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Dentoalveolar changes associated with deep bite correction using invisalign aligners

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Abstract:
Deep bite correction with clear aligners depends on vertical tooth movements that are often less predictable than planned. Therefore, it is of interest to evaluate dentoalveolar changes and ClinCheck predictability in 42 adults treated with Invisalign and precision bite ramps. Overbite decreased from 4.82 ± 0.91 mm to 2.06 ± 0.74 mm ($p < 0.001$), mainly via mandibular incisor intrusion, proclination and posterior extrusion. Overbite predictability was 47.3%, with incisor intrusion least predictable (35.1–38.6%) and no significant skeletal change. Thus, Invisalign corrects deep bite mainly dentoalveolarly and overcorrection, refinements or TADs should be planned in severe cases.

Keywords: Deep bite, clear aligners, Invisalign, dentoalveolar changes, incisor intrusion, predictability, ClinCheck

Background:
Deep bite, defined as an excessive vertical overlap of the maxillary incisors over the mandibular incisors, is one of the most common vertical malocclusions, with reported prevalence ranging from 15% to 20% in adult populations **[1].** Untreated deep bite is associated with palatal trauma, accelerated incisor wear, temporomandibular dysfunction, periodontal damage and unfavourable smile esthetics, making its correction a clinically meaningful objective **[2].** The biomechanical strategies used to open a deep bite depend on its etiology. Dentoalveolar deep bites are typically managed through anterior intrusion, posterior extrusion, incisor proclination or a combination of these movements, whereas skeletal deep bites may require growth modification or orthognathic surgery in addition to dental compensation **[3].** With fixed appliances, deep bite correction has historically relied on continuous arch wires, reverse curves of Spee, utility arches, anterior bite turbos or miniscrew supported intrusion mechanics **[4].** Since the introduction of the Invisalign system (Align Technology, San Jose, CA, USA) in 1998, clear aligner therapy (CAT) has gained widespread acceptance among orthodontists and patients due to its esthetic advantages, improved oral hygiene and reduced emergency visits **[5].** However, vertical tooth movement's particularly true intrusion and controlled extrusion is historically reported as the least predictable movements achievable with aligners, with accuracy frequently below 50% **[6].** In response, Align Technology has progressively refined its deep bite protocols. The G5 protocol introduced optimized attachments and precision bite ramps for posterior disocclusion, the G6 protocol focused on improved Class II mechanics and the G8 Smart Force Aligner Activation protocol, released in 2021, allowed tooth specific calibration of anterior enmasse intrusion **[7]**. Despite these advances, the literature continues to describe overbite reduction with Invisalign as primarily dentoalveolar in nature, with limited skeletal effect and an average clinical expression substantially below the planned correction **[8].** Although several studies have evaluated the efficacy of clear aligners for deep bite correction, heterogeneity in protocols, sample composition and measurement methods has produced variable estimates of incisor intrusion, posterior extrusion and the relative contribution of each movement **[9].** Therefore, it is of interest to evaluate the dentoalveolar changes associated with deep bite correction using invisalign aligners with precision bite ramps and the SmartForce deep-bite protocol in adult patients and to compare achieved tooth movements with those planned in ClinCheck; and to assess the relative contribution of intrusion, extrusion and incisor inclination changes to overall overbite reduction.

Materials and Methods:
The study was carried out in accordance with the principles of the Declaration of Helsinki and informed consent was obtained from all patients at the time of treatment for the use of anonymized records in research. Records of consecutive adult patients treated between January 2021 and December 2024 with Invisalign aligners were screened. A sample size calculation,

based on a previous study reporting a mean overbite reduction of 1.5 mm with a standard deviation of 0.8 mm, indicated that a minimum of 38 subjects was required to detect a clinically meaningful difference of 0.5 mm in overbite at α = 0.05 and power = 0.80. To allow for potential dropouts, 42 patients were finally included. Inclusion criteria were: (i) age ≥ 18 years at treatment start; (ii) pre-treatment overbite ≥ 4 mm; (iii) non-extraction treatment with Invisalign aligners incorporating precision bite ramps and the G6/G8 SmartForce Aligner Activation deep-bite protocol; (iv) availability of high-quality pre-treatment (T1) and post-treatment (T2) lateral cephalograms and digital models; and (v) completion of the first series of aligners with no more than two refinement series. Exclusion criteria were: (i) skeletal Class II or Class III malocclusion requiring orthognathic surgery; (ii) prior orthodontic treatment; (iii) craniofacial syndromes or cleft lip/palate; (iv) moderate-to-severe periodontitis or significant alveolar bone loss; (v) use of temporary anchorage devices (TADs); and (vi) incomplete records. All patients were treated by orthodontists trained and experienced in clear aligner therapy. Digital intraoral scans (iTero Element, Align Technology) and cone-beam computed tomography or lateral cephalograms were obtained at T1. Treatment planning was performed using ClinCheck Pro software (Align Technology), with the SmartForce Aligner Activation deep-bite protocol activated and 1.5–3.0 mm precision bite ramps placed on the lingual surface of the maxillary incisors. Optimized vertical attachments were assigned to mandibular canines and premolars to support intrusion and rotation control. Aligners were changed every 7–10 days according to the prescribing clinician. Refinement scans were performed at the end of the initial series when residual overbite remained ≥ 1 mm above the planned outcome. Pre- and post-treatment lateral cephalograms were digitized using the same software (Dolphin Imaging 11.95, Dolphin Imaging & Management Solutions and Chatsworth, CA, USA) by a single operator blinded to treatment time point. The reference planes included the sella-nasion (SN), palatal (PP), mandibular (MP) and functional occlusal plane (OPA). The following linear variables were measured (mm): overbite (OB), overjet (OJ), maxillary incisor edge to palatal plane (U1-PP), mandibular incisor edge to mandibular plane (L1-MP), maxillary first molar mesiobuccal cusp to palatal plane (U6-PP), mandibular first molar mesiobuccal cusp to mandibular plane (L6-MP) and lower facial height (ANS-Me). Angular variables (°C) included: SNA, SNB, ANB, mandibular plane angle (SN-MP), maxillary incisor to SN (U1-SN), incisor mandibular plane angle (IMPA) and the occlusal plane angle (OPA). Achieved tooth movements were compared with planned movements by superimposing the final ClinCheck stage on the post-treatment intraoral scan using the palatal rugae and stable mandibular structures as references, following established protocols **[16]**. Predictability for each movement was calculated as (achieved value / planned value) × 100%. To assess intra-examiner reliability, 20 randomly selected cephalograms were retraced two weeks after the initial measurement. The interclass correlation coefficient (ICC) exceeded 0.92 for all variables, indicating excellent reliability. Data were analyzed using SPSS version 28.0 (IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test was used to assess normality. Paired t-tests were used for normally distributed variables and the Wilcoxon signed-rank test was used for non-normally distributed data, to compare T1 and T2 values. Pearson or Spearman correlations were used to examine relationships between dentoalveolar changes and total overbite reduction. Statistical significance was set at $p < 0.05$.

Results:

A total of 42 patients (28 females, 14 males; mean age 27.6 ± 6.4 years; range 18–46 years) were included in the final analysis. Mean total treatment time, including refinement, was 18.4 ± 5.2 months, with a mean number of 38.5 ± 9.1 aligners delivered. No patient required treatment discontinuation and no clinically significant root resorption (> 2 mm) were detected on post-treatment radiographs. Cephalometric Changes (T1–T2) Statistically significant changes were observed in 9 of 13 measured variables (Table 1). The mean overbite decreased from 4.82 ± 0.91 mm at T1 to 2.06 ± 0.74 mm at T2, corresponding to a mean reduction of 2.76 ± 0.83 mm ($p < 0.001$). Overjet decreased by 0.84 ± 0.59 mm ($p < 0.001$). Mandibular incisor intrusion (L1-MP) was the largest dentoalveolar contributor, with a mean decrease of 1.18 ± 0.46 mm ($p < 0.001$), accompanied by labial inclination (ΔIMPA = +3.4°C ± 2.1°C, $p < 0.001$). Maxillary incisor vertical position (U1-PP) showed a smaller but statistically significant change of 0.54 ± 0.39 mm of intrusion ($p < 0.001$), while U1-SN demonstrated mild retroclination (–1.2°C ± 1.8°C, $p = 0.014$). Posterior teeth showed mild but significant extrusion: L6-MP increased by 0.92 ± 0.51 mm ($p < 0.001$) and U6-PP increased by 0.41 ± 0.44 mm ($p = 0.002$). The occlusal plane angle (OPA) decreased by 1.6°C ± 1.2°C ($p < 0.001$), reflecting flattening of the occlusal plane. Skeletal variables (SNA, SNB, ANB, SN-MP, ANS-Me) showed no statistically significant change **(Table 1).** Predictability values are summarized in **Table 2.** Overbite reduction showed an overall predictability of 47.3%, with mean planned reduction of 5.83 ± 1.12 mm and mean achieved reduction of 2.76 ± 0.83 mm. True mandibular incisor intrusion (L1-MP) achieved 38.6% of the planned value and maxillary incisor intrusion (U1-PP) achieved 35.1%. Mandibular molar extrusion exceeded its planned value (114.2%), suggesting some unintended bite-opening through posterior extrusion. Total overbite reduction correlated positively and significantly with mandibular incisor intrusion ($r = 0.62$, $p < 0.001$), mandibular incisor proclination ($r = 0.41$, $p = 0.007$) and mandibular molar extrusion ($r = 0.38$, $p = 0.013$). Maxillary incisor intrusion showed a weaker association ($r = 0.29$, $p = 0.061$). No significant correlation was observed between overbite reduction and changes in mandibular plane angle ($r = 0.11$, $p = 0.482$), suggesting that vertical correction was predominantly dentoalveolar.

Table 1: Cephalometric variables at T1 (pre-treatment) and T2 (post-treatment) (n = 42)

Variable	T1 (mean ± SD)	T2 (mean ± SD)	Δ (T2–T1)	p-value
OB (mm)	4.82 ± 0.91	2.06 ± 0.74	–2.76 ± 0.83	< 0.001*
OJ (mm)	3.61 ± 1.04	2.77 ± 0.86	–0.84 ± 0.59	< 0.001*

U1-PP (mm)	28.34 ± 1.92	27.80 ± 1.86	–0.54 ± 0.39	< 0.001*
L1-MP (mm)	41.52 ± 2.31	40.34 ± 2.18	–1.18 ± 0.46	< 0.001*
U6-PP (mm)	22.06 ± 1.75	22.47 ± 1.71	+0.41 ± 0.44	0.002*
L6-MP (mm)	31.78 ± 1.94	32.70 ± 1.89	+0.92 ± 0.51	< 0.001*
U1-SN (°C)	104.6 ± 6.2	103.4 ± 5.9	–1.2 ± 1.8	0.014*
IMPA (°C)	93.8 ± 5.4	97.2 ± 5.7	+3.4 ± 2.1	< 0.001*
OPA (°C)	9.3 ± 2.6	7.7 ± 2.4	–1.6 ± 1.2	< 0.001*
SN-MP (°C)	31.8 ± 4.7	32.0 ± 4.5	+0.2 ± 0.6	0.082
ANS-Me (mm)	66.4 ± 4.2	66.7 ± 4.1	+0.3 ± 0.8	0.106
SNA (°C)	82.1 ± 3.4	82.0 ± 3.4	–0.1 ± 0.4	0.412
ANB (°C)	3.6 ± 1.9	3.5 ± 1.8	–0.1 ± 0.5	0.378

**Statistically significant ($p < 0.05$). OB, overbite; OJ, overjet; U1-PP, maxillary incisor edge to palatal plane; L1-MP, mandibular incisor edge to mandibular plane; U6-PP, maxillary first molar to palatal plane; L6-MP, mandibular first molar to mandibular plane; U1-SN, maxillary incisor to SN angle; IMPA, incisor mandibular plane angle; OPA, occlusal plane angle; SN-MP, mandibular plane angle; ANS-Me, lower facial height.*

Planned versus Achieved Movements

Table 2: Planned (ClinCheck) versus achieved tooth movements during deep bite correction (n = 42). Predictability calculated as (achieved/planned) × 100%

Movement	Planned (mean ± SD)	Achieved (mean ± SD)	Predictability (%)
Overbite reduction (mm)	5.83 ± 1.12	2.76 ± 0.83	47.3
Mandibular incisor intrusion (mm)	3.06 ± 0.74	1.18 ± 0.46	38.6
Maxillary incisor intrusion (mm)	1.54 ± 0.61	0.54 ± 0.39	35.1
Mandibular molar extrusion (mm)	0.81 ± 0.36	0.92 ± 0.51	114.2
Mandibular incisor proclination (°C)	4.6 ± 1.8	3.4 ± 2.1	73.9

Discussion:

This study evaluated the dentoalveolar changes associated with deep bite correction using Invisalign aligners in adult patients treated with the contemporary SmartForce deep-bite protocol and precision bite ramps. The null hypothesis was rejected, as statistically significant differences were observed between planned and achieved tooth movements for nearly all variables. Our findings confirm that Invisalign aligners produce overbite reduction primarily through dentoalveolar mechanisms-mandibular incisor intrusion, incisor proclination and modest posterior extrusion with minimal change in skeletal vertical parameters. The mean overbite reduction of 2.76 mm is consistent with the 1.5–3.0 mm range reported in recent prospective analyses of deep bite correction with aligners by Blundell *et al.* (2024) **[10]**. Mandibular incisor intrusion was the single largest contributor to overbite reduction, accounting for approximately 43% of the total change. This pattern is in line with the findings of Kravitz *et al.* (2024) **[11]**, who reported significant lower incisor intrusion and lower molar extrusion with deep bite and with Wang *et al.* (2025) **[12]**, who demonstrated effective bite opening at both dentoalveolar and skeletal levels with the G5 protocol and virtual bite ramps in adults with skeletal deep overbite. Importantly, our study shows that even with the more recent G8 SmartForce Aligner Activation protocol, the relative contribution of mandibular intrusion remains dominant, supporting the biomechanical rationale of using bite ramps to disclude posterior teeth and concentrate intrusive forces on the anterior segment. Maxillary incisor intrusion was statistically significant but small in magnitude (0.54 mm), echoing reports that anterior maxillary intrusion is among the least predictable movements with clear aligners **[9, 18].** The accompanying minor retroclination of upper incisors (–1.2°C) is a well-recognized side effect, geometrically bringing the incisal edge into a more occlusal position and partially masking true intrusion; this has been previously described in cephalometric analyses of aligner treated open and deep bite samples **[13]**. Posterior dentoalveolar extrusion was relatively modest (L6-MP +0.92 mm, U6-PP +0.41 mm) but contributed meaningfully to bite opening. Notably, mandibular molar extrusion slightly exceeded the planned value (predictability 114.2%), suggesting that with the use of bite ramps and disocclusion, posterior teeth may erupt or extrude beyond what is digitally programmed a phenomenon that should be carefully managed in patients with high mandibular plane angles to avoid undesirable backward rotation of the mandible **[14].** Skeletal vertical measurements (SN-MP, ANS-Me) showed no significant changes, consistent with studies reporting minimal skeletal effects of Invisalign in adult deep bite patients and predominantly dentoalveolar correction. These findings suggest that severe skeletal deep bites in non-growing patients may still require adjunctive miniscrew or orthognathic surgery rather than aligners alone **[15]**. The predictability of overbite reduction in this study (47.3%) was comparable to previous reports showing correction rates below 50%. This discrepancy between planned and achieved movements highlights the need for overcorrection in ClinCheck planning; possible refinement stages and adjunctive aids such as bite ramps, optimized attachments, or TADs in severe cases. It also emphasizes the importance of realistic patient communication regarding treatment duration and outcomes **[16, 17 and 19]**.

Conclusion:

Invisalign with precision bite ramps effectively reduced deep overbite in adults mainly through dentoalveolar changes, particularly mandibular incisor intrusion and proclination. Skeletal vertical dimensions remained largely unchanged, while the predictability of overbite correction was less than 50%, with anterior intrusion being the least predictable movement. Clinicians should therefore incorporate overcorrection, expect refinement aligners and consider auxiliaries or TADs in severe cases, while future prospective 3D studies with long-term follow-up are needed to confirm stability.

Conflict of interest:

The authors declare no conflict of interest related to this study.

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