Original Article

Comparison of the effects of face mask treatment started simultaneously and after the completion of the alternate rapid maxillary expansion and constriction procedure

Bilge H. Canturk[a]; Mevlut Celikoglu[b]

ABSTRACT

Objective: To test the null hypothesis that there were significant differences for skeletal, dentoalveolar, and soft tissue changes induced by face mask (FM) started simultaneously and after an alternate rapid maxillary expansion and constriction (Alt-RAMEC) procedure.

Materials and Methods: Thirty-six patients with Class III malocclusion due to maxillary deficiency were randomly assigned to Group I (FM started after the completion of the Alt-RAMEC) and Group II (FM started simultaneously with the Alt-RAMEC). The screw of the RME appliance was alternately activated and deactivated twice daily (0.20 mm per turn) for 1 week over the course of 8 weeks. The changes observed in both groups were assessed using the cephalometric lateral films and statistically evaluated using the paired *t*-test and Student's *t*-test.

Results: Thirty patients completed the present prospective study. No significant differences were observed between the groups. Class III malocclusion and negative overjet were improved by means of skeletal changes in conjunction with upper incisor proclination in both groups. Skeletal contribution to overjet correction in Groups I and II was 91.70% and 86.10%, respectively. Maxilla showed a forward movement of 3.84 mm and 3.02 mm in Groups I and II, respectively.

Conclusions: The null hypothesis was rejected. Both groups showed similar results, and, thus, waiting until completion of the Alt-RAMEC procedure for the FM treatment is not necessary. (*Angle Orthod.* 2015;85:284–291.)

KEY WORDS: Class III; Maxillary protraction; Alt-RAMEC; Face mask

INTRODUCTION

Class III malocclusion is considered to be among the most challenging orthodontic problems in orthodontics and is characterized by maxillary retrognathism, mandibular prognathism, retrusive mandibular dentition, protrusive maxillary dentition, and a combination of these components.[1,2] Its prevalence was reported to be approximately 1–5% in White populations,[3] while this prevalence was as high as 14% for Asian populations[4] and 16.7% for orthodontic populations.[5]

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Face mask (FM) treatment combined with rapid maxillary expansion (RME) was shown to be a valuable treatment option for the growing patient with Class III malocclusion associated with maxillary deficiency.[6–9] A review of the literature reveals that acceleration of forward growth of the maxilla (with a counterclockwise rotation), forward movement of the maxillary dentition, backward movement of the mandible (with a clockwise rotation), and backward movement of the mandibular dentition were observed using different maxillary protraction appliances with and/or without RME.[6–12]

RME has been recommended as a routine part of Class III correction, even in the absence of maxillary constriction, since it disarticulates the maxilla and initiates cellular response in the circummaxillary sutures, allowing a more positive reaction to protraction forces.[10,12,13] However, the effects of the RME on maxillary protraction have been disputed. Baik[6] and Sung and Baik[14] showed statistically significant greater forward and downward movement of point A in the FM/RME group compared to the FM group. Recently,

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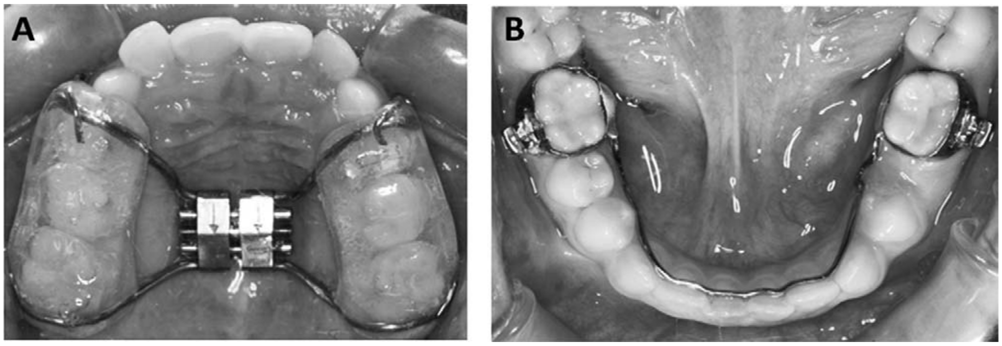

Figure 1. Intraoral photographs of a patient's (A) RME appliance and (B) lingual arch.

Yavuz et al.[8] reported that the RME procedure did not specifically aid FM therapy in the correction of Class III malocclusion. In addition, circummaxillary sutures were found to be less disarticulated with the use of RME compared to the use of alternate RME and constriction (Alt-RAMEC),[15–17] which was firstly presented by Liou.[16]

The effectiveness of FM combined with the Alt-RAMEC procedure was reported in patients affected by clefts as 5.8 mm movement of point A.[15] Isci et al.[18] reported that the anterior movement of point A was approximately twice in the Alt-RAMEC group (4.13 mm) compared to the RME group (2.33 mm). Recently, Kaya et al.[19] assessed the effects of FM therapy anchored with miniplates after Alt-RAMEC procedure without using any control group. None of the previous studies compared the effects of maxillary protraction started simultaneously and after the Alt-RAMEC procedure. Therefore, the present prospective study aimed to test the null hypothesis that there were significant differences for skeletal, dentoalveolar, and soft tissue changes induced by maxillary protraction started simultaneously and after the Alt-RAMEC procedure.

MATERIALS AND METHODS

Ethical approval for the present prospective study was obtained from the Ethical Committee of the Karadeniz Technical University, and an informed consent form was signed by the parents of the children included in the study. The sample size was calculated based on a significance level of .05 and a power of 80% to detect a clinically meaningful difference of 1 mm ($\pm$0.98 mm)[12] for the distance from point A to the vertical reference plane between the groups. The power analysis showed that 16 patients in each group were required. To increase the power of the study and to compensate for possible dropouts during the study period, it was decided to include more patients.

In order to obtain 32 patients that matched the criteria to comprise the study sample, two clinicians simultaneously examined the initial data of 42 patients with Class III malocclusion. Inclusion criteria were as follows: (1) skeletal Class III malocclusion (ANB angle $< 0^\circ$) and negative overjet; (2) vertically normal growth pattern (SN–GoMe $= 32^\circ \pm 6$)[20]; (3) no signs of functional Class III malocclusion; (4) early stages of cervical vertebral maturation detected using the Lamparski method[21]; and (5) no history of temporomandibular disorders, congenital deformities, or previous orthodontic treatment. Thirty-six patients who met the above criteria were divided into two groups using a randomization method with pitch and toss. Three patients in each group discontinued the treatment, and ultimately 15 patients in each group were analyzed (Figure 1). Group I consisted of 15 patients (seven females and eight males; mean age 11.27 $\pm$ 1.26 years) who had maxillary protraction after Alt-RAMEC completed, and Group II consisted of 15 patients (nine females and six males; mean age 10.53 $\pm$ 1.50 years) who had maxillary protraction started simultaneously with the Alt-RAMEC procedure. All patients were treated by the same clinician.

A modified RME and lingual arch appliances were constructed for each patient in the maxilla and mandible, respectively (Figure 2). The screw of the RME appliance was alternately activated and deactivated twice daily (0.20 mm per turn) for 1 week over the course of 8 weeks. After the Alt-RAMEC procedure was completed, the activation of the screw was continued until the crossbite was overcorrected for the patients with posterior crossbite (two patients in Group I), and it was activated for 1 week for the patients without crossbite (13 patients in Group I and 15 patients in Group II). In both groups, a Petit-type FM was used (Figure 3), and a maxillary protraction force of 500 g per side with an anteroinferior force vector of approximately 30° to the occlusal plane was applied from the hooks placed in the canine region on the buccal sides of the expanders. The patients were instructed to wear the appliances for at least 20 hours per day until at least a 2-mm positive overjet was achieved, and the parents were asked to replace the

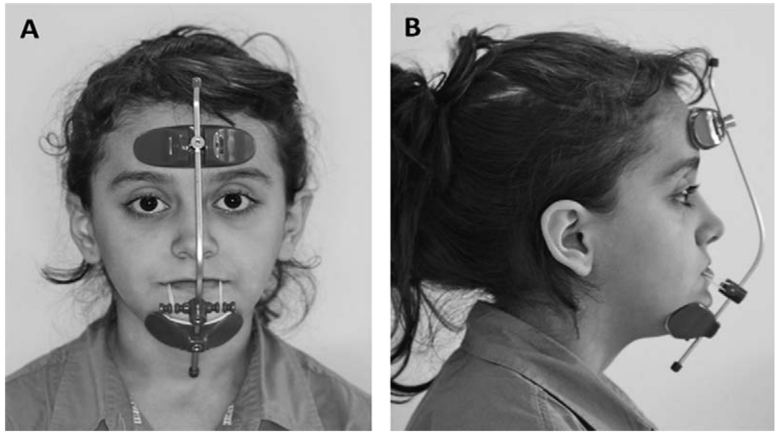

Figure 2. Extraoral photograph of the Petit-type face mask used in the study.

elastics at least once a day and to record the daily use of the appliances.

Standardized lateral cephalograms were taken by an experienced technician at the beginning and end of the FM using the same cephalostat (Siemens Nanodor 2, Siemens AG, Munich, Germany). Frankfort Horizontal Plane was used as the *x*-axis (HRL), and a perpendicular line (VRL), passing through the pterygomaxillare to the *x*-axis, served as the *y*-axis. Seventeen linear and 11 angular measurements were performed to evaluate skeletal, dental, and soft tissue changes in the groups (Figures 4 and 5). After the calibration was done, all radiographs were traced by one researcher with a random queue of the cephalometric films; the researcher did not know to which group the patient belonged so that the researcher was blinded.

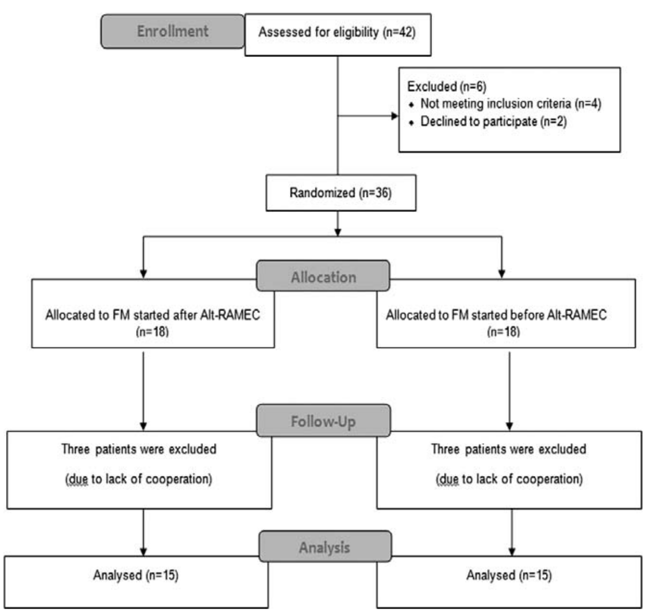

Figure 3. Flow diagram of the study.

Statistical Analyses

The Shapiro-Wilk test showed that the data were normally distributed. Therefore, parametric tests were used. Intragroup comparisons were performed by means of a paired *t*-test, and intergroup comparisons were analyzed by means of Student's *t*-test. Distribution of the genders and the maturation stages were tested using the Pearson chi-square test. Chronological age, treatment duration, daily use of the appliance, and amounts of screw activation were compared using the Student's *t*-test.

Fifteen radiographs were selected randomly 2 weeks after the initial examination, and all procedures, such as landmark identification, tracing, and measurements, were repeated by the same researcher. The method error was determined using the coefficient of reliability, as described by Houston.[22] All statistical analyses were performed using the SPSS software Package program (SPSS for Windows 98, version 10.0, SPSS

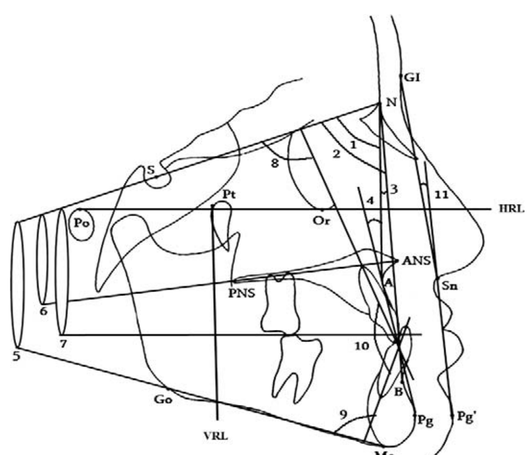

Figure 4. Angular measurements used in the study (°): (1) SNA, (2) SNB, (3) ANB, (4) Convexity, (5) SN-GoMe, (6) SN-PP, (7) SN-OP, (8) U1-SN, (9) IMPA, (10) U1-L1, and (11) Gl-Sn-Pog (soft).

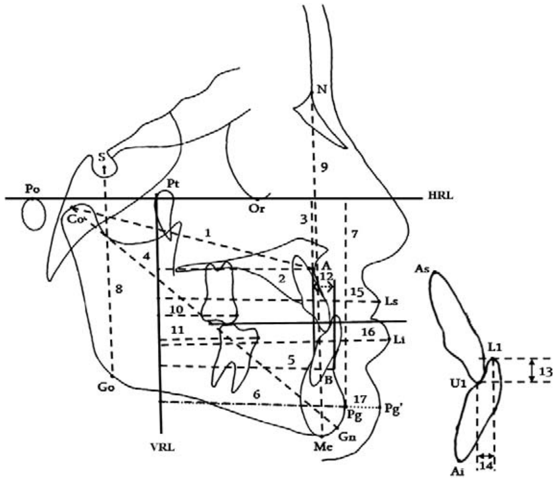

Figure 5. Linear measurements used in the study (mm): (1) Co-A, (2) A-VRL, (3) A-HRL, (4) Co-Gn, (5) B-VRL, (6) Pog-VRL, (7) Pog-HRL, (8) S-Go, (9) N-Me, (10) U6-VRL, (11) L6-VRL, (12) Wits, (13) overbite, (14) overjet, (15) Ls-VRL, (16) Li-VRL, and (17) Pog (soft)-VRL.

Inc, Chicago, Ill).The significance level was set at $P <$ .05 for all tests.

RESULTS

The coefficients of reliability for all measurements were above .841 (.841–.999), confirming the measurement reliability.

The comparisons of the chronological ages, gender and maturation distribution, daily use of the appliances, and amounts of screw activation between the groups showed that the groups were well matched (Table 1). A statistically significant difference was found only for the treatment duration (7.33 $\pm$ 1.60 and 5.76 $\pm$ 1.84, respectively) ($P <$ .05). The patients in both groups used their appliances for approximately 20 hours in a day, and the screw was activated approximately 3 mm, with no statistically significant difference ($P >$ .05) between groups.

The results of the Student's *t*-test comparing the initial measurements between the groups are shown in Table 2. No statistically significant differences were observed between the groups for all variables ($P >$ .05), except for U1-L1 angle ($P =$ .036).

Table 3 shows the comparison of the changes in Groups I and II. According to the results of the Student's *t*-test, statistically no significant differences were present between the groups ($P >$ .05), confirming the similar effects of both protraction procedures. The maxilla significantly moved forward (A-VRL, 3.84 mm and 3.02 mm; SNA, 3.70° and 3.68°) ($P <$ .001); there were also statistically significant rotations of the palatal and occlusal planes (SN-PP, −1.60° and −2.13°; SN-OP, −1.16° and −1.52°) ($P <$ .01) in Groups I and II, respectively. The mandible was displaced backward and downward (SNB, −1.91° and −1.54°; B-VRL, −2.61 mm and −2.22 mm; Pog-VRL, −2.51 mm and −2.75 mm; Pog-HRL, 2.51 mm and 2.67 mm) ($P <$ .01). The changes in both maxilla and mandible caused a significant improvement in the intermaxillary sagittal relationship (ANB, 5.65° and 5.25°; Wits, 5.37 mm and 4.86 mm; convexity, 12.07° and 11.52°) ($P <$ .001). In addition, significant increases were observed for SN-GoGn (1.37° and 1.77°; $P <$ .01) and anterior face height (2.77 mm and 2.64 mm; $P <$ .01). The maxillary incisors showed significant proclination in both groups (2.81° and 2.33°; $P <$ .05), whereas no significant changes were observed for the mandibular incisors (−0.01° and −0.70°; $P >$ .05). Overjet significantly increased (6.92 mm and 6.70 mm; $P <$ .001), whereas the overbite decreased (−1.96 mm and −2.58 mm; $P <$ .01) in both groups. Skeletal contributions to overjet correction in Groups I and II were 91.7% and 86.1%, respectively (Figure 6). The upper lip moved forward (3.40 mm and 2.83 mm; $P <$ .01), and the lower lip (−0.93 mm and −0.46 mm; $P >$ .05) and soft tissue pogonion (−1.81 mm and −2.28 mm; $P <$ .001) moved backward, resulted in a more convex profile.

DISCUSSION

In the present study, the effects of FM started simultaneously and after Alt-RAMEC completed were

Table 1. Comparisons of the Demographic Data Between the Groups[a]

	Group I	Group II	P
Chronological age, y	11.27 ± 1.26	10.53 ± 1.50	.174[b]
Maturation stages	CS1, n	7 10	.506[c]
	CS2, n	2 2	–
	CS3, n	6 3	–
Gender distribution (females/males)	–	7/8 9/6	.464[c]
Treatment duration, mo	7.33 ± 1.60	5.76 ± 1.84	.024[b]
Daily use, h	20.47 ± 1.95	20.16 ± 1.98	.682[b]
Amounts of screw activation, mm	3.26 ± 0.93	2.80 ± 0.00	.066[b]

[a] Group I indicates maxillary protraction started after alternate rapid maxillary expansion and constriction (Alt-RAMEC) completed; Group II, maxillary protraction started simultaneously with the Alt-RAMEC; and n, number.

[b] Results of Pearson chi-square test.

[c] Results of Student's t-test.

Table 2. Comparison of the Initial Measurements Between the Groups[a]

Measurements	Group I		Group II		P
	Mean	SD	Mean	SD	
Maxillary measurements					
SNA, °	78.60	2.45	77.75	2.61	.387
Co-A, mm	77.85	4.12	75.02	3.48	.600
A-VRL, mm	45.38	2.21	43.84	1.96	.620
A-HRL, mm	24.95	3.63	24.34	2.08	.602
Mandibular measurements					
SNB, °	81.18	2.84	79.94	2.82	.257
Co-Gn, mm	105.85	6.23	101.79	4.14	.061
B-VRL, mm	47.73	3.46	45.03	3.35	.067
Pog-VRL, mm	49.03	6.56	45.67	3.67	.101
Pog-HRL, mm	70.38	5.70	69.12	3.50	.479
Maxillomandibular measurements					
ANB, °	−2.56	2.21	−2.19	1.82	.626
Wits, mm	−6.98	5.94	−5.72	4.12	.518
Convexity, °	−7.18	3.91	−7.02	2.08	.893
Vertical measurements					
SN-MP, °	34.87	4.97	36.36	4.28	.402
SN-PP, °	8.40	4.13	10.28	3.76	.219
SN-OP, °	17.56	3.42	19.34	2.91	.151
S-Go, mm	66.92	4.91	65.25	4.53	.359
N-Me, mm	102.74	6.30	101.89	4.60	.684
Dental measurements					
U1-SN, °	102.96	5.93	105.78	6.71	.252
IMPA, °	84.56	8.06	86.01	5.67	.585
U1-L1, °	138.67	7.93	131.82	8.42	.036
U6-VRL, mm	23.47	2.61	22.21	2.92	.242
L6-VRL, mm	25.85	3.41	24.70	3.32	.373
Overjet, mm	−1.46	1.39	−1.36	1.22	.838
Overbite, mm	2.58	2.39	2.74	2.48	.862
Soft tissue measurements					
Ls-VRL, mm	61.65	2.65	60.63	2.89	0.343
Li-VRL, mm	60.65	3.47	60.12	3.37	0.684
Pog (s)-VRL, mm	60.21	5.85	56.35	4.62	0.662
Soft tissue convexity, °	4.30	6.77	6.72	5.51	0.307

[a] Group I indicates maxillary protraction started after alternate rapid maxillary expansion and constriction (Alt-RAMEC) completed; Group II, maxillary protraction started simultaneously with the Alt-RAMEC; VRL, vertical reference line; HRL, horizontal reference line; P, results of Student's *t*-test comparing the initial values of the groups; and SD, standard deviation.

assessed. In both groups, the screw was activated twice daily (0.20 mm per turn) for 1 week (2.8 mm) and was then deactivated (2.8 mm) for the next week. The procedure was repeated for 8 weeks, as suggested by Liou.[16] At the end of the Alt-RAMEC procedure completion, maxillary expansion was mainly performed in order to disarticulate the maxillary sutures, regardless of posterior crossbite diagnosis, in both groups. Both groups had similar screw activation amounts. In addition, the factors, including the chronological age, maturation stage, gender distribution, and daily use of the appliances, that might affect the results of maxillary protraction were well matched between the groups. Both groups had a retrusive maxilla and upper lip, protrusive mandible and lower lip, retroclined lower incisors, and reduced overjet. These pretreatment findings coincide with those of similar relevant studies in the literature.[2,11,12,23]

The results of the present study showed that FM treatment started simultaneously and after Alt-RAMEC is completed induced similarly significant skeletal, dentoalveolar, and soft tissue changes ($P > .05$). Our findings revealed a significant forward movement of the maxilla, represented by the increase in the SNA, Co-A, and A-PTV measurements, in combination with statistically significant rotations of palatal and occlusal planes. Several studies[8,10–12,24] observed significant rotations of the occlusal and palatal planes and forward movement of the maxilla during FM treatment. To eliminate this problem, a maxillary protraction force of 500 g per side, with an anteroinferior force vector of approximately 30° to the occlusal plane, was

Table 3. Statistical Analyses of the Intra- and Intergroup Differences[a]

Measurements	Group I		Group II		
	Mean	SD	Mean	SD	P
Maxillary measurements					
SNA, °	3.70***	1.46	3.68***	1.12	.995
Co-A, mm	3.26***	1.58	2.14**	2.02	.119
A-VRL, mm	3.84***	1.87	3.02***	1.04	.179
A-HRL, mm	−0.26 NS	1.62	−0.10 NS	2.33	.828
Mandibular measurements					
SNB, °	−1.91***	1.06	−1.54***	1.07	.362
Co-Gn, mm	0.85*	1.16	0.70 NS	1.26	.743
B-VRL, mm	−2.61***	1.81	−2.22**	1.97	.594
Pog-VRL, mm	−2.51***	1.86	−2.75***	2.13	.757
Pog-HRL, mm	2.51***	1.50	2.67***	2.16	.827
Maxillomandibular measurements					
ANB, °	5.65***	1.28	5.25***	0.99	.363
Wits, mm	5.37***	1.88	4.86***	1.45	.427
Convexity, °	12.07***	3.27	11.52***	2.01	.586
Vertical measurements					
SN-GoGn, °	1.37**	1.49	1.77***	0.82	.384
SN-PP, °	−1.60**	1.75	−2.13**	1.84	.462
SN-OP, °	−1.16***	0.49	−1.52***	0.57	.091
S-Go, mm	0.60 NS	1.82	1.25*	1.92	.367
N-Me, mm	2.77**	2.46	2.64**	2.30	.881
Dental measurements					
U1-SN, °	2.81***	1.95	2.33*	3.01	.626
IMPA, °	−0.01 NS	1.01	−0.70 NS	2.15	.275
U1-L1, °	−4.08**	4.13	−3.33**	3.85	.623
U6-VRL, mm	5.43***	2.61	3.85**	3.88	.226
L6-VRL, mm	2.29 NS	0.94	1.18 NS	2.12	.084
Overjet, mm	6.92***	1.37	6.70***	1.12	.651
Overbite, mm	−1.96**	1.93	−2.58***	1.72	.381
Soft tissue measurements					
Ls-VRL, mm	3.40***	1.90	2.83**	2.54	.517
Li-VRL, mm	−0.93 NS	2.82	−0.46 NS	2.79	.667
Pog (s)-VRL, mm	−1.81**	1.77	−2.28**	2.33	.564
Soft tissue convexity, °	8.32***	2.88	8.52***	2.57	.850

[a] Group I indicates maxillary protraction started after alternate rapid maxillary expansion and constriction (Alt-RAMEC) completed; Group II, maxillary protraction started simultaneously with the Alt-RAMEC; P, results of Student's *t*-test comparing the groups; NS, not significant, paired *t*-test; and SD, standard deviation.

* $P < .05$, paired *t*-test; ** $P < .01$, paired *t*-test; *** $P < .001$, paired *t*-test.

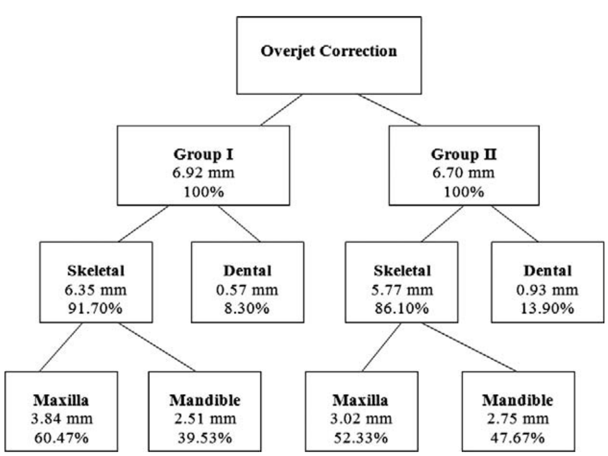

Figure 6. Skeletal and dental contributions to overjet correction in both groups.

applied from the hooks placed in the canine region on the buccal sides of the expanders, as suggested previously.[8,10–12] Anterior movements of point A in Groups I and II were 3.84 mm ($P < .001$) and 3.02 mm ($P < .001$), respectively. These are approximately twice the amounts in the findings published by Sung and Baik[14] (1.7 mm), Altug and Arslan[10] (1.73 mm), Kilic et al.[11] (1.48 mm), and Cha[25] (0.97 mm). In agreement with this finding, Isci et al.[18] and Liou and Tsai[15] showed that maxillary advancement in the Alt-RAMEC group (3.0 mm to 5.8 mm respectively) was approximately twice greater than in the FM/RME group (1.6 mm to 2.5 mm, respectively). The differences might be due to several factors, including chronological age, gender distribution, treatment duration, force magnitude, cleft presence, and patient cooperation.

Liou and Tsai[15] suggested that the circummaxillary sutures were separated and stretched to a greater degree by Alt-RAMEC compared to the RME. This was also confirmed by Wang et al.,[17] who reported that the Alt-RAMEC procedure opened both the sagittally and coronally circummaxillary sutures quantitatively more than did the RME. However, the advancement of the maxilla was surprisingly found to be only 2.0 mm in a recent study[19] using both Alt-RAMEC and miniplate anchorage. The force magnitude (350–400 g), chronological ages of the patients (11.6 $\pm$ 1.6 years), and long treatment duration due to insufficient cooperation (9.9 $\pm$ 1.6 months) might be potential factors related to that finding.[19]

In the present study, downward and backward rotation of the mandible (SNB, -1.91° and -1.54°; B-VRL, -2.61 mm and -2.22 mm; Pog-VRL, -2.51 mm and -2.75 mm, respectively) contributed to Class III correction and improved the maxillomandibular relationship (ANB, 5.65° and 5.25°; Wits, 5.37 mm and 4.86 mm, respectively) and facial convexity (12.07° and 11.52°, respectively) in both Groups I and II. However, these changes resulted in an increase in the vertical measurements. These findings were consistent with the results of the previous studies[8–12,25] and may be due to the retractive force on the chin or the vertical movement of the maxilla and/or maxillary teeth.

It has been well documented that FM treatment results in a protrusion of the maxillary incisors and a retrusion of the mandibular incisors.[8–12,19,26] A significant amount of maxillary incisor protrusion was observed in both groups, while no significant retrusion of the mandibular incisors was present as a result of the presence of the lingual arch in the mandible. These skeletal and dentoalveolar changes resulted in a significant overjet correction in both groups. In Group I, overjet correction (6.92 mm) was achieved by 91.70% (6.35 mm) skeletal and by 8.30% (0.57 mm) dental changes. In Group II, skeletal and dental contributions to overjet correction (6.70 mm) were 86.10% (5.77 mm) and 13.90% (0.93 mm), respectively. Skeletal contribution to overjet correction found in the present study was higher than that of the previous studies,[12,27] which reported approximately 65% skeletal contribution. Isci et al.[18] also found an approximately 90% skeletal contribution to the overjet correction.

The soft tissue effects of both groups were more marked for the upper lip and soft tissue pogonion than for the lower lip. Forward movement of the upper lip and backward movements of the lower lip and soft tissue pogonion could be attributed to the underlying skeletal and dentoalveolar changes. These changes were in accordance with the results of the previous studies.[8,11,12,19]

The present randomized and prospective study has some limitations, including its short-term results and the lack of an untreated Class III control group. An untreated Class III control group was not used for ethical reasons, and the authors think it will be important to evaluate the long-term results in a future study.

CONCLUSIONS

- The null hypothesis was rejected; Class III malocclusion and negative overjet were improved by means of skeletal changes in conjunction with upper incisor proclination in both groups, with no statistically significant differences.
- Inclination of the mandibular incisors was not significantly changed in both groups as a result of the presence of the lingual arch, and, thus, dental contribution to overjet correction was less in both groups.
- The authors suggest not waiting until completion of the Alt-RAMEC procedure for the FM treatment, since both groups showed similar results.

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