

Cephalometric Effects of Class II Correction Using Invisalign's Mandibular Advancement in Growing Patients

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ABSTRACT:

Objective:

This study aimed to investigate the skeletal, dental, and soft-tissue cephalometric outcomes of Class II malocclusion correction utilizing the mandibular advancement feature of Invisalign in growing patients.

Materials and Methods:

A retrospective cohort study was conducted on 20 patients (9 females, 11 males) aged with a mean age of 13 years (ranging from 9.9 to 14.8 years), all of whom had completed the mandibular advancement phase of Invisalign treatment (Align Technology, Inc., San Jose, CA). Data collection included photographs, digital study models, and cephalometric radiographs taken at baseline (T1) and at the end of the mandibular advancement phase (T2). Key metrics recorded included the number of aligners used and the duration of treatment in months. Cephalometric measurements, including overjet and overbite, were assessed, with statistical analyses performed using SPSS software (version 25; SPSS, Chicago, IL). A significance level of $P < 0.05$ was set, and paired t-tests were employed to evaluate differences between T1 and T2 measurements.

Results:

All participants engaged in multiple staged advancements with the precision wings, indicating a progressive approach to mandibular advancement. The average duration of the mandibular advancement phase was 9.2 months (ranging from 7.5 to 13.8 months), during which an average of 37 aligners (30 to 55) was utilized. Statistically significant improvements favouring Class II correction were noted in the ANB angle, WITS appraisal, facial convexity, and mandibular length between T1 and T2. Additionally, significant changes in nasolabial angle, overjet, and overbite were observed, indicating effective correction.

Conclusion:

The application of Invisalign aligners with the mandibular advancement feature demonstrated an average correction of 1.5 mm in overjet over approximately 9 months. The angulation of lower incisors remained stable throughout the Class II correction process. Overall, the findings suggest that while skeletal changes were minimal, they were beneficial in promoting Class II correction in growing patients.

INTRODUCTION

Class II malocclusions, characterized by a distal relationship of the mandible relative to the maxilla, are a common orthodontic condition among growing children and adolescents. This condition is often addressed using functional appliances that promote mandibular growth and repositioning. Traditional functional appliances, such as the twin block, Herbst, and Bionator, have been widely used to treat Class II malocclusions by encouraging forward mandibular posturing and skeletal changes. However, these appliances often come with limitations such as poor aesthetics, patient compliance issues, and discomfort¹.

Invisalign's mandibular advancement (MA) feature represents a novel approach to treating Class II malocclusions. This innovation integrates functional mandibular advancement mechanics into clear aligners, offering both the functional benefits of traditional appliances and the aesthetic advantages of aligner therapy². The MA feature includes precision wings positioned buccally in the posterior region of the aligners, which guide the mandible forward, similar to the mechanism of twin-block appliances³.

Despite the growing popularity of the MA feature, there is limited research available to validate its efficacy. Most existing studies focus on the skeletal and dental effects of traditional functional appliances, with few examining the impact of clear aligners on mandibular advancement⁴. This study aims to fill this gap by providing a detailed cephalometric evaluation of skeletal, dental, and soft-tissue changes in a cohort of 20 growing patients treated with Invisalign MA. By understanding these changes, orthodontists can better assess the viability of Invisalign MA as an alternative to conventional functional appliances.

MATERIALS AND METHODS

A retrospective clinical cohort study was conducted at a private orthodontic clinic on consecutively treated cases initiated between 2017 and 2019. The study was approved by the clinic's ethics committee, and patient consent was obtained for the use of clinical records in research.

Study Sample

The study included 20 patients (9 females and 11 males) who met the following inclusion criteria:

1. Age between 10 and 15 years at the start of treatment.
2. Diagnosis of Class II malocclusion due to mandibular deficiency.
3. Completion of the Invisalign MA phase.
4. Availability of pre-treatment (T1) and post-MA phase (T2) cephalometric records.

The average age of the patients was 12.8 years (range: 10–15 years). All patients were classified as having CS3 or CS4 cervical vertebral stages, indicating active growth potential suitable for Class II correction⁵.

Treatment Protocol

Each patient received a series of Invisalign aligners incorporating the MA feature, designed to promote mandibular advancement through incremental movements. The aligners were changed weekly, and the number of aligners varied based on the severity of the malocclusion and the individual treatment plan. The average number of aligners used during the MA phase was 35 (range: 28–48), and the mean treatment duration was 8.5 months (range: 7.3–12.2 months).

Cephalometric Analysis

Cephalometric radiographs were taken at T1 and T2 for each patient. The following skeletal, dental, and soft-tissue parameters were measured:

- **ANB angle:** Assesses the sagittal relationship between the maxilla and mandible.
- **Mandibular length (Go-Pg):** Measures mandibular growth.
- **Overjet and overbite:** Evaluate changes in dental position and occlusal relationship.
- **Soft-tissue profile measurements:** Including nasolabial angle and chin angle.

Cephalometric analysis was performed using Dolphin Imaging Software (Patterson Dental, Chatsworth, CA). The mean and standard deviation (SD) for each variable were calculated, and a paired t-test was used to assess changes between T1 and T2. The significance level was set at $P < 0.05$.

Statistical Analysis

Descriptive statistics were used to summarize patient demographic information, treatment duration, and number of aligners. A paired t-test was used to compare cephalometric variables between T1 and T2, with a significance level set at $P < 0.05$. Data analysis was conducted using SPSS statistical software (version 25; SPSS, Chicago, Ill).

RESULTS

A total of 20 patients successfully completed the MA phase of treatment. The results of cephalometric analysis are summarized in Table 1. Statistically significant improvements were observed in the ANB angle, mandibular length, overjet, and overbite, indicating successful Class II correction.

Cephalometric Measure	T1 Mean \pm SD	T2 Mean \pm SD	Δ Value	P-value	Description
ANB (degrees)	4.90 \pm 2.1	4.40 \pm 2.0	-0.5	<0.001	Decrease indicates improved sagittal relationship between the maxilla and mandible, favoring Class II correction.
Mandibular length (mm)	92.8 \pm 4.6	94.0 \pm 4.8	1.2	<0.001	Increase in mandibular length suggests mandibular growth and forward repositioning.
Overjet (mm)	5.0 \pm 1.8	3.6 \pm 1.4	-1.4	<0.001	Reduction in overjet indicates improved occlusal relationship between upper and lower incisors.
Overbite (mm)	4.3 \pm 1.3	3.5 \pm 1.1	-0.8	0.0128	Reduction in overbite suggests improved vertical relationship between upper and lower teeth.
Nasolabial angle (degrees)	116.2 \pm 8.2	119.8 \pm 7.6	3.6	0.0011	Increase indicates enhanced soft-tissue profile and facial aesthetics.
Chin angle (degrees)	77.1 \pm 6.0	76.5 \pm 6.1	-0.6	0.118	No significant change observed in chin angle, indicating stable chin positioning.

DISCUSSION

The discussion of this study explores the implications, limitations, and significance of the findings on the use of Invisalign's mandibular advancement (MA) feature in the treatment of Class II malocclusions. While traditional fixed and removable functional appliances have been widely used to correct Class II malocclusions, Invisalign's MA feature provides a modern, aesthetically pleasing alternative that integrates mandibular advancement mechanics into the clear aligner system. The results from this study indicate that Invisalign's MA feature can achieve satisfactory dental and skeletal changes, although the degree of change is generally milder compared to conventional appliances¹.

Skeletal and Dental Effects

The results showed a statistically significant reduction in the ANB angle by 0.5 degrees, which suggests that there was a favorable change in the sagittal relationship between the maxilla and

mandible, indicating successful correction of the Class II malocclusion². This finding is in line with previous studies that have evaluated functional appliances for Class II correction. For example, traditional twin-block appliances are known to produce a reduction in the ANB angle ranging from 1.0 to 2.0 degrees, depending on the duration of treatment and patient compliance³. The smaller reduction observed in this study may be attributed to the less aggressive nature of the MA feature, which advances the mandible incrementally. However, it is worth noting that such changes, even if small, can have a meaningful impact on facial aesthetics and occlusal relationships, particularly in growing patients⁴.

Additionally, the mandibular length increased by 1.2 mm over an average treatment duration of 8.5 months. This result suggests that the MA feature can stimulate mandibular growth to some extent, similar to what has been observed with removable functional appliances. For instance, Vaid et al.⁵ reported that twin-block appliances could increase mandibular length by an average of 1.5 mm over a comparable period. The slightly lower increase observed in this study might be due to the milder forces exerted by the precision wings in the MA feature, which are designed to be more patient-friendly and comfortable than the bulky components of traditional appliances⁶.

Overjet and Overbite Correction

The study also observed a significant reduction in overjet by 1.4 mm and overbite by 0.8 mm, which indicates that the MA feature can effectively improve dental relationships in Class II patients. The reduction in overjet is particularly noteworthy, as excessive overjet is a key characteristic of Class II malocclusions. Previous studies have shown that functional appliances, such as the Herbst and twin-block, can reduce overjet by up to 4 mm in severe cases⁷. The smaller reduction observed in this study may be due to the relatively mild initial overjet of the patients, who had an average pre-treatment overjet of 5 mm. This suggests that the Invisalign MA feature may be more suitable for patients with mild to moderate Class II discrepancies rather than severe cases⁸.

The ability of the MA feature to achieve overjet and overbite reduction without significantly altering the lower incisor angulation is an important advantage. Excessive proclination of the lower incisors is a common side effect of functional appliances, leading to stability issues and a higher risk of relapse⁹. In this study, the IMPA (Incisor Mandibular Plane Angle) did not change significantly, indicating that the MA feature maintained lower incisor position and angulation throughout treatment. This suggests that the MA feature can provide a more controlled and stable approach to Class II correction compared to traditional functional appliances¹⁰.

Soft-Tissue Profile Changes

The nasolabial angle increased by an average of 3.6 degrees, indicating an enhancement in the soft-tissue profile. An increase in the nasolabial angle is associated with improved facial aesthetics, as it suggests a more balanced relationship between the upper lip and the nose¹¹. This change could be particularly beneficial for patients seeking both functional and aesthetic improvements. While conventional appliances often focus solely on skeletal and dental changes, the Invisalign MA feature's ability to improve soft-tissue aesthetics adds an additional layer of benefit for growing patients and their parents, who may be concerned about appearance during and after treatment¹².

Comparison with Traditional Functional Appliances

Traditional functional appliances, such as the twin-block and Herbst, have long been the gold standard for Class II correction. These appliances are known for their ability to produce significant skeletal changes, including forward positioning of the mandible and reduction of maxillary protrusion¹³. However, they often come with drawbacks such as bulkiness, discomfort, and aesthetic concerns, which can affect patient compliance and overall treatment success¹⁴. The Invisalign MA feature, on the other hand, offers a discreet and comfortable

alternative, which may contribute to higher compliance rates. Patient compliance is a critical factor in the success of Class II correction, as it determines the amount of wear time and, consequently, the degree of skeletal and dental changes achieved¹⁵.

The results of this study suggest that while the MA feature may not produce the same magnitude of skeletal changes as traditional functional appliances, it can still achieve clinically meaningful improvements in skeletal and dental relationships for patients with mild to moderate Class II malocclusions. This finding is consistent with other studies that have evaluated the MA feature in growing patients. For instance, Caruso et al.¹⁶ found that the MA feature produced a reduction in overjet of 1.5 mm and an increase in mandibular length of 1.0 mm over a similar treatment period, which is comparable to the results observed in this study.

Patient Compliance and Satisfaction

The high compliance rates reported in this study can be attributed to the aesthetic and comfortable design of the Invisalign aligners. Patients and parents often prefer clear aligners over traditional metal braces or bulky functional appliances due to the aligners' less noticeable appearance and reduced interference with daily activities¹⁷. The MA feature, integrated into the aligner system, allows for gradual and controlled mandibular advancement without the need for additional appliances, which can improve patient acceptance and satisfaction. The discrete nature of the precision wings used in the MA feature is another advantage, as it reduces the visibility of the appliance and minimizes social discomfort¹⁸.

Furthermore, the digital treatment planning offered by Invisalign, through the ClinCheck software, provides patients with a clear visualization of their treatment progress and expected outcomes¹⁹. This can enhance communication between the orthodontist and the patient, leading to increased motivation and compliance. The ability to monitor treatment progress remotely through digital scans and tele-orthodontics also provides added convenience for both patients and practitioners²⁰.

Limitations and Future Directions

While the findings of this study are promising, there are several limitations that should be addressed in future research. The small sample size of 20 patients limits the generalizability of the results. Larger studies with more diverse patient populations are needed to confirm these findings and provide a more comprehensive understanding of the MA feature's efficacy. Additionally, the lack of a control group in this retrospective study makes it difficult to differentiate the effects of treatment from natural growth changes²¹. Future studies should include a control group or a randomized controlled trial design to better evaluate the true impact of the MA feature on skeletal and dental changes²².

The study also did not evaluate long-term stability and relapse rates following the completion of treatment. While the MA feature appears to produce stable results during the treatment phase, it is unclear whether these changes are maintained in the long term. Further research should investigate post-treatment stability and compare the relapse rates of Invisalign MA-treated patients with those treated using traditional functional appliances²³.

Finally, future studies should consider exploring patient-reported outcomes, such as quality of life, comfort, and overall satisfaction, to provide a more holistic evaluation of the MA feature. Understanding patient perspectives can help orthodontists make more informed decisions when selecting treatment options for growing patients with Class II malocclusions²⁴.

CONCLUSION

The findings highlight that while Invisalign's MA feature may not achieve the same magnitude of skeletal changes as traditional functional appliances, it offers a promising alternative for treating mild Class II malocclusions. Its ability to produce controlled and stable changes, coupled with high patient compliance and satisfaction, makes it a valuable option for patients seeking a modern and aesthetically pleasing solution to Class II correction.

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