*Original Article*

# Effects of maxillary molar distalization with Zygoma-Gear Appliance

**Metin Nur[a]; Mehmet Bayram[a]; Mevlut Celikoglu[a]; Dogan Kilkis[b]; Ali Alper Pampu[c]**

**ABSTRACT**

**Objective:** To evaluate the dentoalveolar, skeletal, and soft tissue effects of the Zygoma-Gear Appliance (ZGA) when used for bilateral distalization of the maxillary molars.

**Materials and Methods:** The study group included 15 patients (mean age, 15.87 ± 1.09 years; range: 14–18 years) treated with the ZGA system supported with zygomatic anchorage miniplates. The changes due to the distalization were evaluated from the lateral cephalometric films taken before and after distalization by means of a paired *t*-test.

**Results:** The mean treatment period required to achieve a Class I molar relationship was 5.21 months. The distalization amount of the maxillary molars was 4.37 ± 2.15 mm ($P < .001$), and, thus, the rate for the distal movement of the molars was 0.84 mm per month. Maxillary first molars showed a slight intrusion (0.50 mm) ($P > .05$), while distal tipping was only 3.30° ± 2.31° ($P > .05$). Furthermore, there was a decrease in overjet (−0.50 mm) ($P > .05$), indicating that there was no anchorage loss with use of the ZGA.

**Conclusions:** Maxillary molar distalization without anchorage loss can be achieved in a short time with ZGA. (*Angle Orthod.* 2012;82:596–602.)

**KEY WORDS:** Class II; Molar distalization; Zygoma-Gear Appliance

## INTRODUCTION

Treatment of Class II malocclusions, without extractions, frequently requires distalization of maxillary molars into a Class I relationship by means of extraoral or intraoral forces. Several methods and devices can be used to distalize maxillary molars and to correct Class II malocclusions. The most conventional method for distalizing the maxillary molars involves use of cervical headgear, which can either be used for orthodontic or orthopedic corrections. It is easy to apply and may distalize not only the maxillary first molars but also the first and second premolars via transeptal fibers.[1] Although it has been shown that a unilateral Class II malocclusion can be corrected by headgear with the application of asymmetric facebows,[2] the undesirable lateral forces that tend to move maxillary molars into crossbite were unavoidable.[3] In addition, the success of the treatment depends heavily on patient cooperation, and lack of patient cooperation results in anchorage loss and unsatisfactory treatment results. The disadvantages of the extraoral appliances have motivated many investigators to develop the mechanics of intraoral molar distalization.

Several intraoral appliances have been used to distalize the maxillary molars in Class II patients without the patient's cooperation; these include nickel-titanium spring,[4–6] magnet,[4] distal jet,[7,8] first class,[9] Jones jig,[10,11] pendulum,[10,12] and Keles slider[3,13] appliances. All of these intraoral distalization appliances distalize the maxillary molars; however, in most of those studies mentioned above, anchorage loss was unavoidable, characterized by the protrusion of maxillary incisors, an increase in overjet, and decrease in overbite.[14,15]

Recent studies have described the use of osseointegrated implants,[16,17] onplants,[18] intraosseous screws,[14,19,20] and plates[21–23] as anchorage units in orthodontic patients requiring distalization.

Recently, Nur et al.[24] designed an intraoral appliance, named the Zygoma-Gear Appliance (ZGA), for bilateral maxillary molar distalization using the titanium anchor plates placed in the zygomatic process of the

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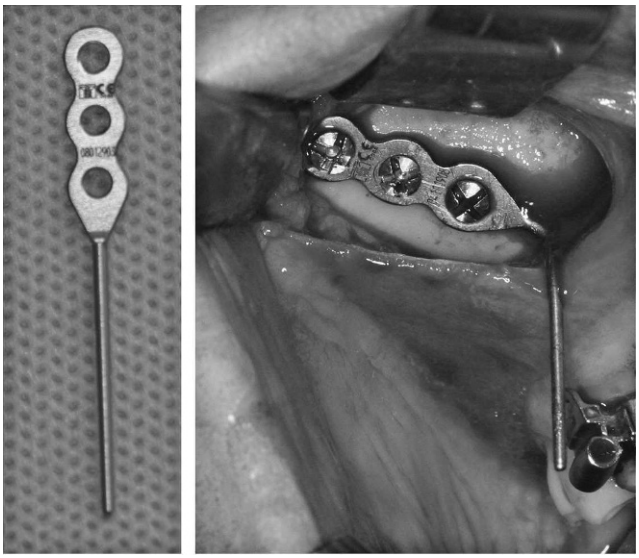

**Figure 1.** Zygomatic anchor plate used for distalization.

maxilla. The authors demonstrated that an effective maxillary molar distalization without anchorage loss could be achieved in a short time using the ZGA.

The aim of this prospective clinical study was to evaluate the dentoalveolar, skeletal, and soft tissue effects of the ZGA when used for bilateral distalization of the maxillary molars in patients with Class II malocclusion.

## MATERIALS AND METHODS

Ethical approval for the present prospective, clinical study was obtained from the local Ethical Committee of Karadeniz Technical University. An informed consent was signed by parents of the patients.

The sample size for the present study was calculated based on a significance level of .05 and a power of 90% to detect a meaningful difference of 0.5 mm per month ($\pm$0.45 mm per month) in distal molar movement. The power analysis showed that 11 patients were required. To compensate for possible dropouts during the trial and to increase the power even more we decided to select 17 patients for the present study.

The inclusion criteria for all patients were (1) a bilateral Class II molar relationship, defined by at least an end-to-end molar relationship, and (2) a nonextraction treatment requiring distalization of maxillary molars. Exclusion criteria included (1) past orthodontic treatment; (2) crossbite; (3) poor oral hygiene; and (4) a vertical growth pattern (SN-MP $> 38^{\circ}$). Two patients were excluded because of infection of the zygomatic miniplates. No other problems with zygomatic miniplates, such as mobility, breakage, patient discomfort, and hygiene problems, were observed. Finally, 15 patients (eight females and seven males) remained for the statistical analyses. Nine patients had a half-cusp molar relationship, four had a three-quarter–cusp molar relationship, and two had a full-cusp molar relationship. The mean age for the study group was 15.87 $\pm$ 1.09 years (range, 14–18 years), and all patients had the maxillary second molars erupted. Three patients had bilateral third molar agenesis and two patients had extracted third molars prior to the orthodontic treatment; while the other 10 patients had bilateral third molars.

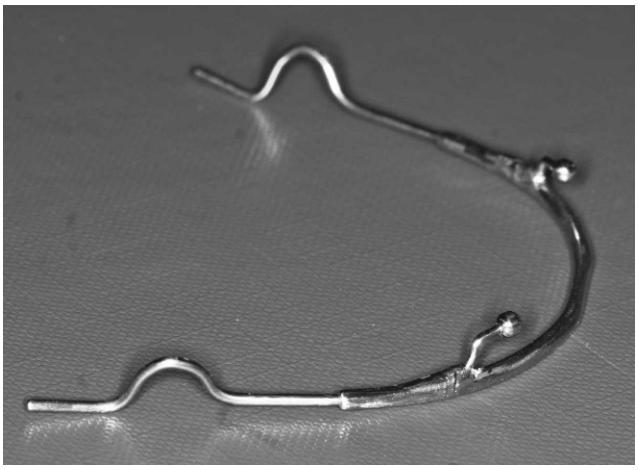

**Figure 2.** Modified inner bow used for the distalization.

### Treatment Protocol

ZGA, as described by Nur et al.,[24] was used in this study. The ZGA consists of two zygomatic miniplates (Multi Purpose Anchor MPI 1000, Tasarim Med, Istanbul, Turkey), an inner bow, and a closed coil spring. The plates were titanium miniplates with three holes, which continue into a round bar.

The miniplates were placed at the zygomatic buttress of the maxilla under local anesthesia, and they were adjusted to fit the contour of the lower face of each zygomatic process and were fixed by three bone screws made of titanium (length, 5.0 mm; diameter, 2.0 mm) (Figure 1).

The inner bow (1.1 mm) was a modified version of the inner part of a conventional facebow. Two hooks were soldered onto the inner bow at the lateral teeth regions, and U bends were bent in front of the maxillary first molars (Figure 2). It was adjusted to the headgear tubes on the maxillary first molar bands, as the anterior component of the inner bow was 3 mm away from the anterior teeth. The appliance was adjusted by widening the U bends with pliers if needed.

Three weeks after the surgery, a distalization force of 300 g per side was applied to the maxillary molars via the closed coil spring (GAC International, Bohemia, NY) attached with 0.01-inch stainless-steel ligature

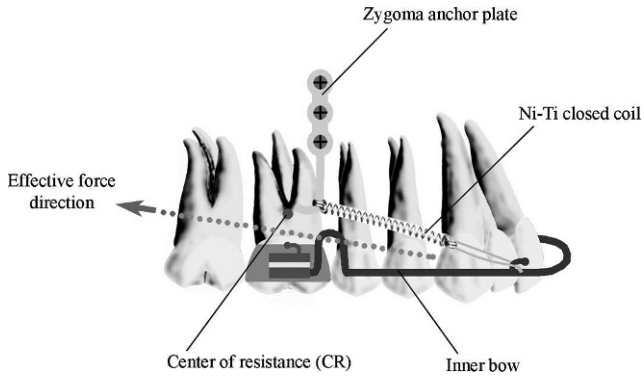


**Figure 3.** Schematic illustration of the components of the Zygoma-Gear Appliance.

(Figure 3). The force was checked and calibrated with a gram-force gauge (Correx; Haag-Streit, Koeniz, Switzerland) during the initial activation and at 4-week intervals. Figure 4 shows the photographs of a patient treated with ZGA. After super Class I relationship was achieved, fixed appliances were performed for the second phase of the orthodontic treatment. All anchor plates were used for anchorage control during the retraction of the premolar and anterior teeth, if required, and then they were removed after debonding.

### Cephalometric Measurements

Lateral cephalometric films, taken before (T1) and after (T2) distalization, were used (Figure 5). The films were taken in a standard condition by one operator using the same X-ray machine and cephalostat (Veraviewepocs; Morita, Kyoto, Japan). The pterygoid vertical and Frankfort horizontal planes were used as vertical and horizontal reference lines (VRL and HRL) for measuring the cephalometric changes, respectively. Evaluation of the dentoalveolar, skeletal, and soft tissue changes was made with 33 variables (21 linear and 12 angular measurements) (Figures 6–8). All cephalometric tracings and measurements were performed by a single researcher.

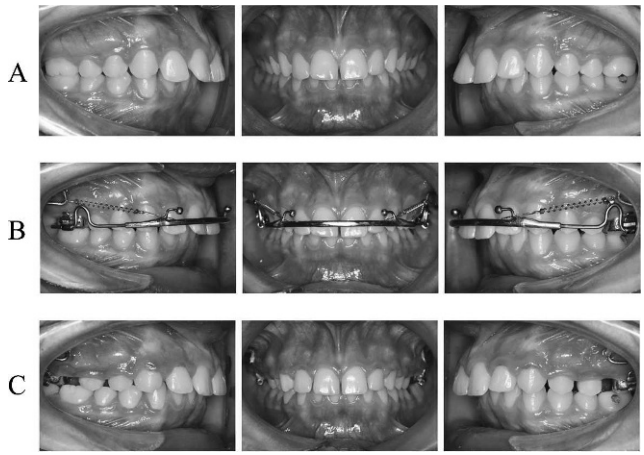


**Figure 4.** Intraoral photographs of a patient before (A), during (B), and immediately after (C) the distalization.

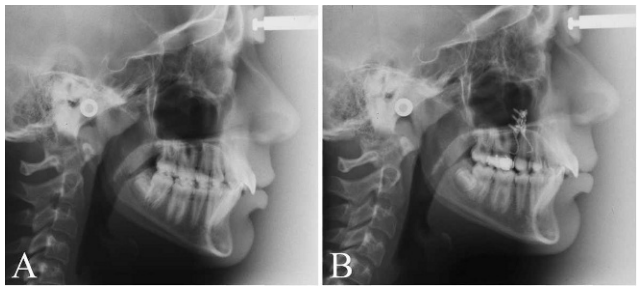


**Figure 5.** Lateral cephalometric radiographs of a patient before (A) and immediately after (B) the distalization.

### Statistical Analyses

The normality test of Shapiro-Wilks and Levene's variance homogeneity test were applied to the data, and all data were found to be normally distributed. Thus, the changes of each variable from T1 to T2 were analyzed with a paired *t*-test. Student's *t*-test was performed to compare the mean age and distalization periods of the sexes.

To determine the errors associated with radiographic measurements, 10 radiographs were selected randomly. Landmark identification, tracing, and measurements were repeated 1 month after the first measurements by the same author. Intraclass correlation coefficients were performed to assess the reliability of the measurements.[25] Statistical analyses were performed using the SPSS software for Windows (version 12.0, SPSS, Chicago, Ill). The level of significance for all tests was set at $P < .05$.

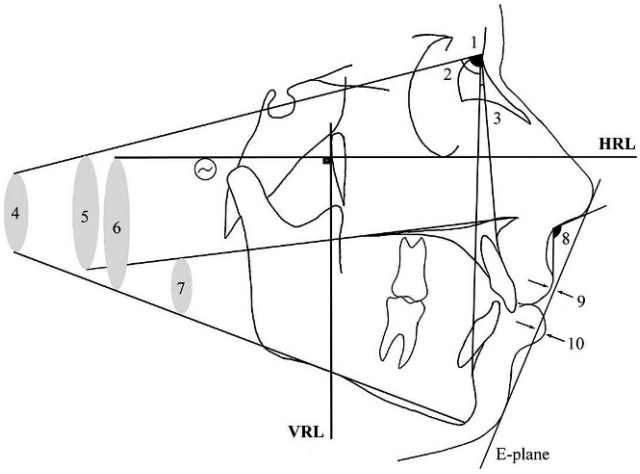


**Figure 6.** Soft tissue and angular skeletal measurements: (1) SNA (°); (2) SNB (°); (3) ANB (°); (4) MP/PP (°); (5) SN/MP (°); (6) FMA (°); (7) SN/PP (°); (8) UL-E (mm); (9) LL-E (mm); and (10) nasolabial angle (°).

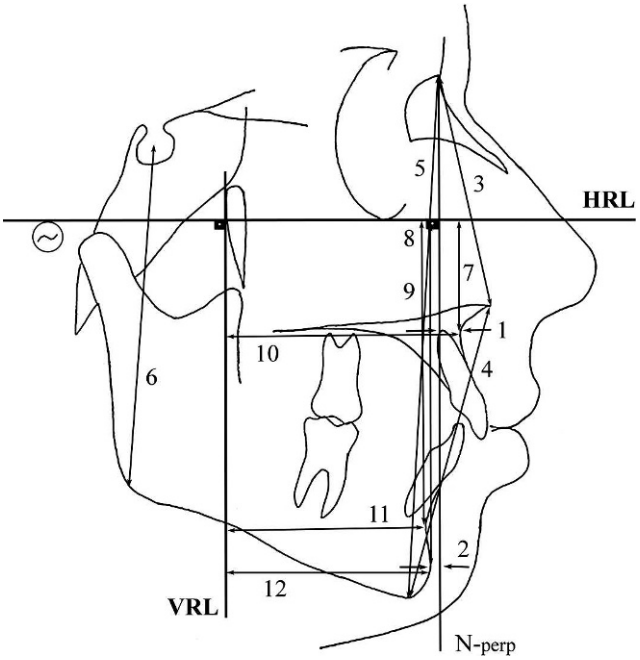


**Figure 7.** Linear skeletal measurements (mm): (1) A point to Nasion perpendicular; (2) Pg point to Nasion perpendicular; (3) N-ANS; (4) ANS-Me; (5) N-Me; (6) S-Go; (7) A-HRL; (8) B-HRL; (9) Pg-HRL; (10) A-VRL; (11) B-VRL; and (12) Pg-VRL.

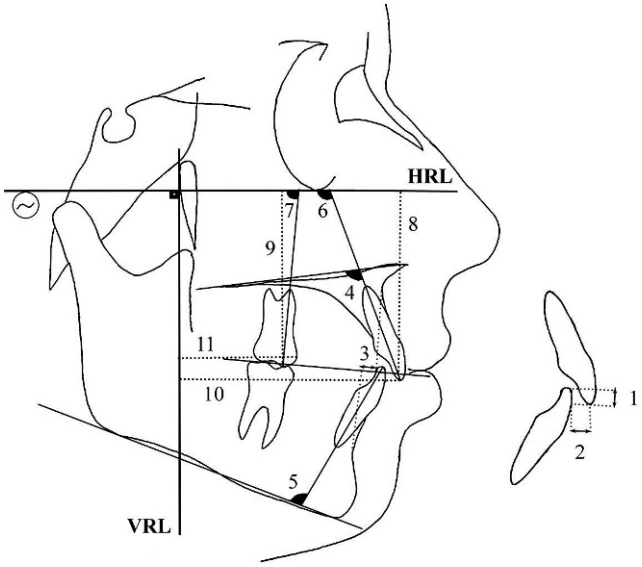


**Figure 8.** Linear and angular maxillary and mandibular dentoalveolar measurements: (1) Overbite (mm); (2) Overjet (mm); (3) Wits (mm); (4) U1/PP (°); (5) L1/MP (°); (6) HRL-U1 (°); (7) HRL-U6 (°); (8) HRL-U1 (mm); (9) HRL-U6 (mm); (10) VRL-U1 (mm); and (11) VRL-U6 (mm).

## RESULTS

The coefficients of reliability for all measurements were above 0.93, confirming the reliability of the measurements. The maxillary molars were distalized into a Class I relationship in all patients. The mean treatment period required to achieve a full Class I molar relationship was 5.21 ± 0.96 months. There were no significant differences between genders for the mean distalization period ($P = .877$) and for the mean age before distalization ($P = .551$).

Descriptive statistics, including mean and standard deviation for observations at T1 and T2, and changes during the distalization are shown in Table 1. The ZGA caused insignificant changes in both skeletal and soft tissue measurements. The distalization amount of the maxillary molars was 4.37 ± 2.15 mm ($P < .001$), and, thus, the rate for the distal movement of the molars was 0.84 mm per month; while distal tipping was only 3.30° ± 2.31° ($P > .05$) (Figure 9). In addition, there was a statistically significant change in the Wits appraisal (1.13 mm) ($P < .05$). Furthermore, there was a decrease in overjet (−0.50 mm) and VRL-UI (−0.60 mm) ($P > .05$), indicating that no anchorage loss resulted from using the ZGA.

## DISCUSSION

Several reports[9,11,12,20,26–30] have shown different appliances for molar distalization in the treatment of dental Class II malocclusions. However, anchorage loss of the maxillary premolars and flaring of the maxillary incisors as well as a considerable amount of relapse during retraction of the premolar and the anterior teeth were reported.[7] Therefore, intraoral distalizing mechanics combined with palatal implants have recently been used for distalization of maxillary molars.[1,14,31–33] Although these methods can be used effectively to achieve distalization of maxillary molars without anchorage loss, the retraction of the anterior teeth is limited as a result of the proximity of palatal implant to the roots of anterior teeth or the presence of a bulky acrylic Nance appliance behind the upper incisors.[24] In addition, Liou et al.[34] and Kinzinger et al.[35] examined the anchorage quality of the miniscrews and concluded that they did not fully maintain their positions under continuous loading. Sugawara et al.[22] reported that the zygomatic process of the maxilla could be used to prevent the anchorage loss. The ZGA has been produced as a noncompliance appliance, and it has been shown that it is possible to move maxillary molars distally with ease.[24]

According to the results of this study, the maxillary molars were effectively distalized (4.37 mm) into overcorrected Class I molar relationship in 5.21 months, and, thus, the average monthly distalization amount was found to be 0.84 mm. This amount of tooth movement per month is similar to that generated by intraoral mechanics supported with a skeletal anchorage, ranging from 0.66 to 1.2 mm per month.[14,32,33,36,37] Gelgor et al.[14] found a distalization of 0.85 mm per

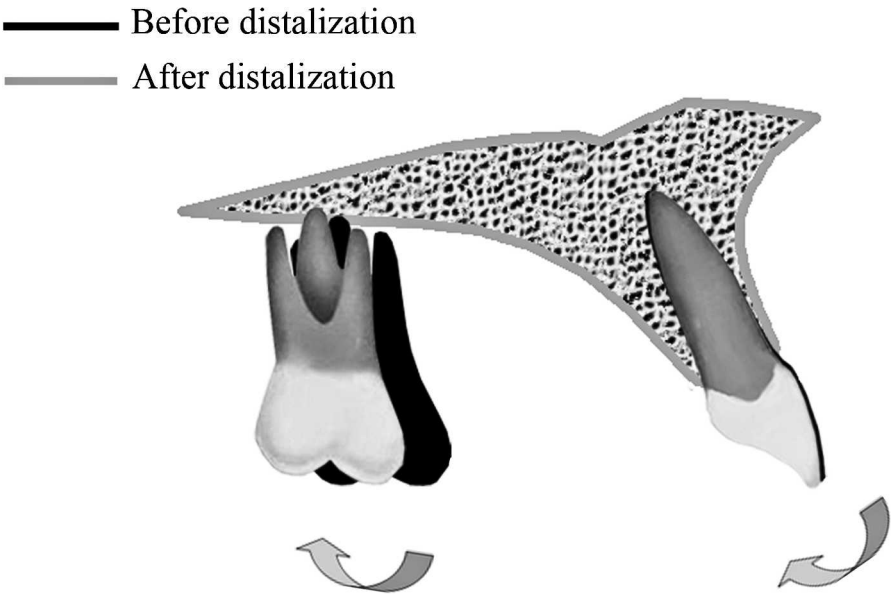


**Figure 9.** Schematic illustration of the dentoalveolar changes due to the distalization.

**Table 1.** Skeletal, dentoalveolar, and soft tissue changes due to the distalization by means of Zygoma-Gear Appliance

| Measurements | Before Distalization | After Distalization | Mean Difference | *P* |
|---|---|---|---|---|
| **Skeletal** | | | | |
| **SNA (°)** | 78.63±4.71 | 77.9±4.46 | −0.73±0.41 | NS |
| **SNB (°)** | 74.83±4.65 | 74.16±4.76 | −0.67±0.37 | NS |
| **ANB (°)** | 3.8±1.53 | 3.73±1.61 | −0.06±0.25 | NS |
| **A-Nvert (mm)** | 3.53±4.6 | 3.16±4.53 | −0.36±0.48 | NS |
| **Pg-Nvert (mm)** | 5.73±6.81 | 5±6.71 | −0.73±1.28 | NS |
| **MP-PP (°)** | 22.06±5.74 | 21.7±6.93 | −0.36±1.24 | NS |
| **SN-MP (°)** | 32.03±5.91 | 31.8±6.99 | −0.23±1.16 | NS |
| **FMA (°)** | 20.8±6.06 | 19.63±5.73 | −1.16±1.57 | NS |
| **SN-PP(°)** | 9.06±2.38 | 9.03±2.42 | −0.03±0.38 | NS |
| **N-ANS (mm)** | 56.56±2.97 | 56.96±3.22 | 0.40±0.35 | NS |
| **ANS-Me (mm)** | 69.23±6.04 | 69.8±6.7 | 0.56±0.47 | NS |
| **N-Me (mm)** | 123.7±7.03 | 124.76±7.4 | 1.06±1.30 | NS |
| **S-Go (mm)** | 84.23±6.32 | 84.6±7.34 | 0.36±0.77 | NS |
| **HRL-A (mm)** | 30.46±5.19 | 30.1±6.54 | −0.36±0.17 | NS |
| **HRL-B (mm)** | 68.4±7.22 | 68.9±7.44 | 0.50±0.40 | NS |
| **HRL-Pg (mm)** | 83.56±6.85 | 84.16±7.52 | 0.60±0.85 | NS |
| **VRL-A (mm)** | 56.16±3.36 | 56.63±4.09 | 0.46±0.12 | NS |
| **VRL-B (mm)** | 49.6±4.62 | 50.46±5.13 | 0.86±0.56 | NS |
| **VRL-Pg (mm)** | 54.0±9.21 | 54.66±5.83 | 0.66±0.68 | NS |
| **Dentoalveolar** | | | | |
| **Overbite (mm)** | 4.53±1.7 | 5±1.71 | 0.46±0.31 | NS |
| **Overjet (mm)** | 6.73±3.47 | 6.23±3.6 | −0.50±0.22 | NS |
| **Wits** | 6.56±3.82 | 5.43±3.74 | −1.13±1.55 | 0.013* |
| **U1-PP (°)** | 111.43±6.71 | 110.63±8.04 | −0.80±0.57 | NS |
| **L1-MP (°)** | 96.2±5.01 | 96.33±4.93 | 0.13±0.29 | NS |
| **HRL-U1 (mm)** | 54.06±5.7 | 54.93±5.76 | 0.86±0.58 | NS |
| **HRL-U6 (mm)** | 48.9±4.98 | 48.4±4.69 | −0.50±0.46 | NS |
| **HRL-U1 (°)** | 113.6±7.71 | 112.26±7.32 | −1.33±0.97 | NS |
| **HRL-U6 (°)** | 104.46±13.95 | 101.16±17.52 | −3.30±2.31 | NS |
| **VRL-U1 (mm)** | 62.26±4.51 | 62.86±4.56 | 0.60±0.98 | NS |
| **VRL-U6 (mm)** | 32.03±4.01 | 27.66±4.17 | −4.36±2.15 | 0.000*** |
| **Soft Tissue** | | | | |
| **UL-E plane (mm)** | 3.36±1.88 | 3.46±2.15 | 0.10±0.87 | NS |
| **LL-E plane (mm)** | 2.33±2.72 | 2.56±2.73 | 0.23±0.90 | NS |
| **Nasolabial angle (°)** | 121.26±11.41 | 120.16±11.73 | −1.10±4.05 | NS |

month by using intraosseous screw-supported anchorage; Escobar et al.[33] found 0.77 mm per month with the bone-supported pendulum; and Oberti et al.[37] found 1.18 mm per month with a bone-supported molar distalizing appliance.

Karlsson and Bondemark[6] showed that it is more effective to distalize the maxillary first molars before the second molars have erupted. In addition, it is recommended to extract the third molars before distalization. In this study, all second molars were erupted and none of the third molars were extracted before the distalization. Furthermore, an effective distalization was achieved in all patients treated with ZGA.

The amount of maxillary molar inclination in the present study was smaller than that described in previous studies[32,33,36] describing more than 9° molar inclination with other implant-supported distalization appliances. In this study, the vector of the distalizing force was located close to the center of the resistance of the maxillary first molars, and the force vector of the ZGA could be adjusted to obtain bodily molar movements by changing the level of the zygomatic anchor hooks and the height of the inner bow hooks. Therefore, the amount of the maxillary molar inclination was 3.30° ± 2.31°, representing a lower amount than described in the previously published data.

Suguwara et al.[22] and Kaya et al.[23] used zygomatic anchorage for molar distalization and found approximately 3.50 mm in 19 months and 4.5–5 mm in 9 months, respectively. In both studies, buccal segmental distalization was performed, and different skeletal malocclusions (Class I, II, III and open bite) (with an average participant age of 23.1 years) were included in the study of Suguwara et al.[22] These might be possible factors for the different findings. Yamada et al.[38] used miniscrew anchorage in the buccal interradicular region for distalization. Although the authors stated that successful molar distalization of 2.8 mm without patient compliance and with no undesirable side effects was achieved, this amount is less than the ZGA amount. In addition, it is difficult to use the mechanism of Yamada et al.[38] for patients requiring more than 3 mm of molar distalization.

It is recommended[23] that following the distalization, the molars not be used for distalization and retraction of the other teeth. With the ZGA, the molars are never required for anchorage during the retraction of the premolars and anterior teeth since the orthodontic forces can be provided directly from the zygomatic anchor plates. In addition, the maxillary central incisors were retruded after distalization, showing that there was no anchorage loss by using the ZGA. On the contrary, first and second premolars moved distally via transeptal fibers, as seen in the patient shown in Figure 4.

Suguwara et al.[22] indicated that the patients with open bite could be treated with the skeletal anchorage system using the zygomatic process. In agreement with those authors, we found that maxillary molars were intruded (0.50 mm) by ZGA. Additionally, there was an approximately 1 mm ($P < .05$) change in the Wits distance, and this change might have occurred because the maxillary first molars tipped, since Wits distance depends on the occlusal plane change. The vertical measurements were not increased as a result of the ZGA (Table 1). This is in agreement with the findings of Suguwara et al.[22] and Kaya et al.,[23] who used the zygomatic anchorage. However, previous distalization mechanics with and without mini-implants showed the increase in vertical measurements.[13,32,35,37]

## CONCLUSIONS

- The maxillary molars were distalized into a Class I relationship in all patients in a short time despite the presence of the maxillary second and third molars.
- The rate for the distal movement of the molars was 0.84 mm per month without anchorage loss, while distal tipping measured only 3.30°.

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