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Prediction of overbite improvement in deep bite correction using clear aligner therapy

Thu-Trang Pham¹, Hong Thuy Pham Thi², Cao Binh Tran³, Ngoc Quang Dong⁴ and Viet Hoang⁵

Abstract

OBJECTIVES: This study aimed to determine the accuracy of overbite correction in patients with deep bite using the clear aligner therapy (CAT).

MATERIALS AND METHODS: This retrospective study included 31 patients prescribed orthodontic treatment using CAT from January 2020 to January 2024. Clinical information was collected via X-ray results at pre-treatment and post-treatment stages. Treatment outcomes were measured at three stages: pre-treatment, post-treatment (clinical results), and predict treatment (predict results) as programmed in ClinCheck®.

RESULTS: Significant changes were observed in X-ray in both overbite (3.85 ± 1.38 mm to 2.93 ± 1.13 mm) and overjet (5.19 ± 1.79 mm to 3.43 ± 1.14 mm) following CAT. For clinical crown lengthening (CCL) of tooth 31, significant differences were noted between pre-treatment and post-treatment (-0.31 ± 0.66 mm) and between predicted and clinical results (-0.21 ± 0.58 mm). For CCL of tooth 41, significant differences were found between pre-treatment and post-treatment (-0.36 ± 0.66 mm) and between prediction and post-treatment (-0.32 ± 0.65 mm). The percentage of deep bites differed significantly between pre-treatment vs predicted treatment ($38.10 \pm 14.90\%$), pre-treatment vs post-treatment ($11.80 \pm 14.30\%$), and predicted treatment vs post-treatment ($-26.40 \pm 12.60\%$). Similar trends were observed in mean overbite (2.77 ± 1.07 mm, 0.69 ± 0.93 mm, and -2.08 ± 0.83 mm, respectively).

CONCLUSIONS: Our findings support the use of CAT as a reliable and aesthetic option for treating deep bite malocclusions.

Keywords:

Accuracy, clear aligner therapy, ClinCheck®, overbite

Introduction

The application of digital technology in medicine, in general, and dentistry, in particular, has become increasingly robust, heralding an era of digitalization that enhances the ease and accuracy of diagnosis and treatment for doctors. The introduction of clear aligners (CAs) has significantly increased the popularity of orthodontic treatment among adult patients.^[1] In recent

years, orthodontic treatment with CA has become a trend due to its aesthetics and comfort.^[2] The treatment of orthodontic conditions with CA is also expanding, successfully addressing challenging cases such as deep bite correction.

As CA continues to develop and gain popularity, questions regarding the accuracy of their predictions persist. A review in 2024 demonstrated that aligner therapy is gaining acceptance in orthodontics, including its application in challenging cases, and highlights key factors that bolster

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¹Department of Orthodontics, National Hospital Odonto and Stomatology, Ha Noi, ²Department of Orthodontics, Hai Phong Medical University, Hai Phong, ³Department of High Technology, National Hospital Odonto and Stomatology, Ha Noi, ⁴Department of Plastic and Aesthetic Surgery, National Hospital Odonto and Stomatology, Ha Noi, ⁵Department of Orthodontics and Pedodontics, Faculty of Dentistry, Van Lang University, Ho Chi Minh City, Vietnam

Address for correspondence:

Dr. Thu-Trang Pham,
Department of
Orthodontics, National
Hospital Odonto
and Stomatology,
Ha Noi, Vietnam.
E-mail: trangpham368@
gmail.com

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its long-term efficacy.^[3] As the need for orthodontic treatment increases in adults and the treatment of deep bites becomes routine in orthodontic practice, clinicians need to understand the predictive ability of treatment simulations to effectively apply them in clinical practice.

Globally, numerous studies have assessed the accuracy of tooth movement with CA. For instance, a 2023 review confirmed that clear aligner therapy (CAT) is a safe, effective, and convenient orthodontic treatment that provides patients with a nearly invisible option for achieving a straighter, more attractive smile.^[4] With ongoing technological advancements and increasing research supporting its effectiveness, the future of CAT looks promising. A 2018 retrospective study conducted in Egypt aimed to evaluate changes in tooth length as an indicator of orthodontically induced tooth root resorption (OITRR) following high-frequency mechanical vibration (HFV) treatment alongside Invisalign Smart Track® aligners.^[5] Using cone beam computed tomography, the study found that patients treated with HFV showed minimal changes in tooth length, suggesting that HFV may help reduce OITRR when used with CA. Additionally, a cross-sectional study conducted in 2020 aimed to compare gingival parameters between CA treatment and three other types of brackets: conventional metal, conventional ceramic, and metal self-ligating.^[6] The study found that CA treatment resulted in better periodontal indices compared to the other orthodontic treatments, including conventional metal and ceramic brackets.

Overbite is considered an important aspect of occlusion, and it is well-known that orthodontic correction of a deep overbite is challenging. While there are many ways to correct a deep overbite using conventional orthodontics, the choice of biomechanics must be made on a case-by-case basis.^[7] Since the introduction of Invisalign, there has been conflicting evidence regarding the efficacy of Invisalign appliances in correcting deep overbite. A consensus exists that ClinCheck® models do not accurately reflect the patient's final occlusion upon completion of Invisalign treatment.^[8] Given these challenges and the growing interest in the effectiveness of CAT, this study aimed to determine the accuracy of overbite correction in patients with deep bite using the CAT with the Invisalign system.

Materials and Methods

Study design and study participants

This was a retrospective study that included 31 patients who were prescribed orthodontic treatment using CA from January 2020 to January 2024. Eligible patients met the following criteria: (1) age 18 years or older;

(2) presence of permanent teeth; (3) dual arch Invisalign® treatment in the first stage; (4) diagnosed with Class I or Class II malocclusion (Angle's Classification); (5) overbite > 1/3 length of crown lower incisor and (6) prescribed non-extraction Invisalign® orthodontic treatment.

Patients were excluded if they: (1) required auxiliary treatment (such as the use of vertical elastics, bite ramps, cross elastics, fixed appliances, TADs, or Carrier); (2) had interproximal enamel reduction performed; (3) required orthognathic surgery, or restorative occlusal/anterior buildups (Cephalometric: ANB > 8°); (4) had deep overbites greater than 8 mm; (5) required extraction orthodontic treatment; (6) required additional aligners; (7) had a mental disorder; or (8) had a cleft lip or palate or syndrome-associated orofacial malformations.

Study measures and instruments

For each subject included in this study, the following characteristics were recorded: age and gender of the patient; number of aligner trays; and duration of treatment with aligner therapy. The clinical information was collected via X-ray results at the initial and after-treatment stages. For treatment outcomes, data were gathered on clinical crown lengthening (CCL) of teeth 11, 21, 31, and 41; the overbite tooth from 11 to 21 and from 31 to 41; the percentage of deep bite (% deep bite); and the mean overbite. These indicators were measured at three stages: initial results (before treatment), predicted results (ClinCheck®), and achieved results (after treatment).

Study analysis

For descriptive statistical analysis, the mean and standard deviation (SD) values were used to compute quantitative variables, while the number and percentage were used to calculate qualitative variables. To validate the effectiveness of CAT in clinical outcomes, paired *t*-tests were used to compare the differences in clinical information obtained from X-ray results at the initial (pre-treatment) and achieved (post-treatment) stages. For comparing the predictive accuracy of ClinCheck® with clinical results, multiple paired *t*-tests were also used to compare the differences in treatment results between predicted (ClinCheck®) and achieved (clinical) outcomes. The ClinCheck® models of the predicted and achieved outcomes, obtained from Align Technology®, were compared using Pearson correlation. Differences were defined as statistically significant if the *P* value was < 0.05. The collected data were transferred to Microsoft Excel version 2016 and subsequently imported into STATA version 16 software (Stata Corp LLC, College Station, TX, USA) for analysis.

Ethical statement

The research was approved by the Scientific Committee Board of the National Hospital of Odonto-Stomatology (No 1070/QD- BVRHMTW 12/10/2023 and No 1233/QD- BVRHMTW 16/11/2023). All participants provided written informed consent after being thoroughly informed about the objectives of the study. Participants had the right to decline participation at any point. Patient information was coded to ensure confidentiality, and both paper surveys and computerized datasets were securely stored.

Results

Participants' characteristics

A total of 31 patients participated in our study with a mean age was 30.5 (SD = 6.14) years, and more than 60% of participants were female [Table 1]. More than half of them are under 30 years old. The average aligner trays used for each patient was 37.3 (SD = 10.6) trays with more than 50% of patients using 40 and under trays. The mean treatment time of our study population was around 9 months.

Effectiveness of clear aligner therapy (CAT) in clinical outcomes

There were some differences in the X-ray results between before and after the treatment [Table 2]. Significant changes were observed in both overbite and overjet measurements following the CAT. Post-aligner therapy, patients exhibited an increased U1 to SN measurement compared to pre-treatment values. Additionally, reductions were noted in U6-PP, U1-PP, and L1-MP after the treatment. Both the lower and upper lip to E-plane measurements significantly declined post-therapy.

Table 1: Demographic characteristics of study participants

Demographic characteristics n (%)	Total (n=31)
Age (years)	
Mean (SD)	30.5 (6.14)
≥ 30 years	17 (54.8)
<30 years	14 (45.2)
Sex	
Male	12 (38.7)
Female	19 (61.3)
Number of aligners (aligners)	
Mean (SD)	37.3 (10.6)
≤ 40 aligners	16 (51.6)
>40 aligners	15 (48.4)
Treatment time (months)	
Mean (SD)	9.31 (2.64)
≤ 10 months	16 (51.6)
>10 months	15 (48.4)
Type of treatment	
Comprehensive	26 (83.9)
Moderate	5 (16.1)

Comparing the predictive accuracy of ClinCheck® with clinical results

The treatment outcomes reveal various clinical parameters at the initial, predicted, and achieved stages, along with the accuracy, differences, and statistical significance [Table 3]. For clinical crown lengthening of teeth 11, the measurements at the initial, predicted, and achieved stages were very close, with a strong correlation and statistical significance. The accuracy was high, with a negligible difference between the predicted and achieved results. For teeth 21, the measurements at all three stages were nearly identical, showing high accuracy and a strong correlation, with no significant difference between the predicted and achieved results. For teeth 31 and 41, the initial measurements were lower than the achieved measurements, but the predicted results were close to the achieved ones, indicating high accuracy. Both showed strong correlations and statistically significant differences.

Regarding overbite for teeth 11 to 41 and 21 to 31, the predicted measurements were much lower than the initial and achieved ones. The achieved results were closer to the initial measurements, indicating lower accuracy in prediction but a strong correlation. The differences between predicted and achieved results were statistically significant. The percentage of deep bites initially was much higher than the predicted percentage. The achieved percentage was closer to the initial percentage, indicating lower predictive accuracy but still a strong correlation. The difference between predicted and achieved results was statistically significant. Finally, the mean overbite showed similar trends, with predicted measurements significantly lower than the initial and achieved ones. The achieved results were closer to the initial measurements, indicating lower predictive accuracy but a strong correlation and statistically significant differences.

Discussion

Our study evaluated the accuracy of overbite correction in patients with deep bites using the Invisalign system in Vietnam. The results provide insights into the impact of using the Invisalign system to predict the clinical outcomes of stomatology treatment. Among the 31 patients studied, there was a significant improvement in clinical results in the deep bite for participating patients. Furthermore, the difference between the predicted outcomes on ClinCheck® with clinical outcomes was quite small, around 2 mm, suggesting a significant accuracy of using the Invisalign system for stomatology treatment in Vietnamese patients.

For the difference between pre and post-treatment results, comparing to the study in Pennsylvania (2023), which found that mean overbite correction was 33%, with

Table 2: X-ray results among pre and post-treatment of study participants

X-ray results Mean (SD)	Initial (n=31)	Achieved (n=31)	Different (n=31)	P
Overbite (mm)	3.85 (1.38)	2.93 (1.13)	0.92 (1.14)	<0.001
Overjet (mm)	5.19 (1.79)	3.43 (1.14)	1.75 (1.66)	<0.001
SNA (°)	82.5 (3.96)	82.6 (3.23)	-0.15 (3.30)	0.81
SNB (°)	78.7 (3.73)	78.9 (3.37)	-0.25 (3.02)	0.65
ANB (°)	3.83 (2.57)	3.73 (2.44)	0.11 (1.35)	0.67
SN to maxillary plane (°)	9.32 (3.38)	9.22 (3.36)	0.10 (2.37)	0.82
Gonial angle (°)	115 (5.35)	114 (6.02)	0.43 (2.58)	0.36
Mandibular plane angle (°)	21.4 (5.36)	21.5 (5.18)	-0.07 (2.33)	0.87
U1 to SN (°)	109 (8.09)	104 (8.04)	4.35 (7.80)	0.004
IMPA (mm)	100 (8.21)	99.9 (7.76)	0.22 (5.13)	0.81
RFH (mm)	95.7 (3.74)	95.4 (4.25)	0.31 (2.93)	0.56
U6-PP (mm)	19.9 (3.81)	18.8 (5.11)	1.06 (2.75)	0.04
U1-PP (mm)	27.0 (6.48)	25.2 (7.10)	1.88 (3.39)	0.004
L6-MP (mm)	29.0 (6.05)	28.3 (8.11)	0.772 (4.23)	0.32
L1-MP (mm)	39.2 (8.36)	37.1 (10.8)	2.11 (5.12)	0.029
Lower lip to E-plane	1.53 (2.76)	0.794 (2.16)	0.74 (1.78)	0.028
Upper lip to E-plane	0.54 (2.54)	0.06 (2.07)	0.47 (1.27)	0.047
Nasolabial angle (°)	84.8 (11.7)	83.9 (11.6)	0.89 (9.85)	0.62
Anterior facial height (mm)	113 (22.6)	108 (29.6)	5.22 (15.0)	0.06
Lower anterior facial height (mm)	62.1 (13.3)	59.6 (16.8)	2.50 (8.54)	0.11
Lower AFH ratio	53.2 (1.77)	53.6 (1.80)	-0.38 (1.18)	0.08
UFH	53.2 (10.5)	50.4 (13.8)	2.81 (6.97)	0.030

Table 3: Treatment outcomes

Measurement	Initial	Predicted	Achieved	Predicted and achieved		Accuracy (%)	Difference	
	Mean (SD)	Mean (SD)	Mean (SD)	Correlation	P	Mean (SD)	Mean (SD)	95% CI
Clinical lengthening crown teeth 11 (mm)	9.24 (0.65)	9.28 (0.57)	9.23 (0.69)	0.90	<0.001	101 (3.33)	0.05 (0.31)	-0.06 to 0.16
Clinical lengthening crown teeth 21 (mm)	9.27 (0.83)	9.28 (0.78)	9.29 (0.78)	0.87	<0.001	100 (4.31)	-0.01 (0.40)	-0.16 to 0.14
Clinical lengthening crown teeth 31 (mm)	7.27 (0.98)	7.37 (0.76)	7.58 (0.67)	0.68	<0.001	97.3 (7.27)	-0.21 (0.58)	-0.43 to -0.001*
Clinical lengthening crown teeth 41 (mm)	7.25 (0.79)	7.28 (0.72)	7.61 (0.84)	0.66	<0.001	96.2 (7.98)	-0.32 (0.65)	-0.56 to -0.08*
Overbite 11-41 (mm)	4.07 (1.20)	1.24 (0.53)	3.33 (1.12)	0.62	<0.001	38.1 (13.20)	-2.09 (0.90)	-2.42 to -1.76*
Overbite 21-31 (mm)	3.87 (1.17)	1.18 (0.46)	3.20 (1.06)	0.53	0.002	39.8 (18.00)	-2.02 (0.91)	-2.35 to -1.69*
% deep bite	55.0 (15.70)	16.9 (6.60)	43.2 (15.50)	0.60	<0.001	40.9 (14.90)	-26.40 (12.60)	-30.99 to -21.72*
Mean overbite (mm)	3.98 (1.13)	1.21 (0.48)	3.29 (1.06)	0.66	<0.001	37.7 (11.00)	-2.08 (0.83)	-2.39 to -1.78*

*Statistically significant

a 1.15 mm improvement after the first set of aligners, the findings in our study were lower in both indicators, with 11.8% and 0.69 mm respectively.^[9] The reason might be due to that the initial overbite study participants in our study were quite smaller than the Pennsylvania study, 3.85 (SD = 1.38) mm compared with 5.20 (SD = 0.95) mm. Furthermore, the reference study also demonstrated that all teeth of participants had significant differences between planned and achieved amounts in vertical movement and inclination change, which was quite similar findings in our study.

Effectiveness of clear aligner therapy in clinical outcomes

The significant changes observed in both overbite and overjet measurements post-therapy indicate the

reliability of using CAT, particularly with Invisalign's ClinCheck® digital treatment-planning facility. A similar study conducted in Australia in 2024 also found significant changes in overbite and overjet using Geomagic Control X software to compare pre-treatment and predicted outcomes.^[10] The authors concluded that the changes from the initial to the predicted treatment outcome with Invisalign's ClinCheck® are valid and reliable.

One of the most notable findings in our study was the decreased U1 to SN measurement post-treatment with CAT. This finding aligns with results from a 2024 study in Saudi Arabia.^[11] In that study, 62 participants with Class I skeletal patterns and mild crowding were divided into groups treated with CA (Invisalign) and

conventional metal brackets. The study found that upper incisal palatal root torque decreased after CAT, with U1-SN changing from 106.19 ± 7.57 mm pre-treatment to 101.83 ± 5.97 mm post-treatment. This suggests that the upper incisors were effectively proclaimed and repositioned, contributing to the correction of the deep bite. Proclination of the upper incisors is desirable in deep bite cases as it helps reduce the overbite and improve the overall occlusal relationship.

The reductions in U6-PP, U1-PP, and L1-MP measurements reflect the vertical movements of these teeth during treatment. However, our findings differ from a 2017 study conducted in the USA.^[12] The US study measured multiple indicators between pre- and post-treatment of CA therapy to evaluate the vertical effects of non-extraction treatment in adults with anterior open bites. The authors found statistically significant differences in L1-MP, but no differences in U6-PP and U1-PP indicators. These differences might be due to our study focusing on patients with an overbite $> 1/3$ length of crown incisor and overbite between 0-8 mm, while the reference study recruited patients with no vertical overlap between the upper and lower incisors, with edge-to-edge canines deemed acceptable. These findings suggest that CAT effectively controls the vertical dimension of the occlusion, which is crucial for achieving a stable and functional bite. The vertical repositioning of the upper and lower molars and incisors helps to distribute occlusal forces more evenly, reducing the risk of relapse and enhancing long-term treatment stability.

The significant decline in both lower and upper lip to E-plane measurements post-therapy indicates improved facial aesthetics as a result of the treatment. Our findings differ from those of a 2020 study in the United States, which evaluated the effects of CAT on upper airway dimensions and daytime sleepiness in eight adults with dentoskeletal Class II malocclusion.^[13] This study found no statistically significant difference in the distances of the lower and upper lip to the E-plane after therapy. This discrepancy might be due to the reference study focusing on patients with Angle Class II division 1 malocclusion, a first-molar relationship of end-to-end or greater, overjet < 10 mm, and those presenting for multi-arch comprehensive orthodontic treatment with aligners, which are quite different from our study population.

Comparing the predictive accuracy of ClinCheck® with clinical results

Our study highlights that ClinCheck® predictions align closely with actual clinical outcomes, although significant discrepancies in some areas suggest opportunities for improvement in treatment planning and execution. For instance, significant differences observed in clinical crown lengthening (CCL) between initial and achieved

results indicate that ClinCheck® effectively anticipates treatment progress and outcomes.

Significant differences observed in CCL between pre-treatment and clinical outcomes, as well as between pre-treatment and predicted outcomes, suggest that ClinCheck® effectively anticipates treatment progress and final results. For example, the significant changes in the overbite measurements from teeth 11 to 41 and 21 to 31 across the three stages demonstrate that ClinCheck® provides reliable predictions for correcting overbites. Our findings are consistent with research conducted in Saudi Arabia in 2023, which evaluated the accuracy of ClinCheck® before and after Invisalign treatment.^[14] That study found significant differences in upper and lower crowding among 206 patients who underwent dual-arch CAT exclusively with Invisalign. Additionally, a 2019 retrospective study in the USA involving 30 consecutively treated patients showed that high-frequency vibration, used alongside CA, enabled early aligner changes, leading to shorter treatment times in cases of mild to moderate crowding.^[15] These findings underscored the importance of incorporating advanced tools like ClinCheck® in orthodontic planning to achieve predictable and efficient treatment outcomes.

Furthermore, the differences in the clinical lengthening of crown of teeth 41 between the predict treatment and post-treatment stages indicate that certain individual tooth movements may not be perfectly predicted. These discrepancies may arise due to biological variations, patient compliance, or limitations in the ClinCheck® software's ability to model complex tooth movements accurately. The limitations of the software were highlighted in a 2023 study in Italy, which analyzed the orthodontic outcomes of 79 patients and demonstrated that the predictability of orthodontic movement with aligners still has limitations related to the biomechanics of the system.^[16] These include the shape of some attachments and the characteristics of aligner material that need to be redefined. Additionally, a 2022 review of commonly used orthodontic materials found that clinicians should be mindful of material aging and its impact on treatment outcomes, emphasizing the need for careful monitoring to achieve effective and predictable results.^[17]

Overall, the predictive accuracy of ClinCheck® in our study is generally high and aligns closely with actual clinical results in many cases. However, orthodontists must remain vigilant for potential discrepancies and be prepared to adjust treatment plans as necessary.^[18-20] By combining digital treatment planning with proactive clinical management,^[21] the effectiveness of Invisalign therapy can be maximized, ensuring high levels of patient satisfaction and successful treatment outcomes.

Study limitations

The retrospective nature of the study and the relatively small sample size may limit the generalizability of the findings. Future research with larger sample sizes and prospective study designs is needed to confirm these results. Additionally, long-term follow-up studies are necessary to evaluate the stability of the treatment outcomes achieved with Invisalign.

Conclusions

Our study demonstrates that CAT, particularly with Invisalign's ClinCheck® digital treatment-planning facility, is effective in correcting deep bites and improving occlusal relationships. Significant improvements were observed in overbite, overjet, and vertical dental measurements post-treatment. The decrease in U1 to SN measurements and reductions in U6-PP, U1-PP, and L1-MP measurements highlight the therapy's ability to control tooth movements both horizontally and vertically. The overall effectiveness of CAT in enhancing facial aesthetics and achieving stable, functional bites is evident. These findings support the use of CAT as a reliable and aesthetic option for treating deep bite malocclusions.

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Conflicts of interest

There are no conflicts of interest.

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