*Original Article*

# Orthopedic Treatment of Skeletal Class III Malocclusions With Maxillary Deficiency

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**ABSTRACT**

**Objective:** The purpose of this study was to compare the treatment effects of a double-plate appliance (DPA) and a double-plate appliance and facemask combination (DPA-FM) in correcting Class III malocclusions.

**Materials and Methods:** The material consisted of lateral cephalometric radiographs of 40 children with skeletal and dental Class III malocclusion. In the first treatment group, 13 patients (mean age: 10 years 3 months) were treated with DPA. In the second treatment group, 15 patients (mean age: 10 years 9 months) were treated with DPA-FM. In the third group, 12 patients (mean age: 10 years 6 months) were observed without treatment for 9 months. Statistical evaluation was made by ANOVA, Duncan, and paired *t* tests.

**Results:** The increases in SNA and ANB angles were significantly greater in the DPA-FM group than in the DPA group. The proclination of upper incisors (U1/NA) and retroclination of lower incisors (L1/NB) were significantly greater in the DPA group than in the DPA-FM group. The retroclination of lower incisors (L1/NB) in the DPA group showed a significant difference compared with the control group. The increase in ANS-Me length was significantly greater in the DPA-FM group than in the control group.

**Conclusion:** The DPA-FM treatment was more effective in sagittal correction of the maxilla than the DPA treatment. The dental contribution to Class III treatment seemed to be greater in the DPA group, but in this group vertical skeletal changes were more satisfying. (*Turkish J Orthod* 2015;28:19–25)

**KEY WORDS:** Class III, Double-plate appliance, Face mask

## INTRODUCTION

Skeletal Class III malocclusions can be defined as skeletal facial deformities characterized by maxillary growth deficiency, mandibular growth excess, or a combination of both.[1,2] In growing patients with Class III malocclusion and maxillary deficiency, different extraoral and intraoral appliances stimulate the protraction of the maxilla by modifying the growth.[3–13] However, poor patient cooperation is one of the most common problems in extraoral appliances. Many intraoral functional appliances are used in skeletal Class III treatment, such as Frankel III,[4,11] Bionator III,[5] two-piece corrector,[7] mini maxillary protraction appliance,[8] modified tandem traction bow appliance,[10] removable mandibular retractor,[12] and double-plate appliance (DPA).[13]

Class III malocclusion has been corrected mainly by maxillary protraction with the DPA, which was designed as intraoral opposed angulated acrylic blocks.[13] The DPA has also been reported to have less skeletal and more dental contribution to Class III treatment in sagittal direction than face-mask therapy; however, in this group, less increase in the vertical dental and skeletal parameters were also found.[13] Furthermore, previous studies showed that skeletal Class III malocclusion was treated by maxillary sagittal development while controlling vertical dimensions with a DPA and face mask (DPA-FM) combination.[9,14] No previous study has

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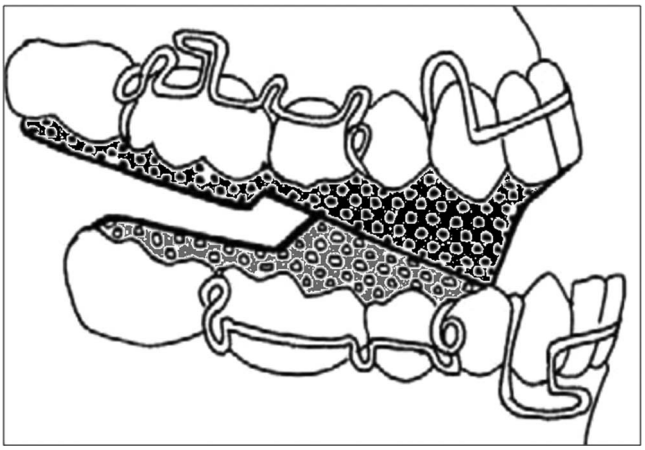

**Figure 1.** Design of the double-plate appliance.

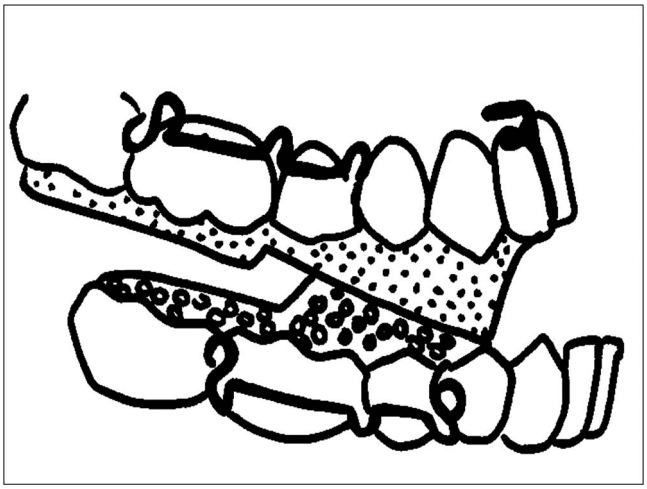

**Figure 2.** Intraoral design of the double-plate appliance and face mask combination.

compared these appliances in literature, so we aimed to compare the effects of the double DPA and the DPA-FM combination in treating skeletal Class III malocclusions.

## MATERIALS AND METHODS

This retrospective study was carried out using pretreatment (T1) and posttreatment (T2) lateral cephalograms of 40 patients with skeletal and dental Class III malocclusion (ANB$<0^0$) due to maxillary retrusion (SNA$<82^0$) or a combination of maxillary retrusion and mandibular protrusion (SNA$<82^0$, SNB$>80^0$) with optimum mandibular plane angle ($26^0$<SN/GoGn<38°) chosen from the archives of the Department of Orthodontics of the university.

In the first treatment group, 13 patients (mean age: 10 years 3 months) wore a DPA with 2 Class III elastics, which exerted a force of 350–400 g. The patients were instructed to wear the appliance day and night except during meals. The construction bites were taken without sagittal activation and with a 5- to 6-mm vertical opening at the molar region. The appliances had modified Adams clasps at the molar region and lower labial bows at the anterior region with hooks for Class III elastics (Fig. 1). Acrylic blocks had an angulation from the upper molar mesial margin to the lower cuspid. At the beginning of treatment and every 3 weeks during treatment, 2 mm was trimmed from the posterior region of the lower angulated acrylic block and the anterior region of the upper angulated acrylic block to allow the free sliding of the upper and lower pieces.

In the second treatment group (DPA-FM) 15 patients (mean age: 10 years 9 months) wore a DPA and a Delaire type facemask. The appliances had modified F clasps between the upper lateral incisors and canines for extraoral elastics (Fig. 2). The protraction elastics were attached to the F clasps, and a force of 350–400 g per side was applied. The patients were instructed to wear the appliance approximately 16 hours a day.

The treatment groups were compared with an untreated control group of 12 patients (mean age: 10 years 6 months). The mean treatment and observation periods were 9 months for all groups.

All patients were matched according to SNA, SNB, and SN/GoGn angles at the beginning and no significant differences were found in these parameters among the groups.

Lateral cephalograms were taken before treatment (T1) and after achieving a positive overjet and/or a Class I molar occlusion (T2). Nine linear (Figure 3) and 12 angular (Figure 4) measurements were evaluated. The lateral cephalometric radiographs of 20 subjects were retraced, and measurements were repeated after 15 days. Method error coefficients were calculated and found to be within acceptable limits (range: 0.98–1.00).

Statistical analysis was performed with SPSS, version 15.0 (Chicago, IL, USA). Analysis of variance and Duncan test were used to compare differences between the groups and a paired *t* test was used to evaluate the treatment effects and changes during the observation period in each group. The level of significance used was $p < 0.05$.

## RESULTS

Descriptive data and treatment/observation changes in groups from T1 to T2 were given in

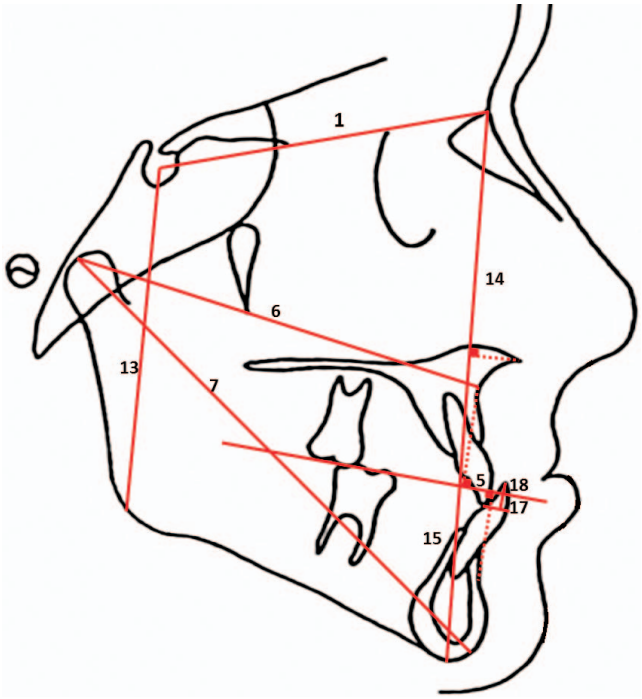


**Figure 3.** Linear measurements.

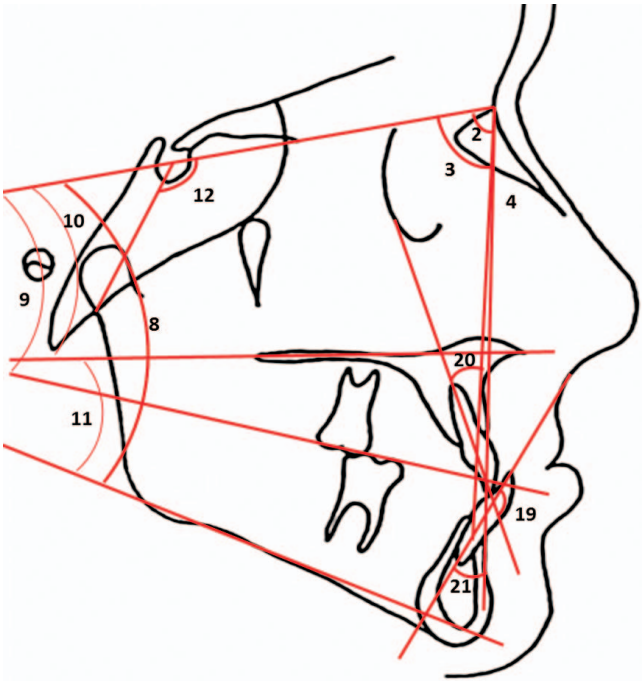


**Figure 4.** Angular measurements.

Table 1. Statistical comparisons for cephalometric changes among the groups were given in Table 2.

In the DPA group, significant increases in S-N length, SNA angle, ANB angle, and Wits appraisal ($p<0.001$) were observed. During treatment, Co-A and Co-Gn lengths increased significantly ($p<0.001$ and $p<0.01$, respectively). A significant decrease in SN/occlusal plane angle ($p<0.05$) was found. Although significant increases in N-Me ($p<0.01$) and ANS-Me lengths ($p<0.001$) were observed, a nonsignificant change was observed in Jarabak ratio (S-Go/N-Me). The increase in overjet and the decrease in overbite were found to be statistically significant ($p<0.001$ and $p<0.01$, respectively). Proclination of the maxillary incisors (U1/NA) and retroclination of the mandibular incisors (L1/NB) in the DPA group were statistically significant ($p<0.001$). A significant decrease in lower lip-S line was observed ($p<0.01$; Table 1).

In the DPA-FM group, a significant increase in S-N length ($p<0.05$) as well as SNA angle, ANB angle, and Wits appraisal ($p<0.001$) was observed. During treatment, significant increases in Co-A and Co-Gn lengths were observed ($p<0.001$ and $p<0.01$, respectively). A significant decrease in SN/ANS-PNS angle ($p<0.01$) and a significant increase in ANS-PNS/Go-Me angle ($p<0.05$) were observed. Although significant increases were observed in S-Go ($p<0.01$), N-Me ($p<0.001$), and ANS-Me ($p<0.001$) lengths, a nonsignificant change was observed in Jarabak ratio. The increase in overjet and the decrease in overbite were found to be statistically significant ($p<0.001$ and $p<0.01$, respectively). Decrease in interincisal angle (U1/L1) ($p<0.01$) and proclination of maxillary incisors (U1/NA) ($p<0.001$) in the DPA-FM group were statistically significant (Table 1).

In the control group, significant increases in S-N length ($p<0.01$) and SNB angle ($p<0.05$) were observed. The Co-A and Co-Gn lengths increased significantly ($p<0.05$ and $p<0.01$, respectively). A significant decrease in SN/occlusal plane angle ($p<0.05$) as well as significant increases in S-Go ($p<0.01$), N-Me ($p<0.001$), and ANS-Me ($p<0.05$) lengths were found (Table 1).

### Comparison Among the Groups

Increases in SNA angle, ANB angle, and Wits appraisal and a decrease in SNB angle in both treatment groups showed significant differences compared with the control group ($p<0.05$). Changes with both treatment alternatives in overbite, overjet, ANS-PNS/Go-Me, and U1/NA angles were significantly different compared with the control group ($p<0.05$). The increases in SNA and ANB angles were significantly greater in the DPA-FM

**Table 1.** Treatment changes of double plate appliance and double plate appliance-facemask groups and observation period changes of control group

| | Cephalometric Measurements | DPA | | | | | DPA-FM | | | | | Control | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | X1 | Sx1 | X2 | Sx2 | p | X1 | Sx1 | X2 | Sx2 | p | X1 | Sx1 | X2 | Sx2 | p |
| 1 | S-N (mm) | 67,25 | 3,70 | 68,05 | 3,61 | *** | 67,60 | 3,54 | 69,21 | 3,29 | * | 65,69 | 3,10 | 66,73 | 3,08 | ** |
| 2 | SNA ($^0$) | 78,08 | 3,44 | 79,23 | 3,56 | *** | 77,20 | 3,17 | 79,77 | 3,01 | *** | 78,63 | 2,91 | 78,96 | 3,51 | |
| 3 | SNB ($^0$) | 79,35 | 4,07 | 78,66 | 4,09 | | 79,87 | 3,37 | 79,47 | 3,44 | | 81,55 | 3,89 | 82,07 | 3,78 | * |
| 4 | ANB ($^0$) | −1,25 | 0,97 | 0,57 | 1,19 | *** | −2,67 | 2,01 | 0,30 | 1,99 | *** | −2,93 | 1,63 | −3,08 | 1,42 | |
| 5 | Wits appraisal (mm) | −7,16 | 2,95 | −3,34 | 2,91 | *** | −7,53 | 2,52 | −4,80 | 1,96 | *** | −9,31 | 2,85 | −8,78 | 2,06 | |
| 6 | Co-A (mm) | 78,78 | 4,52 | 81,08 | 4,25 | *** | 82,40 | 5,95 | 85,83 | 6,05 | *** | 78,26 | 2,80 | 79,32 | 3,34 | * |
| 7 | Co-Gn (mm) | 109,68 | 5,59 | 111,35 | 5,85 | ** | 113,70 | 7,70 | 115,57 | 7,93 | ** | 110,03 | 4,08 | 112,58 | 5,28 | ** |
| 8 | SN/GoGn ($^0$) | 33,59 | 4,31 | 33,79 | 4,86 | | 32,30 | 3,82 | 32,93 | 3,88 | | 31,93 | 3,81 | 31,83 | 3,64 | |
| 9 | SN/Occ Plane ($^0$) | 19,66 | 4,34 | 17,13 | 4,92 | * | 16,80 | 3,62 | 16,37 | 4,60 | | 18,90 | 5,56 | 17,18 | 4,51 | * |
| 10 | SN/ANS-PNS ($^0$) | 3,47 | 3,89 | 2,38 | 3,60 | | 7,97 | 2,97 | 6,11 | 2,88 | ** | 2,72 | 2,75 | 2,51 | 3,56 | |
| 11 | ANS-PNS/GoMe ($^0$) | 24,65 | 3,10 | 25,62 | 3,89 | | 26,90 | 4,63 | 28,39 | 4,59 | * | 23,19 | 4,99 | 22,37 | 4,38 | |
| 12 | Saddle ($^0$) | 123,32 | 6,63 | 123,17 | 6,24 | | 124,80 | 5,66 | 125,07 | 5,70 | | 122,83 | 4,02 | 123,32 | 3,90 | |
| 13 | S-Go (mm) | 76,28 | 3,59 | 77,28 | 4,04 | | 75,47 | 4,98 | 77,36 | 5,23 | ** | 72,43 | 3,63 | 74,43 | 3,41 | ** |
| 14 | N-Me (mm) | 117,02 | 7,23 | 119,05 | 7,00 | ** | 116,50 | 8,74 | 119,54 | 8,45 | *** | 109,84 | 3,94 | 112,78 | 4,40 | *** |
| 15 | ANS-Me(mm) | 64,48 | 3,11 | 66,52 | 3,56 | *** | 64,10 | 7,01 | 66,79 | 6,83 | *** | 61,04 | 3,57 | 62,16 | 4,34 | * |
| 16 | Jarabak Ratio | 65,28 | 3,78 | 65,04 | 4,28 | | 64,73 | 2,86 | 66,61 | 7,98 | | 65,98 | 3,16 | 66,03 | 2,65 | |
| 17 | Overjet (mm) | −2,63 | 0,93 | 3,99 | 1,46 | *** | −2,40 | 1,58 | 2,87 | 1,59 | *** | −2,44 | 0,79 | −2,54 | 0,96 | |
| 18 | Overbite (mm) | 2,97 | 1,79 | 1,43 | 1,81 | ** | 2,53 | 1,92 | 1,37 | 1,51 | ** | 3,43 | 2,39 | 3,96 | 2,61 | |
| 19 | U1/L1 ($^0$) | 136,53 | 6,47 | 134,15 | 9,48 | | 139,53 | 8,53 | 133,10 | 5,28 | ** | 140,33 | 8,17 | 140,83 | 6,50 | |
| 20 | U1/NA ($^0$) | 20,64 | 4,80 | 27,71 | 5,63 | *** | 23,57 | 4,77 | 26,43 | 4,23 | *** | 22,50 | 5,09 | 22,18 | 4,92 | |
| 21 | L1/NB ($^0$) | 24,01 | 3,40 | 17,54 | 6,03 | *** | 20,53 | 5,15 | 20,03 | 5,24 | | 20,08 | 4,89 | 20,08 | 4,35 | |

DPA indicates double plate appliance; DPA-FM, double plate appliance-facemask; X1, pretreatment/preobservation mean; Sx1, standard error of pretreatment/preobservation mean; X2, posttreatment/postobservation mean; Sx2, standard error of posttreatment/postobservation mean.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

group than in the DPA group ($p<0.05$). The increases in Co-A and ANS-Me lengths and the decrease in interincisal angle (U1/L1) were greater in the DPA-FM group than in the control group ($p<0.05$). The proclination of upper incisors (U1/NA) and retroclination of lower incisors (L1/NB) were significantly greater in the DPA group than in the DPA-FM group ($p<0.05$). The retroclination of the lower incisors in the DPA group showed a significant difference compared with the control group ($p<0.05$, Table 2).

## DISCUSSION

A review of the literature shows that in treating Class III malocclusions, maxillary protraction treatment with several extraoral and intraoral orthopedic devices improves the skeletal relationship by anterior displacement of the maxilla and/or redirection of the mandibular position.[4–14] Successful Class III treatment with either DPA or DPA-FM appliances were reported, however to our knowledge no comparative studies were found in the literature. So, this study aimed to compare the dentofacial effects of the DPA and DPA-FM therapies in treating Class III malocclusions.

In this study, significant increases in SNA angle and CoA length showed that maxillary growth was stimulated in both DPA and DPA-FM groups. In previous DPA and DPA-FM studies, treatment also resulted in significant increases in Co-A and SNA.[9,13,14] Concomitant with this finding, Class III malocclusions have been successfully treated with anterior replacement of maxilla in several studies of face masks and functional appliances.[5,10,11,13,15–17] In contrast with this, Chong *et al.*[18] found that sagittal changes of the maxilla were not significant after face-mask therapy. As significantly greater increases in SNA and ANB angles were found in the DPA-FM group in this study, DPA-FM therapy seemed to be more effective in stimulating maxillary growth than DPA. Üçem *et al.*[13] reported that face-mask treatment was more effective than DPA

**Table 2.** Comparison of treatment/observation changes among the groups

| | Cephalometric Measurements | DPA (1) | | DPA-FM (2) | | Control (3) | | *p* | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | D | Sx | D | Sx | D | Sx | 1-2 | 1-3 | 2-3 |
| 1 | S-N (mm) | 0,80 | 0,50 | 1,14 | 1,18 | 1,03 | 0,89 | | | |
| 2 | SNA ($^0$) | 1,15 | 0,87 | 2,54 | 0,84 | 0,33 | 0,97 | * | * | * |
| 3 | SNB ($^0$) | −0,68 | 1,14 | −0,32 | 1,22 | 0,52 | 0,62 | | * | * |
| 4 | ANB ($^0$) | 1,82 | 0,60 | 2,86 | 1,06 | −0,14 | 0,74 | * | * | * |
| 5 | Wits appraisal (mm) | 3,82 | 1,91 | 2,79 | 1,83 | 0,53 | 1,60 | | * | * |
| 6 | Co-A (mm) | 2,30 | 1,49 | 3,29 | 2,36 | 1,06 | 1,22 | | | * |
| 7 | Co-Gn (mm) | 1,67 | 1,56 | 1,86 | 2,44 | 2,55 | 1,82 | | | |
| 8 | SN/GoGn ($^0$) | 0,20 | 1,81 | 0,64 | 1,50 | −0,10 | 0,90 | | | |
| 9 | SN/Occ Plane ($^0$) | −2,53 | 3,04 | −0,64 | 2,13 | −1,72 | 2,13 | | | |
| 10 | SN/ANS-PNS ($^0$) | −1,09 | 2,80 | −1,50 | 1,49 | −0,21 | 3,52 | | | |
| 11 | ANS-PNS/GoMe ($^0$) | 0,97 | 1,64 | 1,43 | 1,99 | −0,83 | 2,11 | | * | * |
| 12 | Saddle ($^0$) | −0,15 | 1,82 | 0,46 | 1,73 | 0,49 | 1,67 | | | |
| 13 | S-Go (mm) | 0,99 | 1,82 | 1,86 | 1,78 | 2,01 | 1,46 | | | |
| 14 | N-Me (mm) | 2,03 | 1,63 | 3,07 | 2,43 | 2,93 | 1,34 | | | |
| 15 | ANS-Me(mm) | 2,03 | 1,29 | 2,54 | 2,17 | 1,12 | 1,36 | | | * |
| 16 | Jarabak Ratio | −0,25 | 1,20 | 1,84 | 8,15 | 0,05 | 1,12 | | | |
| 17 | Overjet (mm) | 6,62 | 1,57 | 5,43 | 2,48 | −0,10 | 0,80 | | * | * |
| 18 | Overbite (mm) | −1,54 | 1,48 | −1,04 | 1,46 | 0,53 | 1,15 | | * | * |
| 19 | U1/L1 ($^0$) | −2,39 | 4,78 | −5,61 | 5,64 | 0,49 | 5,16 | | | * |
| 20 | U1/NA ($^0$) | 7,07 | 3,84 | 2,87 | 3,41 | −0,32 | 4,34 | | | |
| 21 | L1/NB ($^0$) | −6,47 | 4,50 | −0,50 | 3,54 | −0,01 | 3,00 | | | |

DPA indicates double plate appliance; DPA-FM, double plate appliance-facemask; D, mean difference; Sx, standard error of mean difference.

* $p < 0.05$.

treatment in achieving maxillary protraction. In contrast, Tollaro *et al*.[19] found increased maxillary protrusion with the early functional treatment of Class III malocclusion.

In this study, nonsignificant decreases in the SNB angle in both groups were significantly different compared with the significant increase in the control group. It could be concluded that the main effect of both DPA and DPA-FM therapies was advancement of the maxilla. These findings are in accordance with some DPA, DPA-FM, and face-mask studies.[13,14,20,21] In contrast with this finding, backward rotation associated with a reduction in mandibular growth has been reported with some functional appliances in treating Class III malocclusions.[5,10,11] Furthermore, most face-mask studies have reported a significant decrease in SNB angle due to the maxillary anterior rotation and mandibular backward rotation.[6,15,17,22–24]

The ANB angle and Wits appraisal showed significant increases in both treatment groups, and a significant difference was found in these parameters compared with the control group. So, both DPA and DPA-FM are effective in treating subjects with Class III malocclusion. Successful treatment of Class III malocclusion was demonstrated by the increase in ANB angle in the previous investigations that aimed to correct Class III malocclusion.[5,6,10,11,16,18,22–24] Our result is in contrast with the findings of Falck and Zimmermann-Menzel,[25] who reported a significant decrease in ANB angle using the FR-3 appliance, which was less than in the control group.

Although the increase in anterior face height (ANS-Me) was significant in both DPA and DPA-FM groups, the Jarabak ratio and SN/GoGn angle did not change significantly. In contrast with these findings, several studies showed that the mandible was rotated posteriorly by the functional orthopedic appliances, resulting in a significant increase in SN/GoGn angle.[5,6,10,15,18,22,23] Cozza *et al*.[26] reported that the posterior rotation of the mandible was prevented by the use of a bite block with the face mask. Increase in lower facial height (ANS-Me) was significantly greater in the DPA-FM group than in the control group in the present study, which might be related to the significant anterior rotation of maxilla (SN/ANS-PNS). The anterior rotation of the maxilla

was also reported in several face-mask studies.[17,26–28] Palatomandibular plane angle (ANS-PNS/Go-Me) increased significantly in only the DPA-FM group. However, increases in this angle in both treatment groups were significantly different compared with the nonsignificant decrease in the control group, which might be attributed to nonsignificant changes occurring in the palatal and mandibular planes. Vertical skeletal changes seemed to be more satisfying in the DPA group.

Labioversion of the upper incisor was significant in both treatment groups and was significantly different compared with the control group. In agreement with this study, Class III treatment studies with face mask and functional appliances have showed significant protrusion of the upper incisors.[10,11,17] Labioversion of the upper incisor was significantly greater in the DPA group than in the DPA-FM group. Retroclination of the lower incisor was significant in the DPA group only and was significantly different compared with the DPA-FM and control groups, which might be related to the lower labial bow's retraction by intraoral elastics in the DPA group. In the DPA-FM group, retrusion of the lower incisor was not significantly different compared with the control group, as the contact of the lower incisors to the acrylic surface of the DPA probably prevented the retrusion effect of the face mask. In several face-mask studies, proclination of the maxillary incisors and retroclination of the mandibular incisors were reported.[13,15,18] In contrast, Cozza *et al*.[26] reported nonsignificant protraction of the maxillary incisors or retrusion of the mandibular incisors with face mask and a bite-block appliance.

The improvement in overjet was significantly greater in the treatment groups compared with the control group because of the dental and skeletal changes achieved by the DPA and DPA-FM treatments. However, changes in upper and lower incisors seemed to be more effective in the increase of overjet in the DPA group. Westwood *et al*.[29] reported that positive overjet was maintained by the skeletal changes and retrusion of lower incisors with face-mask therapy. Protrusion of the upper incisor with the modified tandem traction bow appliance was reported to contribute to the positive overjet in addition to the skeletal changes.[10,30] Concomitant with our study, Seehra *et al*.[31] found no significant difference in overjet between the face mask and reverse twin block therapies. The significant decrease in overbite in the treatment groups might be due to maxillary incisor protrusion and increases in lower facial height. The significant retrusion of lower lip in the DPA group might be attributed to the significant lower incisor retrusion.

## CONCLUSIONS

Both appliances were effective in the treatment of Class III malocclusions. The DPA-FM treatment was more effective in sagittal correction of the maxilla than the DPA treatment. The dental contribution to Class III treatment seemed to be greater in the DPA group, but, at the same time, vertical skeletal changes were more satisfying in this group.

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