Original Article

Effects of face mask treatment with and without rapid maxillary expansion in young adult subjects

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ABSTRACT

Objectives: To investigate the skeletal, dental, and soft tissue effects of the face mask (FM) treatment with and without rapid maxillary expansion (RME) in young adult subjects with maxillary retrognathia.

Materials and Methods: Pretreatment and posttreatment cephalometric radiographs from 32 subjects who had a skeletal Class III malocclusion were analyzed. The subjects were divided into two groups: FM group (N = 17; 3 male and 14 female subjects; mean [SD] age 14.47 [0.89] years) was treated with FM only, while the RME+FM group (N = 15; 3 male and 12 female subjects; mean [SD] age 14.67 [1.28] years) was treated with both FM and RME. Ten cephalometric linear and nine angular variables were measured to assess dentofacial changes. Within-group and between-group comparisons were determined by a paired *t*-test and Student's *t*-test, respectively.

Results: Forward displacement of the maxilla and a clockwise rotation of the mandible occurred in both groups. The maxillary-mandibular relationship improved and soft tissue changes resulted in a more convex profile. The maxillary incisors were more proclined in the FM group than in the RME+FM group, the only difference between the two groups. Notably, the mandibular incisors moved backward in both groups.

Conclusions: Forward movement of the maxilla can be obtained in young adults after face mask treatment. However, there was no difference in this phenomenon between the FM and RME+FM groups. (*Angle Orthod.* 2014;84:853–861.)

KEY WORDS: Face mask; Rapid maxillary expansion; Young adults; Cephalometric

INTRODUCTION

Until the 1970s, skeletal Class III malocclusion was considered to originate only from the mandible.[1,2] Orthodontic use of face mask (FM) treatment increased with awareness of maxillary deficiency as an essential cause of the skeletal Class III malocclusion. The mechanisms of action of FM treatment are sutural remodeling[3] and maxillary forward movement.[4–7] It was commonly accepted that FM treatment may be the most effective at an early age. In younger patients, maxillary deficiency can be treated conservatively due to the growth potential of the circummaxillary sutural articulations. Authors have recommended a wide age range for use of FM treatment such as early mixed dentition,[8] before the age of 8 years,[5,9] until the age of 12 years,[10] and even during puberty.[6,11]

However, clinicians are often confronted with the treatment of young adult patients with maxillary deficiency. Although all human facial sutures except the midpalatal suture remain patent until late in life,[12] a limited number of published studies discuss the use of FM in nongrowing patients.

A number of authors have recommended the implementation of maxillary expansion together with FM. In adolescent and preadolescent patients, maxillary expansion disrupts the circummaxillary sutural system and increases the orthopedic effects of FM even if there is no deficiency in the transverse dimension.[8,13–15] In addition, it was reported that the

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maxilla might move slightly forward and downward, and mandible rotation might move backward and downward after rapid maxillary expansion (RME).[16] These changes also may be increased as effects of FM.

Although research into FM with or without RME has grown in the past years, no study until now has been carried out to compare the skeletal, dental, and soft tissue effects of FM treatment, with and without RME, in young adult subjects. In this study, we aimed to compare FM treatment results between expansion and nonexpansion groups in young adults; both groups were matched by age and sagittal skeletal relationship.

MATERIALS AND METHODS

The material of this retrospective study consisted of the cephalometric and hand-wrist radiographs of 32 young adult subjects (6 male, 26 female) who were treated using a FM with and without RME in the Department of Orthodontics, Faculty of Dentistry, Atatürk University, who did not accept the orthognathic surgery option. This retrospective study was approved by the local ethical committee.

Inclusion criteria were negative overjet, a Class III molar relationship, and ANB angle of 0° or less and Wits appraisal of -1 mm or less due to maxillary retrusion according to SNA (degree) and Co-A (mm) values. We excluded subjects with severe skeletal problems, craniofacial syndromes, and cleft lip or palate. Additionally, the skeletal maturation and pubertal growth of these subjects were determined with hand-wrist radiographs using the method described by Fishman.[17]

All cephalometric radiographs were taken in the same cephalostat (Siemens Nanodor 2, Siemens AG, Munich, Germany) in the habitual body posture. The patients were requested to keep their teeth in centric occlusion during exposure, and special attention was given to ensure that the lips were at rest to prevent possible soft tissue changes. Lateral cephalometric radiographs were taken at the beginning (pretreatment, T1) and, after achieving a positive overjet and/or a Class I occlusion, at the end of the observation period (posttreatment, T2). Subjects were divided into two groups representing those who were treated with RME and a FM (RME+FM group; N = 15; 3 male, 12 female) and those patients who were treated with only a FM (FM group; N = 17; 3 male, 14 female). If a posterior crossbite was presented when the patient's maxillary model was advanced to establish Class I occlusion, these subjects had undergone RME. The mean (SD) ages of the RME+FM and FM groups were 14.67 (1.28) years and 14.47 (0.89) years, respectively. All subjects represented the complete adolescent growth spurt (skeletal maturation stage according to Fishman[17]=10,11).

A banded RME appliance was used for RME, which included a Hyrax screw (Forestadent, St. Louis, MO), and bands were compatible with the permanent maxillary first premolars and the first molars. A screw was soldered to these bands in the palatal side. These teeth were linked together by soldered labial stainless steel wires. In addition, two hooks were twisted from stainless steel wires at the mesial of the maxillary canine for extraoral elastics. After cementation, the Hyrax screw was activated two quarter-turns a day during the full expansion phase until the desired change in the transverse dimension was achieved. The RME appliance was not removed during the FM treatment in order to maintain retention.

A Petit type FM (GAC Intl Inc, Bohemia, NY) was used for about 16 hours a day. Anchorage for FM was provided via metal bands cemented to the permanent maxillary first premolars and first molars, which were linked together by soldered palatal and labial stainless steel wires. Hooks were made at the mesial of the maxillary canine for extraoral elastics.

The total force of the FM was approximately 600–1000 g, and the angle between the occlusal plane and the direction force applied by the FM was approximately 30°–40° in both groups. FM treatment of all patients in the present study was ended after the anterior crossbite was corrected satisfactorily. The mean (SD) treatment period was 9.10 (1.15) months for the RME+FM group, while the mean (SD) treatment duration was 8.44 (1.48) months for the FM group.

Nine angular and 10 linear variables were measured to assess skeletal, dental, and soft tissue changes. The angular and linear measurements are shown in Figures 1 and 2, respectively. A cephalometric analysis was performed using the Quick Ceph program (Quick Ceph Systems, San Diego, Calif).

Fifteen randomly selected radiographs were retraced and remeasured by the same investigator 2 weeks after the initial analysis. The method error was determined using the coefficient of reliability, calculated for each measurement: coefficient of reliability $= 1 - Se^2/St^2$, where Se^2 was the variance due to random error, and St^2 was the total variance of the measurements.[18]

Statistical Analysis

All statistical analyses were performed using the SPSS software package for Windows (version 15.0, SPSS, Chicago, Ill); $P < .05$ was considered statistically significant. The Kolmogorov-Smirnov test was applied to the data, and all data were found to be

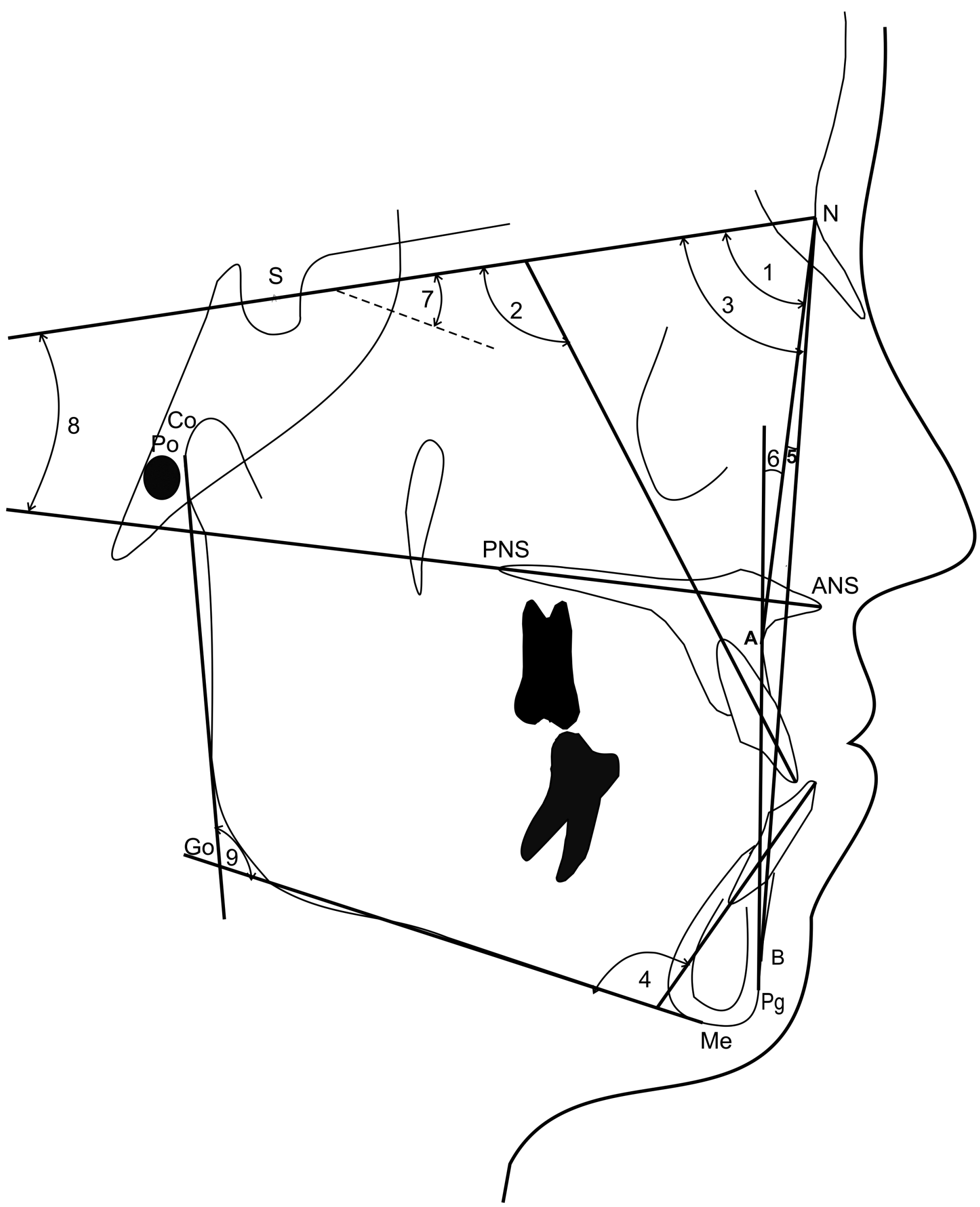

Figure 1. Angular measurements. (1) SNA. (2) Maxillary incisor-SN. (3) SNB. (4) Mandibular incisor-MP. (5) ANB. (6) Convexity angle. (7) MP-SN. (8) PP-SN. (9) Gonial angle.

normally distributed. Thus, parametric tests were used for statistical evaluations. A paired *t*-test was used to determine the differences within each group. Due to abnormal distribution of male and female subjects in each group, a Mann-Whitney *U*-test was performed to determine potential differences by sex in both groups. In addition, the Student's *t*-test was applied to investigate the differences between the two groups.

RESULTS

The value of the coefficient of reliability was above 0.90 (range 0.90–0.98) for all measurements. No statistically significant differences were found between groups in the chronologic ages and treatment periods ($P = .609$ and $P = .176$, respectively) (Table 1). Mann-Whitney *U*-test showed no statistically significant differences between the sexes in the measurements used except the SNA (degrees) and A-N perp (mm) values in the RME+FM group ($P < .05$). Therefore, data from male and female subjects were pooled. The pretreatment measurements were compared, and no statistically significant difference was present for the initial values of the groups (Table 2). Descriptive statistics, including means and standard deviations of T1 and T2 measurements and the results of the paired *t*-test are presented in Tables 3 and 4, respectively. The results of Student's *t*-test are shown in Table 5.

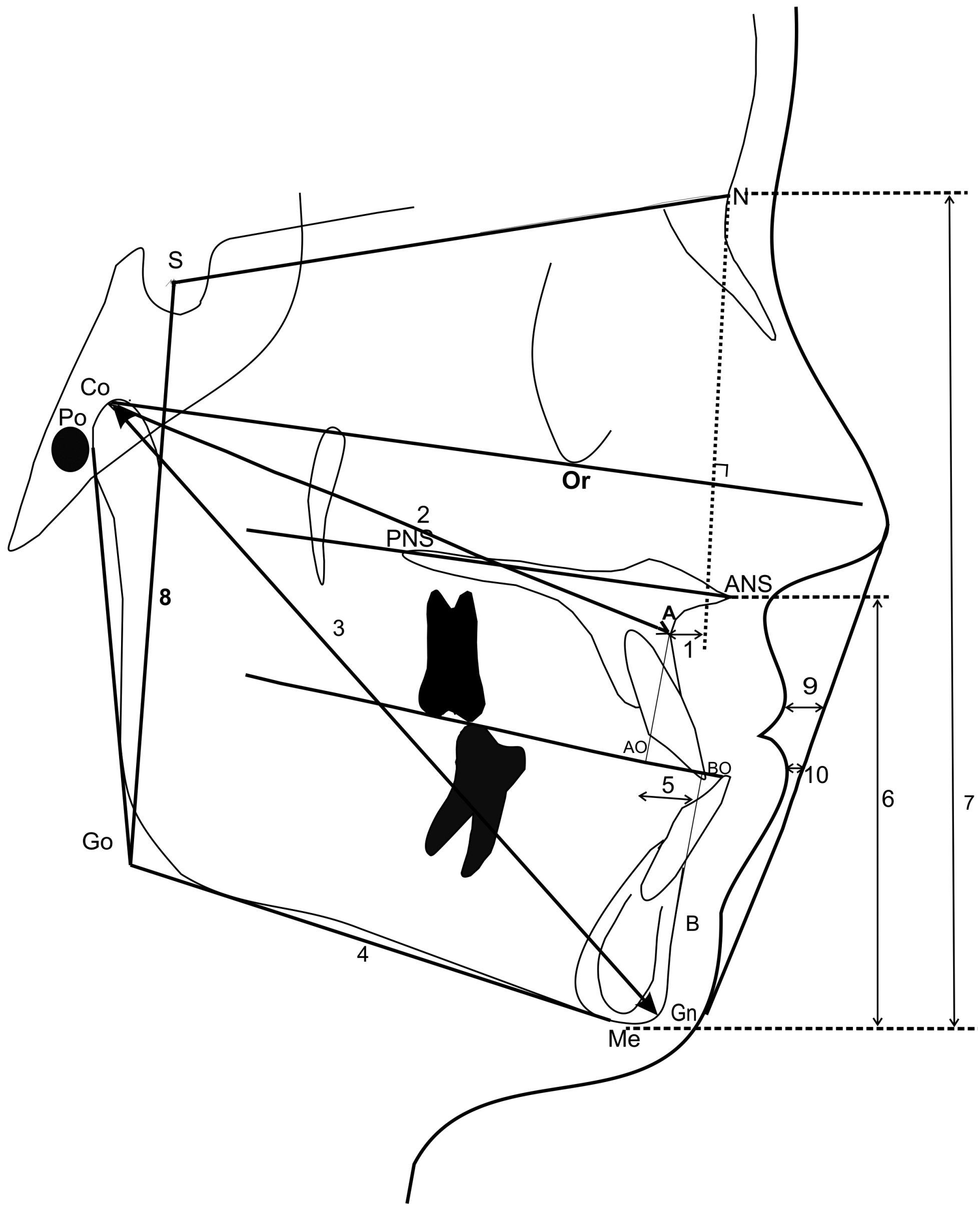

Figure 2. Linear measurements. (1) A-N perp. (2) Co-A. (3) Co-Gn. (4) Go-Me. (5) Wits. (6) LAFH (lower anterior face height). (7) TAFH (total anterior face height). (8) TPFH (total posterior face height). (9) UL-EL. (10) LL-EL.

The changes in the RME+FM group were statistically significant except for the maxillary incisor-SN, PP-SN, and gonial angles and the Co-Gn, UL-E line, and LL-E line distance measurements. The changes in the FM group were statistically significant except for the gonial angle and the Co-Gn and LL-E line distance measurements. In both groups, the measurements of SNB and mandibular incisor-MP angles exhibited a significant decrease, whereas some other measurements showed a significant increase.

Table 1. Means and Standard Deviations of Chronologic Age and Treatment Period for Each Group, and the Results of Student's *t*-Test

	RME+FM[a]		FM[a]			
	Mean	SD	Mean	SD	*t* Value	*P* Value
Chronologic age, y	14.67	1.28	14.47	.89	−.516	.609
Treatment period, mo	9.10	1.15	8.44	1.48	−1.386	.176

[a] FM indicates face mask; RME, rapid maxillary expansion.

Forward displacement of the maxilla and clockwise rotation of the mandible occurred in both groups, with increases occurring especially in the vertical dimension. The mandibular incisors uprighted in both groups; however, while the maxillary incisors moved forward in both groups they did so only with statistical significance in the FM group. The upper lip moved forward in the FM group, while no statistically significant changes

Table 2. Initial Cephalometric Measurements of Class III Malocclusion Patients Treated With Face Mask (FM) With and Without Rapid Maxillary Expansion (RME)

	FM		RME+FM			
	Mean	SD	Mean	SD	*t* Value	*P* Value
Maxillary skeletal						
SNA, degree	76.88	4.40	76.81	4.69	.043	.966
A-N perp, mm	−5.45	4.19	−4.91	3.83	−.379	.707
Co-A, mm	85.19	6.71	85.25	4.92	−.028	.978
Maxillary dental						
Maxillary incisor-SN, degree	106.72	5.62	103.70	5.77	1.496	.145
Mandibular skeletal						
SNB, degree	78.93	4.37	78.56	4.23	.242	.810
Co-Gn, mm	118.04	7.90	119.49	5.81	−.585	.563
Go-Me, mm	75.81	8.16	74.57	3.92	.535	.596
Mandibular dental						
Mandibular incisor-MP, degree	84.91	7.74	85.13	6.27	−.088	.931
Maxillary-mandibular relationship						
ANB, degree	−2.05	2.00	−1.77	2.68	−.345	.732
Convexity angle, degree	−5.65	4.47	−6.66	6.32	.525	.603
Wits, mm	−7.62	3.96	−5.81	2.51	−1.516	.140
Vertical relationship						
MP-SN, degree	37.26	6.01	35.11	7.50	.898	.377
PP-SN, degree	9.11	2.94	8.21	2.94	.857	.398
Gonial angle, degree	128.59	7.15	128.37	7.64	.082	.935
LAFH, mm	70.47	5.19	71.71	5.11	−.677	.503
TAFH, mm	125.08	6.47	126.59	6.27	−.666	.511
TPFH, mm	78.18	6.58	80.97	6.28	−1.220	.232
Soft tissue						
UL-E line, mm	−7.63	2.34	−8.69	2.65	1.200	.240
LL-E line, mm	−3.97	2.47	−5.15	2.84	1.253	.220

were observed in the lower lip in either group (Table 3 and 4).

According to Student's *t*-test, no statistically significant differences were found between the RME+FM and FM groups, except for the maxillary incisor-SN angle (Table 5).

DISCUSSION

Maxillofacial growth modification with FM is an effective method for resolving maxillary deficiency in children and adolescents.[6,13] FM has been widely used to treat hypoplastic maxilla in orthodontic clinics for the last 40 years. However, maxillary expansion has been advocated and recommended as a routine procedure, with FM, for skeletal Class III treatment in children or adolescents. For young adult patients who did not accept orthognathic surgery, an alternative is to treat them with dentoalveolar compensation. However, in young adult patients, there was no statistical evaluation of RME in conjunction with FM.

Therefore, the aim of the present study was to examine the skeletal, dental, and soft tissue effects of FM treatment with and without associated RME. To our knowledge, this study is the first to compare the skeletal, dental, and soft tissue effects of FM treatment with and without RME in young adult patients. In addition, this study has the oldest patient group treated with FM.

In both groups, statistically significant increases in SNA angle, A-N perpendicular, and Co-A distances suggested the forward movement of the maxilla, which is a common result in a number of FM studies with or without expansion.[5,6,8,19–21] However, after a thorough literature search, it is understood that the degree of forward movement of the maxilla changes with age. Kapust et al.[5] stated that the SNA angle increased 3.71°, 1.98°, and 1.89° in the 4- to 7-, 7- to 10-, and 10- to 14-year-old age groups who were treated with RME+FM, respectively. Takada et al.[11] noted a significant SNA angle increase in the 7- to 10-year-old (1.51°) and 10- to 12-year-old (2.04°) age groups, whereas the 12- to 15-year-old age group showed a less significant increase (0.94°). Cha[22] reported that the SNA angle increased in the prepubertal growth peak group (2.18° with mean [SD] age 9.82 [1.50] years), the pubertal growth peak group (2.03° with mean [SD] age 11.31 [1.16] years), and the postpubertal growth peak group (0.53° with mean [SD] age

Table 3. Means and Standard Deviations of Pretreatment and Posttreatment Measurements and the Results of the Paired *t*-Test in the RME+FM[a] Group

	Pretreatment		Posttreatment			
	Mean	SD	Mean	SD	*t* Value	*P* Value
Maxillary skeletal						
SNA, degree	76.81	4.69	77.83	4.89	−6.019	.000
A-N perp, mm	−4.91	3.83	−3.77	3.94	−7.112	.000
Co-A, mm	85.25	4.92	86.70	4.88	−5.930	.000
Maxillary dental						
Maxillary incisor- SN, degree	103.70	5.77	104.07	5.48	−.502	.624
Mandibular skeletal						
SNB, degree	78.56	4.23	77.39	4.09	3.923	.002
Co-Gn, mm	119.49	5.81	119.53	5.58	−.163	.873
Go-Me, mm	74.57	3.92	74.79	3.88	−4.172	.001
Mandibular dental						
Mandibular incisor-MP, degree	85.13	6.27	81.49	7.65	5.272	.000
Maxillary-mandibular relationship						
ANB, degree	−1.77	2.68	0.47	2.45	−7.057	.000
Convexity angle, degree	−6.66	6.32	−1.69	5.06	−5.415	.000
Wits, mm	−5.81	2.51	−1.65	2.28	−7.043	.000
Vertical relationship						
MP-SN, degree	35.11	7.50	37.23	7.09	−6.313	.000
PP-SN, degree	8.21	2.94	7.07	4.12	1.594	.133
Gonial angle, degree	128.37	7.64	128.47	7.71	−.621	.545
LAFH, mm	71.71	5.11	75.83	5.49	−7.478	.000
TAFH, mm	126.59	6.27	129.49	5.87	−6.802	.000
TPFH, mm	80.97	6.28	82.37	6.32	−15.940	.000
Soft tissue						
UL-E line, mm	−8.69	2.65	−8.15	2.78	−1.206	.248
LL-E line, mm	−5.15	2.84	−4.97	3.44	−.402	.693

[a] Face mask treatment with rapid maxillary expansion.

13.07 [1.43] years) after RME+FM treatment. Yavuz et al.[6] noted that SNA angles increased in adolescents (2.31° with mean [SD] age 11.8 [0.8] years) more than in young adults (0.78° with mean [SD] age 14.02 [0.63] years), when all subjects were treated with FM. These results are very compatible with our findings. In the present study, the SNA angle increased in both the RME+FM group (1.03°) and the FM group (0.95°).

Many authors[5,6,11,19] advised that palatal plane counterclockwise rotation occurs where the posterior drops more than the anterior. Like changes with age in the forward movement of the maxilla, Kapust et al.[5] showed that PP-SN angles decreased by 2.47°, 1.46°, and 0.70° in the 4- to 7-, 7- to 10-, and 10- to 14-year-old age groups, respectively. Yavuz et al.[6] stated that the PP-SN angle decreased more in adolescents (2.45°) more than in young adults (1.39°). In the present study, this angle decreased in both the RME+FM group (1.14°) and the FM group (1.02°), in accordance with previous studies. In addition, no statistically significant difference was observed between the two groups.

Downward and backward movement of the mandible is consistent with previous studies,[5,6,15,19,22,23] and it improved the maxillomandibular skeletal relationship and the convexity of the profile.[19] The maxillary incisors were more proclined in the FM group than the RME+FM group, which is the only difference between the two groups. This difference may be explained by the expansive effect of the RME in the maxillary anterior segment. The mandibular incisors retroclined spontaneously without any orthodontic intervention. We thought that the cause was soft tissue pressure from the force exerted by the chin cup part of the FM.

Kilic et al.[24] reported that Class III patients with maxillary deficiency often have an anterior crossbite with a concave facial profile, as observed in the present study. They stated that the concave soft tissue profiles of the Class III subjects with maxillary deficiency were corrected by anterior movement of the maxilla and a concomitant increase in the fullness of the upper lip in growing children (mean [SD] age 12.69 [10.8] years), and that the upper lip protruded a mean 1.15 mm after use of FM. However, Yavuz et al.[6]

Table 4. Mean and Standard Deviation of Pretreatment and Posttreatment Measurements and the Results of the Paired *t*-Test in the Face Mask (FM) Group

	Pretreatment		Posttreatment			
	Mean	SD	Mean	SD	*t* Value	*P* Value
Maxillary skeletal						
SNA, degree	76.88	4.40	77.83	4.36	−4.102	.001
A-N Perp, mm	−5.45	4.19	−4.22	4.42	−4.141	.001
Co-A, mm	85.19	6.71	86.38	7.31	−2.766	.014
Maxillary dental						
Maxillary incisor- SN, degree	106.72	5.62	109.56	5.97	−5.326	.000
Mandibular skeletal						
SNB, degree	78.93	4.37	77.56	4.44	5.314	.000
Co-Gn, mm	118.04	7.90	118.31	8.99	−.632	.536
Go-Me, mm	75.81	8.16	76.19	8.10	−5.303	.000
Mandibular dental						
Mandibular incisor-MP, degree	84.91	7.74	81.14	8.12	3.551	.003
Maxillary-mandibular relationship						
ANB, degree	−2.05	2.00	0.20	1.45	−6.864	.000
Convexity angle, degree	−5.65	4.47	−1.27	3.29	−8.168	.000
Wits, mm	−7.62	3.96	−4.13	3.78	−7.414	.000
Vertical relationship						
MP-SN, degree	37.26	6.01	38.60	6.30	−3.520	.003
PP-SN, degree	9.11	2.94	8.08	2.60	2.983	.009
Gonial angle, degree	128.59	7.15	127.89	7.51	1.515	.149
LAFH, mm	70.47	5.19	73.76	5.94	−9.633	.000
TAFH, mm	125.08	6.47	128.21	7.46	−5.818	.000
TPFH, mm	78.18	6.58	79.55	6.57	−3.389	.004
Soft tissue						
UL-E line, mm	−7.63	2.34	−6.62	2.32	−2.259	.038
LL-E line, mm	−3.97	2.47	−4.20	2.78	.399	.695

reported that UL-E distance decreased in adolescents (1.42 mm) more than in young adults (1.07 mm). As can be seen, there is a relationship between forward movement of the maxilla and upper lip protrusion. In addition, Yavuz et al.[19] showed that UL-E distance decreased both in the FM group (1.59 mm) and in RME+FM group (0.97 mm) in adolescent patients. In the present study, UL-E distance decreased in both the RME+FM (0.54 mm) and FM (1.01 mm) groups, as in the studies above, and no statistically significant difference was observed between the two groups.

Yavuz et al.[25] evaluated the changes in the maxillary sutures as a result of FM treatment in a 16-year-old female patient by single photon emission computerized tomography. They observed in measuring the stimulated bone activity that there were significant increases in both sides of the zygomaticomaxillary suture and the outer zygomaticomaxillary area and concluded that the determination of bone activity by scintigraphic records at suture regions demonstrates that FM treatment may be useful to obtain improved facial esthetic and dental relation in nonsevere cases. Hamamci et al.[26] presented a nonsurgical treatment of a 16-year-old female patient with skeletal Class III malocclusion using FM. They observed more dental effects than skeletal effects, with only a 0.5° increase in the SNA angle. However, the results of the present study showed that FM treatment with and without RME led to significant dentoalveolar and mild skeletal changes, which affected many areas of the dentofacial complex, in young adult patients. Therefore, it can be stated that FM treatment may be considered an alternative to orthognathic surgery in young adult patients with nonsevere skeletal Class III malocclusion.

There were some authors[19,20,27] who have claimed that the use of RME should be based on purely clinical criteria rather than assisting the FM treatment in adolescent and preadolescent patients. In the present study, in contrast to the many authors[8,13–15] who recommend the use of RME together with FM in adolescent and preadolescent patients, no statistically significant difference was observed between the two groups, except in one parameter. This result may be explained as follows: patient age is an important determinant when considering the effects of RME on craniofacial structures, and RME treatment has been found more effective in children than in adults.[28–30]

Table 5. The Results of Student's *t*-Test Regarding the Differences Between Treatment Groups

	FM[a]		RME+FM[a]			
	Mean	SD	Mean	SD	*t* Value	*P* Value
Maxillary skeletal						
SNA, degree	0.95	0.96	1.03	0.66	−.250	.804
A-N perp, mm	1.22	1.22	1.14	0.62	.239	.813
Co-A, mm	1.18	1.76	1.45	0.94	−.518	.608
Maxillary dental						
Maxillary incisor-SN, degree	2.84	2.20	0.37	2.88	2.741	.010
Mandibular skeletal						
SNB, degree	−1.36	1.06	−1.17	1.15	−.507	.616
Co-Gn, mm	0.28	1.80	0.05	1.11	.427	.673
Go-Me, mm	0.38	0.29	0.22	0.20	1.730	.094
Mandibular dental						
Mandibular incisor- MP, degree	−3.77	4.38	−3.63	2.67	−.105	.917
Maxillary-mandibular relationship						
ANB, degree	2.25	1.35	2.24	1.23	.028	.978
Convexity angle, degree	4.38	2.21	4.97	3.56	−.572	.572
Wits, mm	3.49	1.94	4.17	2.29	−.907	.372
Vertical relationship						
MP-SN, degree	1.34	1.57	2.12	1.30	−1.515	.140
PP-SN, degree	−1.02	1.41	−1.14	2.77	.153	.880
Gonial angle, degree	−0.70	1.91	0.09	0.58	−1.547	.132
LAFH, mm	3.29	1.41	4.13	2.14	−1.315	.198
TAFH, mm	3.12	2.21	2.91	1.66	.310	.758
TPFH, mm	1.36	1.66	1.40	0.34	−.081	.936
Soft tissue						
UL-E line, mm	1.01	1.84	0.54	1.73	.735	.468
LL-E line, mm	−0.23	2.37	0.18	1.73	−.551	.585

[a] FM indicates face mask; RME, rapid maxillary expansion.

Difficulties of orthopedic movement in young adults and adults have been attributed to rigidity of facial skeleton, ossification of the midpalatal suture, and the rigidity of the articulation of the zygomatic complex contiguous to the maxilla. Kanekawa and Shimizu[31] investigated age-related changes on bone regeneration during expansion of a midpalatal suture in rats of different ages and demonstrated age-related decrease in bone regeneration after expansion of the suture in young adults and adults. However, there have been no clinical studies that show age-related changes in bone regeneration capacity in maxillary sutures during orthopedic movement like RME and/or FM treatment.

On the other hand, one limitation of the present study was that it included few study samples and abnormal distribution by sex in each group when compared with previous studies about FM. We thought that the reason for this decrease was the fewer number of patients using a FM with advancing age, due to poor cooperation. These factors show that further studies including more patients and equal distribution by sex could be performed in order to discuss our findings.

CONCLUSIONS

After use of FM with or without RME in young adults:

- the maxilla moved forward and upward;
- the mandible rotated downward and backward;
- soft tissue changes produced a more convex profile, while dental changes also contributed to the correction; and
- RME did not increase the effects of FM in young adults.

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