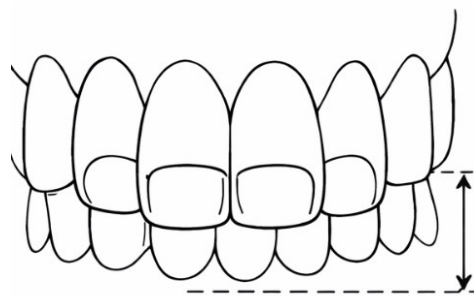


Figure 1. Deep overbite

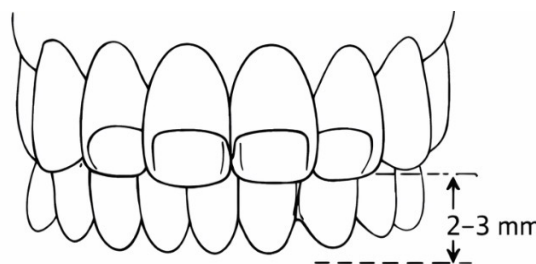


Figure 2. Normal overbite

1.2 Prevalence

Deep overbite is a challenging and common malocclusion, and it is affecting around 15-20% of the American population (13). According to an article, deep overbite of more than 5mm or also referred as severe deepbite have been found in approximately 20% of children and of 13% of adults, constituting 95.2% of malocclusions related to the vertical plane (4). Based on a

systematized review and meta-analysis, the prevalence of deepbites in permanent dentition worldwide has been found to be 27,6%, while in primary dentition 25.2% (6).

1.3 Skeletal deep overbite

The skeletal predispositions to deep bites are a decrease in the gonial angle and a counterclockwise growth pattern (14). The features a skeletal deep overbite is frequently associated with are as following, growth discrepancies between the maxilla and mandible, convergent rotation of the jaw bases, and reduced height of the mandibular ramus. Consequently, the lower third of the face is typically decreased in the vertical dimension (3).

A key skeletal characteristic of deep bite malocclusion as previously stated is a reduced gonial angle, which is strongly associated with a hypodivergent facial growth pattern. This craniofacial pattern promotes a forward and upward mandibular rotation, reducing the lower anterior facial height. This decreased vertical dimension results in the mandible positioning closer to the maxilla, hence increasing the overbite and incisor overlap. According to Bhateja et al. found that 43% of patients with deep bite presented a reduced gonial angle, being the most prevalent skeletal factor in their sample of 106 patients (4).

Furthermore, previous studies suggest that vertical growth component have a greater influence on overbite variation, outweighing the effect of mandibular rotation. Additionally the impact of skeletal changes within the mandible is estimated to be about twice as significant as of dentoalveolar changes in the same region and approximately 2.5 times more significant than alterations affecting the maxillary bone (15).

1.4 Curve of Spee

The curve of Spee originally described by Ferdinand Graf Von Spee in 1890, it is referred to the natural curvature going from the mandibular canine through the buccal cusps of the posterior teeth until the second molar, forming a mandibular concavity and maxillary convexity (16). The depth of the curve of Spee has an important role in the diagnosis and treatment of malocclusions (17). To achieve a stable occlusion and proper excursive movements, the curve of Spee should present a mild and balanced configuration (18).

Leveling an accentuated curve of Spee represents one of the most frequently employed treatment strategies in an orthodontic approach (13). The leveling of the curve of Spee features different treatment strategies such as, intrusion of the incisors or extrusion of the posterior

segment or a mixture of the last two (13,17). Furthermore, levelling an excessive curve of Spee is one of the most common treatment objectives in cases with deep overbite (2,17).

In cases of both dental and skeletal deep overbite malocclusions, the mandibular incisors frequently are up righted and overerupted, and they are commonly associated with an increased curve of Spee (5).

1.5 History of Clear aligners

Clear aligners were officially introduced into the orthodontic practice following the FDA approval of Align technology's Invisalign system in 1998, the concept of using removable appliances to guide tooth movements started many years earlier. Dr. Harold Kesling in 1946 developed the "tooth positioner" and this was one of the first predecessors of modern aligner therapy (19). This laid the foundation for the evolution of clear aligner therapy.

The release of the Invisalign system by Align technology was the first orthodontic appliance that used computer aided design (CAD) and computer aided manufacturing (CAM). This new system made it possible to generate multiple sequential tooth-setups from one single initial impression, unlike traditional technique is not required new impression for new movements, hence greatly improving the efficiency and standardization in treatment planning (20,21). Another important development are the introduction of the three- dimensional (3D) printing into the system (22). This workflow begins with generating a 3D digital model of the dentition from intraoral or scanned impressions, then computed based algorithms segment each crown, allowing the software to display the treatment plan as series of gradual tooth movements. For each of the planned stages, physical models would be manufactured using rapid-prototyping techniques (23).

In 2013 Align technology group replaced the stiffer EX30 material in favor of SmartTrack. This updated material for the aligners was developed to better replicate the force characteristics of nickel titanium arch wires, while the previous EX30 had been behaving more like conventional stainless steel arch wire (24). SmartTrack material is made of several thermoplastic polyurethane sheets, the inner layer are more formable and softer, this provides a better fit of the plastic on the attachment and teeth (5). Furthermore, SmartTrack new material had an increased control of the tooth movements and is also more comfortable for the patients according to an in-house study at Align technology (25).

According to align technology, the SmartTrack material demonstrates greater flexibility and elasticity and hence provides a more consistent force delivery than the previous single layered Exceed- 30 material (EX30). These improved mechanical properties are reported to improve the predictability of tooth movement by around 75%(5).

1.5.1 Invisalign software

Clincheck® is the software Align technology groups uses for the planning of the treatments, it provides the clinicians the ability to review and modify tooth movements, determine the need for interproximal reduction, and design composite-resin attachments. These adjustments are done until a satisfactory digital treatment plan is made. Any needed modifications to the treatment plan can be done directly via Clincheck or indirectly through an Align technician. The aligners are printed and sent to the clinician, once the clinician has checked and approved the treatment plan through Clincheck (26,27).

Other aligners systems such as Spark aligner and Angle aligners also have different software's, but the current studies and article are not available at this moment in time.

1.5.2 Predictability

The success and reliability of orthodontic treatment can be affected by multiple factors. These include differences in how individual patients respond biologically, the patient's adherence to wearing aligners as instructed, the experience and skill level of the treating clinician, and the mechanical limitations of the aligners in performing the intended tooth movements precisely. Together, these variables can lead to differences between the treatment predicted in the digital setups and the actual clinical results, hence outcomes are not entirely guaranteed (28).

The predictability of orthodontic tooth movements means the difference between the planned and the achieved movement and this remains a challenge for all clear aligner systems. Low predictability is when there is an achievement of less than 50% of the planned movement, while moderate is between 50-75% and lastly achieved movement of more than 75% of the planned movement is defined as high predictability (29).

The correction of a deep bite is seen as unpredictable in the literature, and it is considered a challenging movement to achieve with aligner. It is important to state that several case reports have demonstrated that deep bite can be corrected successfully. The reported predictability of the overbite control shows 33-46% in non-extraction cases (29).

Several authors have stated that mesio-distal tipping is the most reliable movement to achieve, while on the other hand extrusion and rotations are the least predictable movements to achieve. In general, the precision of clear aligners induced movements ranges between 55% to 72%, but the canine rotation usually shows a lower accuracy, often less than 36% (8).

According to Krieger et al. found that vertical tooth movements are more difficult to accomplish with clear aligners than transverse and sagittal movements. Krieger also reported that the most challenging to predict and manage with clear aligners are overbite correction, due to difficulties in achieving the wanted movements (30)

Multiple refinements are needed in cases when the predicted tooth movements are not achieved, which can extend the treatment duration and increase the risk of patient's burnout. Additionally, the uncertainty around the predictability of wanted movements makes it challenging to establish an adequate and realistic treatment objective and manage the patient's expectation (29).

1.5.3 Attachments

Attachments in clear aligners were developed to increase the mechanical grip of the aligner on the teeth and to facilitate movements that would otherwise have been difficult or unpredictable to achieve (19). The composite attachments are placed on the vestibular surfaces of the teeth, aside of increasing the retention and transmitting the adequate force to the tooth, it also supports auxiliary functions for instance as placement of elastics (31) . The design of attachments has advanced massively, going from generic shapes to patient-specific configurations made to produce exact needed movement on designated teeth (32).

1.5.4 Bite Ramps

Clinical observations during clear aligner therapy shows that molar extrusion is usually prevented when aligners are worn continuously. This is called the "bite effect" and it refers to that the teeth are constrained within the aligner, and the continuous occlusal forces applied throughout the day helping restricting extrusion of posterior teeth (14). This is prevented by implementing the "bite ramps".

Correction of the deep bite could be achieved by extrusion of the posterior teeth. An important component to this approach is the elimination of the occlusal interferences. This is accomplished by incorporating bite ramps or also called lingual prominences on the palatal surfaces of the upper incisors or canines, placed near the cingulum, which will remove the occlusion of the posterior teeth and promote the intrusion (10).

1.5.5 Tooth movements for the correction of overbite

The tooth movements needed to treat a deep overbite consist of the following, extrusion of the posterior teeth, intrusion of the anterior teeth, a mix of the last two and proclination of incisors (33). The treatment plan will also consider the exposure of the incisors in the smile. In a patient with deep bite presenting a gingival smile, the intrusion of the upper incisors would be recommended. On the other hand, if no gingival smile is present, it would be better to produce a great intrusion of the lower incisors and an extrusion of the posterior segments (2).

The extrusion of premolars and molars is the preferred treatment for the overbite reduction, and the extrusion of the buccal parts is important in brachyfacial patients having an accentuated curve of Spee and normal or a small upper incisor display when smiling (5,34). This is also indicated in growing patients as it is very favorable and stable, provided the freeway space remains unaffected. On the other side the stability for adults is less certain, because of stronger muscle force and augmented occlusal stress (5,34).

The PICO question for this documental research is: How predictable is overbite correction achieved with clear aligner therapy when compared to the virtual treatment plan?

2. OBJECTIVE

2.1 Primary objective

The primary objective of this documental research was to evaluate the predictability of deep bite correction with clear aligner therapy by comparing the planned digital movements with the clinically achieved outcomes.

2.2 Secondary objectives

- To compare the planned and achieved overbite correction reported in the included studies
- To identify factors that may influence the predictability of deep bite correction with clear aligners.
- To evaluate tooth movements involved in overbite correction, including anterior intrusion and posterior extrusion.

3. MATERIAL AND METHODS

3.1 Study design

This review focuses on the predictability of overbite reduction in patients with deep overbite treated with clear aligners, comparing the outcomes obtained with the virtual treatment plan with those clinically achieved.

3.2 Eligibility criteria

To guarantee that only studies with scientific validity and direct relevance to the research topic were incorporated, some inclusion and exclusion criteria were established prior to the article selection process.

Inclusion criteria	Exclusion criteria
Human patients with deepbite/overbite malocclusion	Studies involving fixed appliances or mixed therapies where the effect of aligners could not be isolated
Treatment with clear aligners/Invisalign	Articles not reporting clinical outcome values related to overbite correction
Assessment of predictability of overbite/ curve of Spee correction, comparing planned vs achieved movements	Non- orthodontic or unrelated topics
Articles from the last 10 years	Older than 10-year articles
Clinical studies, retrospective studies,	Case reports (n=1), Systematized reviews
Articles published in English	Articles in other languages than English

Table 1. Inclusion and exclusion criteria applied in this study.

3.3 Information sources and search strategies

A structured bibliographic search was done in the following databases: Medline complete, PubMed, American journal of orthodontics & dentofacial orthopedics (AJO-DO). The access to Medline complete was through the European university of Madrid online library. Boolean operators were used to combine keywords that are useful for this research such as (overbite OR Deep bite OR curve of Spee) AND (aligner OR clear aligners OR Invisalign) AND predictability. The final search was done 4 of February 2026.

3.4 PRISMA chart

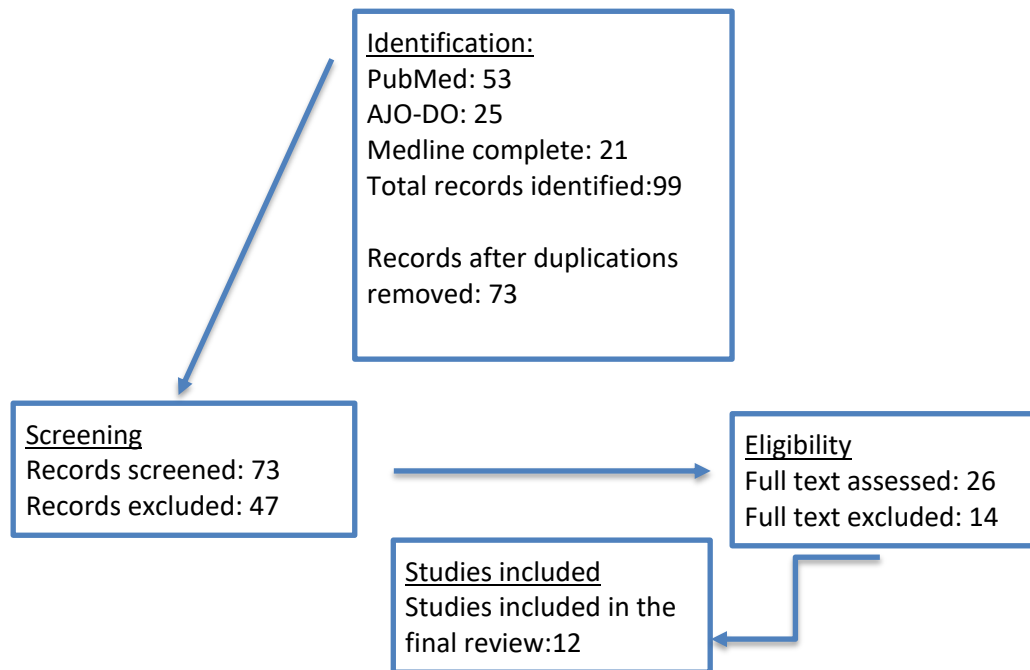


Figure 3. Study selection with the PRISMA chart.

4. RESULTS

4.1 Predictability of overbite correction

A total of 7 studies evaluating the predictability of overbite correction with clear aligners. Sample sizes ranged from 24 patients up to 355 patients. The studies reported outcomes using different measurement approaches. 6 studies presented absolute overbite values at different treatment stages, including initial, planned and achieved overbite. 4 studies reported the planned and achieved amounts of overbite correction. 3 of the studies reported both types of value and all the studies reported the predictability of the planned movements.

Study	Type	Sample	Initial OB	Planned OB	Achieved OB	Predictability (%)
Blundel et al., (2021) (25)	Retro-spective	42 adults	3,9mm	1,9mm	3,3mm	39.2%
Blundel et al., 2024 (35)	Retro-spective	102 adolescents	4,72mm	0.83mm	3,89mm	41.38%
Shahabuddin et al., 2023 (36)	Retro-spective	24 adults	5.20mm			33.35%
Jin et al., 2025 (37)	Retro-spective	24 deepbite patients	4,6mm	-1,9mm	1,3mm	52.2%
Pham et al., 2025 (38)	Retro-spective	31 adults	3,98mm	1.21mm	3.29mm	37.7%
Meade & Weir, 2024 (38)	Retro-spective	355 adults 282 planned with OB decrease. 200 non extraction cases.	3,8mm (Median for non-extraction cases)	1,4mm (Median for non-extraction cases)	2,7mm (Median for non-extraction cases))	45.83%
Dianiskova et al., 2024 (39)	Retro-spective	36	5.03mm	1.80mm	3.03mm	61%

Table 2. Predictability of overbite correction.

Study	Planned reduction	Achieved reduction	Predictability %
Blundel et al.,2021 (25)	3,89mm	1,61mm	39,2%
Blundel et al., 2024 (35)	-	-	41,38%
Shahabuddin et al.,. 2023 (36)	3,35mm	1,15mm	33,35%
Jin et al.,. 2025 (37)	6,4mm	3,3mm	52,2%
Pham et al.,.2025 (38)	-	-	37,7%
Meade & weir, 2024(27)	-	-	45.83%
Dianiskova et al., 2024 (39)	3.23mm	2mm	61%

Table 3. Overbite reduction and probability.

Table 2 display all the studies regarding predictability of overbite correction and the values referring to the overbite reported at the different stages, while **Table 3** display the planned reduction of the overbite and the achieved reduction of the overbite. Both tables display the amount of predictability percentages reported for each study.

Predictability percentages varied from the lowest reported 37,7% reported by Pham et al to the highest being 61% reported by Dianiskova et al.

As shown in the tables, the predictability of overbite reduction varied between the studies, and these findings demonstrate that the planned digital setup frequently overestimated the amount of overbite correction achieved clinically.

4.2 Factors influencing predictability of overbite correction

Several of the included studies evaluated variables associated with differences between predicted and achieved outcomes of overbite correction.

4.2.1 Patient related variables

Blundell et al., 2021 reported that the discrepancy between predicted and achieved overbite correction increased as the pretreatment overbite increased and as the amount of planned overbite reduction increased. In the same study, Clincheck overpredicted overbite reduction in 95,3% of patients (25).

In the adolescent study by Blundell et al., reported that age, bite ramps and an adoption of G8 protocol were not found to have a significant effect on the predictability of the planned movements. The author reported an average discrepancy of 0,49mm per 1mm increase in initial overbite. A difference of more than 1mm between the planned and achieved overbite was observed in 80.4% of patients in the study (35).

4.2.2 Treatment protocol

The study by Meade and Weir reported that the predictability of the planned reduction for the overbite correction in extraction cases was found to be 8,69% (27).

In the study of Shahabuddin 6 patients had undergone treatment with bite ramps, and the average overbite correction predictability was 38,4% and patients without bite ramps was 31,7% (36).

4.2.3 Treatment planning

In the study by Jin et al., all included patients were treated with an overcorrection design in which the final Clincheck position showed an anterior overbite. Factors increasing predictability was reported to be mild initial overbite, normal mandibular plane angle, class II elastics. A deep overbite and a steep mandibular plane angle were reported to decrease the predictability(37).

4.3 Mechanism contributing to overbite correction

Several studies evaluated the tooth movements needed for the reduction of overbite, including anterior tooth intrusion, posterior vertical tooth movements, and leveling the curve of Spee.

4.3.1 Anterior intrusion

Anterior tooth intrusion has been reported as a factor of deep overbite correction in several studies. A statistically significant differences were found between the predicted and achieved vertical movements and inclination changes of each tooth during treatment in the study of Shahabuddin et al. The largest discrepancy between predicted and achieved movement was seen for the maxillary central incisors. An average of 1,4mm of an intrusive movement were planned, but 0,41mm of extrusion happened for the maxillary central incisor. The mandibular incisors had an average predictability of 42,5% intrusion movement (36).

Study by Al-Baala et al, specifically evaluated the predictability of anterior intrusion movement in a CBCT-based study. Significant differences were observed between planned and achieved intrusion of maxillary and mandibular anterior teeth. The mean predictability of anterior intrusion was stated to be 51,19% (40).

A study assessing mandibular incisor intrusion reported limited predictability of planned vertical movement. In the study by Burns et al., had planned and 2,32mm of intrusion of the mandibular incisor, but clinically only 0,22mm of intrusion happened (41).

A prospective study by Haouili et al. evaluating general tooth movement accuracy with Invisalign reported a mean accuracy of 50%, but mandibular incisor intrusion and maxillary incisor intrusion had an accuracy of 34% and 33% (42).

4.3.2 Leveling of curve of Spee

Leveling a curve of Spee was reported as a component of overbite correction, as well as anterior intrusion. Goh et al evaluated the leveling of mandibular curve of Spee with Invisalign and reported that Clincheck overestimated the levelling by 0,55mm and the mean predictability was 35%. 1st molars were reported to have an actual change of 13% compared to the planned change of 41% of an extrusive movement in relative to initial depth and showed the lowest extrusion accuracy with 31% (43).

Lim et al evaluated the maxillary curve of Spee leveling and reported differences between predicted and achieved outcomes. Predicted intrusive movements was more accurate in the posterior sector, but planned extrusion had lower predictability, and an unintended intrusion was reported for the 1st molar and premolars. The authors stated that Clincheck underestimated the curve of Spee levelling of the maxillary arch by 46% (44).

5. DISCUSSION

A common factor throughout all the included studies is that the clinically achieved amount of overbite correction was lower than the amount of prescribed reduction in the digital setup. This indicates that the virtual treatment planning generally overestimated the amount of overbite reduction that could be expressed clinically. There is a considerable variability throughout the included studies, ranging from lowest predictability such as 33,35% in Shahabuddin et al. and 39,2% in the adult study by Blundell et al. to higher values such as 61% in Dianiskova and 52,2% in Jin et al (25,36,37). Despite these differences, the deep overbite is reduced with clear aligners, but the digital setup through Clincheck tend to prescribe a greater reduction than what was clinically possible to achieve.

An important point seen from the included studies is that the initial severity of the overbite appears to influence treatment predictability. In the adult study by Blundell et al., the discrepancy between the predicted and achieved overbite correction increased as pretreatment overbite increased and as larger the amounts of overbite reduction was planned. In the same study, Clincheck overpredicted overbite reduction in 95,3% of patients (25). In the adolescent study by Blundell et al., the difference between predicted and achieved overbite exceeded 1mm in 80,4% of patients, and the discrepancy increased by an average of 0,49mm for each 1mm increase in the initial overbite (35). These findings suggest that as the initial vertical discrepancy becomes larger, the amount of movement needed may exceed what can be expressed predictably by the clear aligner. In other words, the more severe overbite, the higher risk that Clincheck will overestimate the achievable reduction.

Treatment protocol appears to play an important role. Meade and Weir found that achieved overbite outcomes were significantly different from the predicted outcomes, as we have seen in the previous studies. Different to the previous studies, their important finding is notable in extraction cases, in which planned reduction of overbite achieved only 8,69% of the predicted reduction (27). This is one of the lowest values reported in the included studies and suggest that extractions may significantly reduce the predictability of overbite correction with aligners. These results are clinically relevant because they suggest that not all deep overbite cases respond in the same way to clear aligner treatment, resulting in a decreased ability to express the predicted overbite reduction.

On the other side, some variables that might be expected to affect the treatment outcome were not found to have a significant influence. In the adolescent Blundell et al., age, the use of bite ramps, and the use of the G8 protocol were not significantly associated with the discrepancy between predicted and achieved overbite reduction (35). This is an important finding because it suggests that the improvement of vertical control does not depend only on the usage of these specific auxiliaries. Although such auxiliaries may still be useful in selected cases, but the studies included in this review do not support that they consistently overcome the limitations of clear aligner biomechanics in deep overbite correction.

Overcorrection strategies were used in several of the included studies to improve the deep overbite the patients presented. Jin et al designed with purpose a final predicted anterior open bite and still the achieved overbite after treatment remained with a positive overbite on average (37). Similarly, Shahabuddin et al. concluded that overcorrection and refinements were needed in most deep overbite patients (36). The same tendency was also seen in the mandibular and maxillary curve of Spee study by Goh et al, and Lim et al., where the discrepancy between predicted and achieved posterior vertical changes suggest that an overcorrection and refinements are needed and the translation from planned to clinical outcome should not be expected (43,44). Together these findings support a treatment strategy in which the predicted outcome is not used as a literal prediction of the final occlusion, but rather as a plan that may require compensation to produce the final ideal results.

The overall pattern seen from the included studies is consistent with the literature showing that vertical tooth movement is one of the main limitations of clear aligner (36,40,42,44). Haouii et al. reported that an overall mean accuracy of 50% for tooth movement, but intrusion of the mandibular and maxillary incisors remained among the least accurate movements (42). Similarly, the study done by Al-Balaa et al., found a mean accuracy of 51,19% by using CBCT to assess the anterior intrusion, showing again that only a part of the planned intrusion was clinically expressed (40). These findings are relevant because deep overbite correction frequently depends on the ability to intrude the anterior teeth. If these movements are incompletely expressed, the planned outcome may present a final occlusion that is not fully achievable clinically.

Among the different tooth movements involved in deep overbite correction, several of the included studies emphasizes that anterior intrusion, particularly incisors, as a major component of overbite correction (36,37,40). Shahabuddin et al. reported a mean overbite correction accuracy of 33,35%, whereas only 1.15mm was achieved from the 3,35mm planned, and he found statistically significant differences between predicted and planned vertical movement and inclination change for all teeth. The same study reported the largest discrepancy was seen in

the maxillary central incisors, where an extrusion happened instead of an intrusive movement (36). This reinforces the difficulty of achieving the intended vertical correction with clear aligners. On the other side, Jin et al. and his study reported a more favorable clinical result, with a mean overbite reduction of 3.3mm and an overall intrusion accuracy of 52,2% (37). However, an important factor of this study was the use of an extreme overcorrection design, in which an anterior open bite was planned. These indicates that the achieved clinical correction was improved after programming a more extreme digital setup than the wanted clinical outcome. Another tooth movement important for the correction of a deep overbite is the posterior extrusion. The literature suggest that posterior extrusion is less predictable than anterior intrusion and this has important implications for the biomechanics of deep bite correction (45). If posterior extrusion cannot be expressed reliably, then the clear aligner treatment may depend even more on anterior intrusion and incisor inclination changes to reduce the overbite. In the mandibular arch Goh et al. reported a mean curve of Spee accuracy of 35%. The first molar showed the lowest extrusion accuracy relative to the occlusal plane (43). In the maxilla, Lim et al. also reported poor predictability of curve of Spee leveling and stated that Clincheck underestimated maxillary curve of Spee leveling by 46%, while also reporting that teeth programmed for extrusion frequently under expressed the intended movement and, in some regions, even intrusion happened despite extrusion being planned (44). This makes the treatment of a deep overbite even harder, as anterior intrusion is not that predictable either. Ultimately the findings of Dianiskova et al. provided an interesting comparison because that study evaluated both overbite reduction and curve of Spee leveling in the same study. The Authors reported an overbite reduction accuracy of 61% and a curve of Spee leveling accuracy of 62%, with the prescribed movements again exceeding the achieved outcomes (39). These findings may indicate that leveling a curve of Spee represents an important component of deep bite reduction, as both variables showed a similar degree of clinical expression.

Several limitations of the available literature should be considered. Firstly, there was a clear heterogeneity in study design and outcome reporting. Some studies reported initial, predicted and achieved overbite values, while others reported the planned and achieved correction, others reported curve of Spee leveling or intrusion accuracy rather than overbite reduction directly. This complicates the direct comparison. Secondly, most of the included studies were retrospective, which introduces usual limitations related to selection criteria, treatment variability and dependence of existing record. Thirdly, different methods were used to measure treatment effects, including Clincheck data, digital model superimposition, cephalometric analysis and CBCT and this may also contribute to variation.

Despite these limitations, the findings of this review have clear clinical relevance. This evidence suggest that clinicians should be cautious when interpreting digital set up with Clincheck as an exact predictor of the final outcome in deep overbite cases. Overbite correction with aligners shows clear improvements, but the amount of clinically expressed movement is usually smaller than the amount predicted. This is especially true in cases needing great vertical correction, posterior extrusion or in cases of extractions.

6. CONCLUSIONS

The present review indicates that clear aligners can reduce deep overbite, although the predictability of this reduction remains moderate. In all included studies the achieved amount of overbite reduction was significantly lower than the amount prescribed in the digital setup, suggesting that virtual treatment planning with Clincheck frequently overestimates the clinical expression of the overbite correction.

The reviewed evidence suggest that initial deep overbite severity, treatment complexity, and the amount of programmed correction may influence the predictability of the wanted treatment. More severe deep overbite cases and extraction cases appeared to show greater discrepancies between predicted and achieved outcomes. In addition, the reviewed evidence indicates that anterior intrusion is an important component of deep overbite correction with clear aligners, whereas posterior extrusion appears to be less predictable.

Overall, clear aligners can produce clinically meaningful improvement in deep overbite, however careful treatment planning, possible overcorrection and the expectation of refinement stages are often necessary to approach the desired outcome.

Further prospective studies with standardized outcome measures are needed to improve the understanding of the predictability of deep bite correction with clear aligners.

7. SUSTAINABILITY

Treatments with clear aligners has implications for sustainability due to the extensive use of plastic materials and the need for multiple aligners throughout the treatment. Limited predictability as shown by reduced efficacy in overbite correction, may require additional refinement stages and thus increasing the material consumptions, treatment time and cost (46). However, aligners improve the patient comfort and aesthetics, contributing positively to social sustainability (7). Future developments should focus on improving treatment efficiency and reducing the environmental impact.

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