*Original Article*

# Evaluation of maxillary dimensional changes in the mixed dentition: clear aligners vs acrylic expanders

**Hande Pamukçu[a]; Serhat Özsoy[b]; Polat Can Aksoy[c]; Ömur Polat Özsoy[d]**


## ABSTRACT

**Objectives:** To compare changes in upper arch dimension and molar inclination between Invisalign First (IF) and removable acrylic expander (RE) treatments during the mixed dentition period.

**Materials and Methods:** Seventeen patients meeting inclusion criteria underwent IF treatment and were age matched with a group that received treatment with a removable acrylic expander (RE). Intercanine width (ICW), intermolar width, arch depth, buccolingual inclination of the first molars (MI), surface area (SA) and volume (VAP) of the anterior palate, and expansion were compared before and after treatment. The predictability of expansion was calculated for the IF group. Analysis of variance and Kruskal-Wallis tests were used to assess differences.

**Results:** The ICW increased significantly by 2.14 mm in the IF group and 3.49 mm in the RE group, with no significant intergroup difference. Both groups exhibited significant increases in intermolar width ($P < .05$), except for intermolar distopalatal width in the IF group ($P = .246$). Mesiobuccal rotation of the first molar was observed with IF treatment. Although SA and VAP increased in both groups, the changes were not significant for the IF group ($P > .05$). The RE group exhibited significantly higher increases ($P < .05$), with an SA increase of 34.32 $mm^2$ and VAP increase of 119.15 $mm^3$. MI changes were in the opposite directions. The prediction accuracy of expansion was 70.28% for canines and 34.12% for first molars.

**Conclusions:** Both appliances effectively expanded the intercanine region in growing patients. Expansion predictability was lower in first molars than in canines for the IF group. Removable acrylic expanders could be a choice of preference for expansion targeted to the molar region. (*Angle Orthod*. 0000;00:000–000.)


**KEY WORDS:** Clear aligners; Removable orthodontic appliances; Maxillary expansion; Invisalign First

## INTRODUCTION

Early treatment of transverse discrepancy in children has been recommended to eliminate posterior crossbite, resolve crowding, and prevent skeletal asymmetry and for abnormal chewing patterns.[1,2] During the mixed dentition period, maxillary expansion provides several advantages such as the correction of existing malocclusion, alteration of mouth breathing, and esthetic enhancement of the smile.[3–5] In addition, maxillary expansion can create sufficient space for the eruption of the permanent teeth, resolve crowding, and potentially decrease the need for extractions. Maxillary expansion can be performed using different protocols, including rapid, semi-rapid, or slow.[6] Slow maxillary expansion (SME) is typically used for cases of mild crowding. Several appliances are commonly used for SME in the mixed dentition, such as removable acrylic expanders, banded expanders, quad helix, and transpalatal arch.[7–9] Some of these are fixed appliances, offering the advantage of not requiring patient cooperation. However, removable expansion appliances are also available for patients with poor oral hygiene or those seeking more comfortable treatment.

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Accepted: March 2024. Submitted: December 2023.
Published Online: April 9, 2024

Conventional removable acrylic expanders provide satisfactory results but may be limited in achieving specific tooth movements, such as rotation.[10] In addition, allergies to acrylic and/or nickel alloy wires can develop, potentially causing soft-tissue trauma, and metal wires can have an unfavorable esthetic appearance.[11] The recently introduced Invisalign First (IF) system offers the possibility to overcome the disadvantages of these acrylic expanders. With IF, the amount of expansion can be calculated using software, and required tooth movements can be achieved simultaneously during expansion. Limited studies have investigated the treatment effects of IF and have found it to be a viable alternative to SME.[12–15]

This aim of this study was to investigate and compare changes in upper arch size and molar inclination between treatment with Invisalign First and a removable acrylic expander in the mixed dentition period.

## MATERIALS AND METHODS

This study was approved by the Başkent University Institutional Review Board (project No. D-KA23/30) and received support from the Başkent University Research Fund.

The data of patients treated by a single experienced investigator using the Invisalign First System (Align Technology Inc, Tempe, Ariz) were analyzed retrospectively based on following inclusion criteria: mixed dentition malocclusion treated for crowding using the same protocol, nonextraction, fully erupted upper first molars, had no additional mechanics other than Invisalign attachments, required no sagittal correction, maintained a high level of compliance with aligners (20 hours per day), replaced aligners every 7 days, and completed the first series of aligners. Patients with sucking habits, a history of previous orthodontic treatment, missing primary canines, supernumerary teeth, tooth agenesis, use of auxiliary appliances, systemic disease, dental anomalies, syndromes, and craniofacial deformities were excluded from the study.

Seventeen individuals (11 females and 6 males) met the criteria and were included in the IF group. These patients were matched based on age and molar relationship with a group that received nonextraction treatment for crowding using a removable acrylic expander (RE). Similar inclusion and exclusion criteria were applied to the RE group, and 17 patients (9 females and 8 males) in the RE group were identified.

In the IF group, a standardized sequential staging expansion protocol was planned for all patients, starting with the molars and followed by the simultaneous expansion of deciduous molars and canines. The expansion amount at each stage was set at 0.25 mm. Optimized expansion support attachments were used, and SmartForce aligner activations were incorporated into aligner designs without an additional buccal root torque prescription for the first molars. No specific rotation movement was prescribed for the upper first molars. Treatment duration for the IF group was 7.66 $\pm$ 3.09 months.

In the RE group, the acrylic expander had a midline 10-mm expansion screw. Parents activated the screws a quarter turn every week (one activation, 0.25 mm per turn). The patients were instructed to use the appliance full time except during meals. Treatment duration for the RE group was 8.86 $\pm$ 5.67 months.

In the IF group, digital models (.stl files) were generated from intraoral scan data. In the RE group, plaster models of the patients were scanned using an intraoral scanner (Itero, Align Technology, San Jose, Calif) and exported as .stl files. In both groups, maxillary models were measured before treatment (T1) and after treatment (T2) using GOM inspect software (GOM, Braunschweig, Germany) and Rhinoceros 3D modeling software (Rhino, Seattle, Wash). The arch width table in the ClinCheck plan (Invisalign Software) was used to obtain both achieved and predicted arch widths (from the point on the occlusal surface intersecting the long axis of the tooth). The prediction accuracy of expansion was calculated using the formula: (achieved expansion)/(predicted expansion) $\times$ 100%.[16]

The following values were measured only for the maxilla for each dental model at T1 and T2:

- Intercanine width (ICW): The distance from the cusp tip of the right primary canine to the cusp tip of the left primary canine (Figure 1)
- First intermolar mesiobuccal width (6-6 MB): The linear distance between the mesiobuccal cusp tips of the permanent first molars
- First intermolar distobuccal width (6-6 DB): The linear distance between the distobuccal cusp tips of the permanent first molars
- First intermolar mesiopalatal width (6-6 MP): The linear distance between the mesiopalatal cusp tips of the permanent first molars
- First intermolar distopalatal width (6-6 DP): The linear distance between the distopalatal cusp tips of the permanent first molars
- Arch depth (AD): The length of a line constructed from the mesial contacts of the central incisors to a line connecting the mesial contact points of the first molars (Figure 2)
- Landmarks were identified at the most concave points along the lingual margins of primary canines and primary first molars on both sides; measurements of the surface area (SA) and volume (VAP) of the anterior palate (1/3) were calculated (Figure 3)

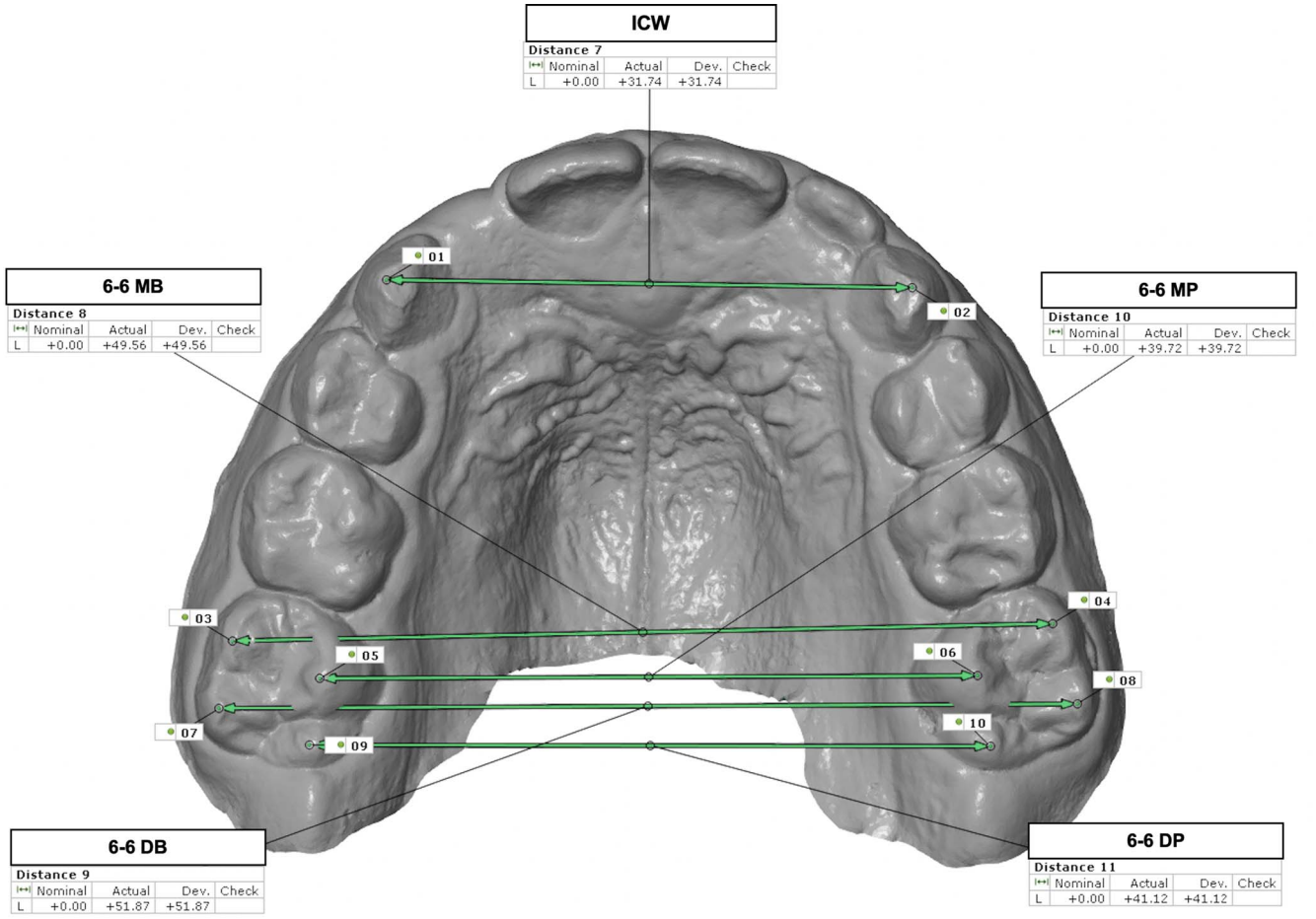


**Figure 1.** Measurement of ICW and intermolar widths. 6-6 DB indicates first intermolar distobuccal width; 6-6 DP, first intermolar distopalatal width; 6-6 MB, first intermolar mesiobuccal width; 6-6 MP, first intermolar mesiopalatal width; ICW, intercanine width.

- First molar buccolingual inclination (MI): The angle formed between a line perpendicular to the occlusal plane (the plane that is horizontal, passing through the points that defined the palatal gingival margins of the upper teeth) and a line that is perpendicular to the best-fit plane (Figure 4)[13]

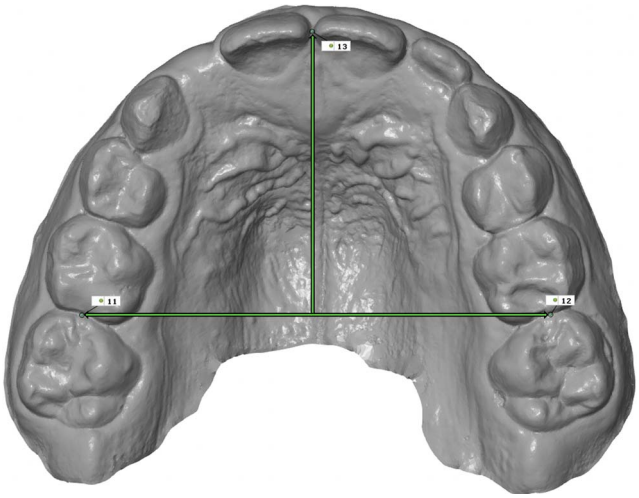


**Figure 2.** Measurement of arch depth.

An observer blinded to the groups conducted all of the digital measurements. Intraobserver reliability was assessed by intraclass correlation (ICC) using 20% of the data that were remeasured 2 weeks after the initial measurements.

## Statistical Analysis

Statistical analysis was conducted using SPSS Statistics software (version 22.0, IBM, New York, NY). A post hoc power analysis was performed to assess the achieved power of the study. The normality of the data was evaluated using the Shapiro-Wilk test. Independent *t*-tests were used for two-group comparisons in normally distributed data, and the Mann-Whitney *U*-test was used for two-group comparisons involving nonnormally distributed data. For within-group, T2-T1 comparisons, a paired *t*-test was used. Demographic statistical analysis was performed using Mann-Whitney *U* and Wilcoxon signed-rank tests. Analysis of variance and

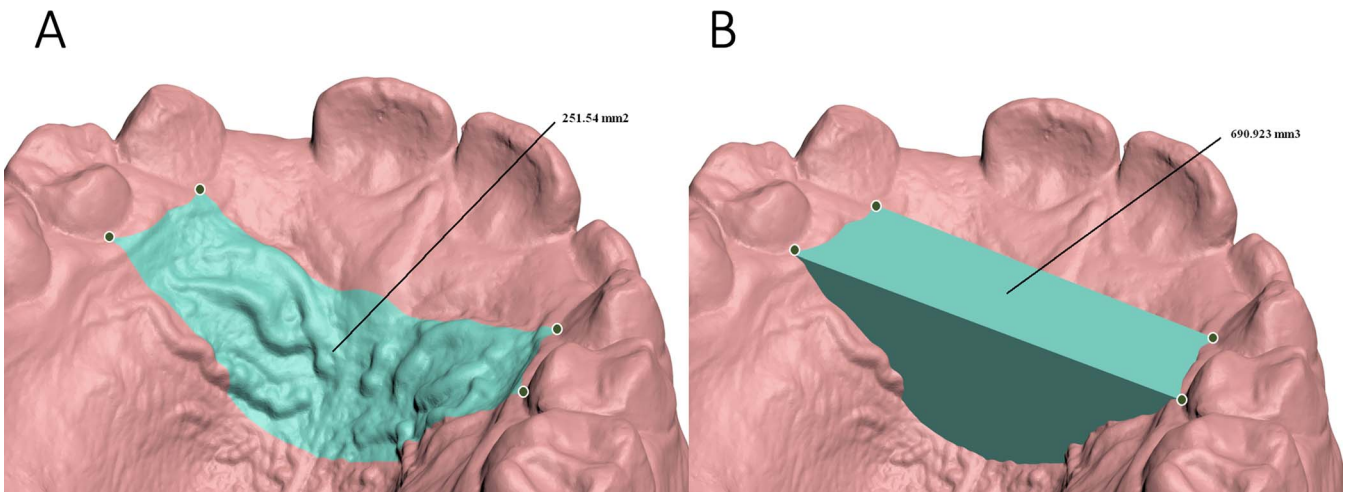


**Figure 3.** Measurement of surface area of the anterior palatal surface (A) and volume (B).

Kruskal-Wallis tests were used to evaluate the differences. The significance level was set at a *P* value of .05.

## RESULTS

The post hoc power calculation revealed a sample power of 88% with the first intermolar distobuccal width variable and an effect size of $d = .99$ at $\alpha = .05$. The ICC values ranged from .93 to .98, indicating high reliability. There were no significant differences for gender, age, treatment duration, crossbite, or initial crowding between the IF and RE groups ($P > .05$; Table 1). The groups showed no significant differences in initial ICW, intermolar widths, AD, MI, SA, and VAP measurements ($P > .05$; Table 1).

ICW increased significantly by 2.14 mm in the IF group and 3.49 mm in the RE group. There was no significant difference between the groups with regard to changes in the ICW (IF = 2.14 ± 1.66 mm; RE = 3.49 ± 2.91 mm; $P = .256$; Table 2). In both groups, the first intermolar widths significantly increased after treatment ($P < .05$), except for the first intermolar distopalatal width in the IF group ($P = .246$; Table 2). The changes in first intermolar width were significantly higher in the RE group than in the IF group ($P < .05$; Table 2). When the intermolar width changes induced by treatment were compared within each group, the intermolar mesiobuccal width of the first molars in the IF group showed a greater increase (2.19 mm) compared with the distobuccal width (0.54 mm) and distopalatal width (0.17 mm; Table 3). These results suggested a mesiobuccal rotation of the first molar with IF treatment. The prediction accuracy of expansion was 70.28% for canines and 34.12% for first molars (Table 4).

There was no statistically significant difference in AD between the groups ($P = .692$; Table 2). Although SA and VAP increased in both groups, the changes were not significant for the IF group (Table 2). A significantly higher increase was observed in the RE group, with an average increase of 34.32 $mm^2$ and 119.15 $mm^3$ for SA and VAP, respectively.

There were no significant MI changes within groups or differences between the groups, but the average inclination changes were in opposite directions between the IF and RE groups. Lingual crown tipping was noted in the IF group on average (MI-16 = −1.03°; MI-26 = −0.98°), whereas buccal crown tipping was observed on average in the RE group (MI-16 = 2.42°; MI-26 = 1.59°).

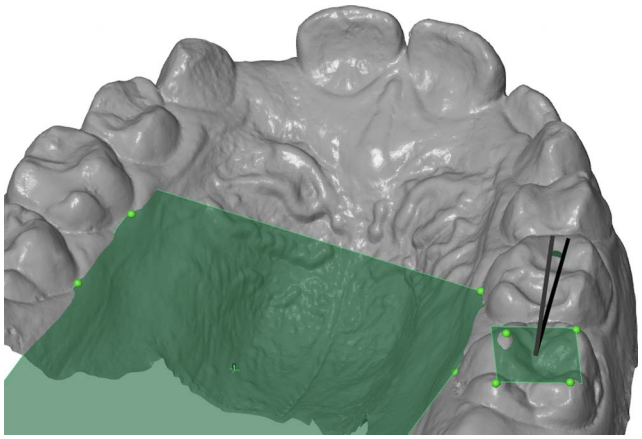

**Figure 4.** Measurement of first molar buccolingual inclination.

## DISCUSSION

While many studies have investigated dental arch changes after clear aligner therapy in the permanent dentition, fewer studies have examined their effects in the mixed dentition.[12–15,17–21] In this study, two different removable appliances used in the mixed dentition were compared. Similar activation protocols were used for

**Table 1.** Comparison of Chronological Age, Gender, Treatment Duration, Space Analysis, and Dental Measurements at T1 Between the Two Groups[a]

| | IF Group n or Mean ± SD or Median (IQR) | RE Group n or Mean ± SD or Median (IQR) | *P* |
|---|---|---|---|
| Chronological age, y | 8.79 ± 0.82 | 8.83 ± 1.02 | .796 |
| Gender | | | |
| Male | 8 | 6 | .727 |
| Female | 9 | 11 | |
| Treatment duration, mo | 7.66 ± 3.09 | 8.86 ± 5.67 | .428 |
| Space analysis, mm | −4.16 ± 1.93 | −4.88 ± 2.18 | .762 |
| Posterior crossbite | | | |
| Unilateral | 4 | 5 | .987 |
| Bilateral | 0 | 0 | 1.00 |
| ICW, mm | 31.90 ± 2.78 | 32.53 ± 2.48 | .491 |
| 6-6 MB, mm | 49.71 ± 3.85 | 49.93 ± 4.74 | .904 |
| 6-6 DB, mm | 52.620 ± 2.98 | 52.68 ± 68 | .642 |
| 6-6 MP, mm | 40.32 ± 2.19 | 40.41 ± 2.66 | .915 |
| 6-6 DP, mm | 42.09 ± 2.44 | 41.64 ± 2.77 | .614 |
| AD, mm | 28.81 ± 2.97 | 27.11 ± 1.36 | .221 |
| SA, $mm^2$ | 245.18 ± 39.84 | 220.80 ± 36.99 | .088 |
| VAP, $mm^3$ | 652.04 (174.41) | 561.19 (138.86) | .117 |
| MI-16, ° | 15.33 ± 4.41 | 15.26 ± 7.80 | .973 |
| MI-26, ° | 14.77 ± 4.38 | 15.21 ± 6.84 | .823 |

[a] 6-6 DB indicates first intermolar distobuccal width; 6-6 DP, first intermolar distopalatal width; 6-6 MB, first intermolar mesiobuccal width; 6-6 MP, first intermolar mesiopalatal width; AD, arch depth; ICW, intercanine width; IF, Invisalign First; MI, first molar's buccolingual inclination; RE, removable expander; SA, surface area of the anterior palate; SD, standard deviation; T1, pretreatment; VAP, volume of the anterior palate.

both appliances, so the effects on arch width, MI, and palatal dimensions were compared.

Early treatment of crowding and posterior crossbite is currently recommended to guide the erupting teeth to their correct positions and to eliminate premature contacts.[22] Removable acrylic expanders have been used for an extended period to solve crowding and provide slow expansion, whereas IF was introduced to clinical practice more recently. IF aligners are designed for the treatment of phase 1 patients, aiming to enhance arch form development and preserve space for the erupting permanent teeth. The software automatically positions optimized attachments, concurrently generating the necessary forces essential for promoting tooth movement required for arch expansion.[14] Unlike removable expanders that provide only arch expansion, it is possible to achieve desired tooth movement simultaneously with the IF system.

Lu et al.[21] compared the treatment effects of IF and the Haas appliance in a total of 34 children in the mixed dentition. The Haas appliance was cemented in the maxilla and activated 0.25 mm per day. Both systems

**Table 2.** Intragroup and Intergroup Comparisons of Changes With Treatment[a]

| | IF Group | | | | RE Group | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variable | T1 Mean ± SD or Median (IQR) | T2 Mean ± SD or Median (IQR) | T2-T1 Mean ± SD | *P* | T1 Mean ± SD or Median (IQR) | T2 Mean ± SD or Median (IQR) | T2-T1 Mean ± SD | *P* | IF Group vs RE Group *P* |
| ICW, mm | 31.90 ± 2.78 | 34.04 ± 2.63 | 2.14 ± 1.66 | .001* | 32.53 ± 2.48 | 36.02 ± 3.74 | 3.49 ± 2.91 | .001* | .256 |
| 6-6 MB, mm | 49.71 ± 3.85 | 51.90 ± 2.71 | 2.19 ± 2.94 | .001* | 49.93 ± 4.74 | 54.52 ± 3.91 | 4.59 ± 3.80 | .0001* | .008* |
| 6-6 DB, mm | 52.620 ± 2.98 | 53.16 ± 3.03 | 0.54 ± 0.72 | .01* | 52.68 ± 68 | 55.97 ± 3.19 | 3.29 ± 2.75 | .0001* | .001* |
| 6-6 MP, mm | 40.32 ± 2.19 | 41.40 ± 2.02 | 1.08 ± 0.91 | .002* | 40.41 ± 2.66 | 43.45 ± 3.72 | 3.04 ± 3.87 | .005* | .051* |
| 6-6 DP, mm | 42.09 ± 2.44 | 42.26 ± 2.29 | 0.17 ± 0.78 | .246 | 41.64 ± 2.77 | 45.00 ± 3.13 | 3.36 ± 3.08 | .001* | .0001* |
| AD, mm | 28.81 ± 2.97 | 28.78 ± 2.15 | −0.02 ± 1.90 | .831 | 27.11 ± 1.36 | 27.76 ± 3.5 | 0.65 ± 3.67 | .868 | .692 |
| SA, $mm^2$ | 245.18 ± 39.84 | 260.834 ± 38.35 | 13.89 ± 26.40 | .084 | 220.80 ± 36.99 | 255.12 ± 33.03 | 34.32 ± 21.69 | .0001* | .030* |
| VAP, $mm^3$ | 652.04 (174.41) | 684.43 (173.71) | 37.32 ± 89.22 | .209 | 561.19 (138.86) | 680.33 (152.94) | 119.15 ± 110.62 | .002* | .043* |
| MI-16, ° | 15.33 ± 4.41 | 14.29 ± 4.14 | −1.03 ± 2.87 | .193 | 15.26 ± 7.80 | 17.68 ± 7.81 | 2.42 ± 7.13 | .227 | .073 |
| MI-26, ° | 14.77 ± 4.38 | 13.78 ± 4.95 | −0.98 ± 3.50 | .266 | 15.21 ± 6.84 | 16.80 ± 7.72 | 1.59 ± 4.87 | .266 | .086 |

[a] 6-6 DB indicates first intermolar distobuccal width; 6-6 DP, first intermolar distopalatal width; 6-6 MB, first intermolar mesiobuccal width; 6-6 MP, first intermolar mesiopalatal width; AD, arch depth; ICW, intercanine width; IF, Invisalign First; MI, first molar's buccolingual inclination; RE, removable expander; SA, surface area of the anterior palate; SD, standard deviation; T1, pretreatment; VAP, volume of the anterior palate.

* Statistically significant differences ($P < 0.05$).

**Table 3.** Multiple Comparisons of Intercanine and Intermolar Width Changes[a]

| | | IF Group | | | | RE Group | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | n | Mean ± SD | *P* | Multiple Comparisons | n | Mean ± SD | *P* | Multiple Comparisons |
| T2-T1 | 1 = ICW (mm) | 17 | 2.14 ± 1.66 | .0001* | 1–3[b] | 17 | 3.49 ± 2.91 | .843 | — |
| | | | | | 1–4[b] | | | | |
| | 2 = 6-6 MB (mm) | 17 | 2.19 ± 2.94 | | 1–5[b] | 17 | 4.59 ± 3.80 | | |
| | 3 = 6-6 DB (mm) | 17 | 0.54 ± 0.72 | | 2–3[c] | 17 | 3.29 ± 2.75 | | |
| | 4 = 6-6 MP (mm) | 17 | 1.08 ± 0.91 | | 2–4[c] | 17 | 3.04 ± 3.87 | | |
| | 5 = 6-6 DP (mm) | 17 | 0.17 ± 0.78 | | 2–5[c] | 17 | 3.36 ± 3.08 | | |

[a] 6-6 DB, first intermolar distobuccal width; 6-6 DP, first intermolar distopalatal width; 6-6 MB, first intermolar mesiobuccal width; 6-6 MP, first intermolar mesiopalatal width; ICW, intercanine width; IF, Invisalign First; RE, removable expander; SD indicates standard deviation; T1, pretreatment; T2, posttreatment.

[b] The T2-T1 value in group 1 is significantly higher than in groups 3, 4, and 5 ($P < .05$).

[c] The T2-T1 value in group 2 is significantly higher than in groups 3, 4, and 5 ($P < .05$).

* Statistically significant differences ($P < .05$).

were found to provide maxillary expansion, but the Haas appliance demonstrated greater expansion. In their IF group, the average increase in ICW was reported as 1.89 mm, whereas in the current IF group, the corresponding width increased by 2.14 mm. The authors concluded that both systems provided expansion during the mixed dentition period, suggesting that IF therapy could be sufficient for mild to moderate cases while recommending the use of the Haas appliance for more severe cases. Due to the different treatment outcomes observed between fixed and removable appliances, the current study compared IF treatment to a group that underwent treatment using a removable expander with slow activation.

Levrini et al.[12] investigated maxillary arch changes in patients treated with IF. Their findings indicated 2.8 mm of expansion in the intercanine region and 3 mm in the intermolar region. They suggested that the IF system could serve as an alternative to traditional slow maxillary expanders for mild crowding and limited transverse deficiency. In the current study, despite achieving similar expansion in the canine region with an acrylic removable expander, expansion in the molar region was found to be less in the IF group than in the RE group. The mean accuracy of expansion decreased from 70% at the canines to 34% in the first molar region. This finding may be attributed to diminishing expansion forces toward the distal aspects of clear aligners. Several other studies have highlighted a decrease in the predictability of expansion movement with clear aligners as they extend posteriorly.[17,23,24] Removable expansion devices therefore remain a viable option, especially for patients who need expansion in the posterior region. However, IF treatment was found to be sufficient for expansion in the anterior region.

Lione et al.[14] investigated transverse changes in the maxillary arch in 23 patients treated with IF, and the magnitude of change at the first molars was less than that in the intercanine area. They found lesser expansion in the intermolar distobuccal and palatal widths. Consistent with the results of the current study, the authors reported mesiobuccal rotation of the upper first molars with IF therapy. This can be attributed to the initial stage of expansion, which involves simultaneous rotation of the first molars around their palatal roots. When digitally planning the new transverse dimension in the IF system, unlike when planning for removable expanders, teeth were adjusted to achieve an ideal cusp-fossa relationship.

The mean SA (34.32 $mm^2$) and VAP (119.15 $mm^3$) were increased significantly in the RE group. However, corresponding increases in SA (13.89 $mm^2$) and VAP (37.32 $mm^3$) were not found to be statistically significant for the IF group. Wang et al.[13] compared palatal dimensional changes of Hass expander and IF treatments; the Haas expander group demonstrated a significantly greater increase compared with the IF group. According to their results, the SA of the anterior palate increased by 22.63 $mm^3$ and VAP increased by 85.32 $mm^3$ after IF treatment,

**Table 4.** Comparison Between Predicted and Achieved Expansion in the Invisalign First (IF) Group (From the ClinCheck Plan Arch Width Table)[a]

| Tooth Type | Predicted Expansion (mm) ± SD | *P* | Achieved Expansion (mm) ± SD | *P* | Predicted Expansion Achieved (%) ± SD | *P* |
|---|---|---|---|---|---|---|
| Maxillary canine | 3.10 ± 0.29 | .904 | 2.19 ± 0.42 | .0001* | 70.28 ± 12.51 | .0001* |
| Maxillary first molar | 3.02 ± 0.31 | | 1.02 ± 0.61 | | 34.12 ± 18.63 | |

[a] The prediction accuracy of maxillary expansion was calculated using the formula = (achieved expansion)/(predicted expansion) × 100%. Arch widths = from the point on the occlusal surface that intersects the long axis of the tooth. SD, standard deviation.

* Statistically significant differences ($P < 0.05$).

both of which were found to be statistically significant. Consequently, the authors indicated that IF treatment could serve as a dentoalveolar expansion option, whereas the Haas-type expander served as a skeletal expansion appliance.

The same study by Wang et al.[13] also compared IF and Haas-type expanders in terms of MI. The IF group showed no effects on MI, while the Haas-type expander group demonstrated buccal crown tipping similar to the results of the RE group in the current study. In the current study, although no significant difference was observed in MI changes between the groups, opposite directions of changes in MI were observed. The buccal crown tipping observed in the RE group may be attributed to the molars being attached to the appliance with only Adams clasps. In contrast, in the IF group, the aligner surrounded the molars on all sides, and the molars were supported with optimized attachments.

This study has several limitations. Despite adhering to strict inclusion criteria, the retrospective design of the study posed a notable limitation due to its susceptibility to selection bias as compared with prospective randomized studies. To minimize the risk of bias, measurement of the digital models was conducted in a blinded manner, and the examiner was unaware of the patient group assignments. Another limitation was the absence of a control group. However, it is important to note that the treatment durations for the groups were 7.66 and 8.86 months, and in this age group, less than 0.5 mm of transverse growth in the maxillary arch is expected during this period.[25]

Removable orthodontic appliances require patient cooperation. A significant drawback of conventional removable appliances is palatal acrylic coverage, which hinders the ability to speak at the onset of treatment. Clear aligners are more patient friendly in the preliminary phases of the orthodontic treatment. On the other hand, the higher costs of clear aligners pose a considerable disadvantage. Future studies evaluating the effectiveness of slow acrylic expanders and clear aligners may elucidate the role that cooperation and ease of use may have when comparisons are made between these two treatment modalities.

## CONCLUSIONS

In the mixed dentition period:

- Invisalign First (IF) and removable expanders (RE) demonstrate effective expansion in the maxillary intercanine area.
- RE may be preferred for cases in which expansion in the molar region is desired.
- IF did not exhibit statistically significant differences in the surface area and volume of the anterior palate, whereas RE showed a significant increase in these measures.
- In IF, the amount of expansion at the molars was less predictable than that at the canines.

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