Original Article

Comparison of facemask therapy effects using skeletal and tooth-borne anchorage: *A longitudinal retrospective study*

Hyeon-Jong Lee[a]; Dong-Soon Choi[b]; Insan Jang[b]; Bong-Kuen Cha[b]

ABSTRACT

Objectives: To investigate long-term outcomes of dentoskeletal changes induced by facemask therapy using skeletal anchorage in Class III patients and compare them to those of conventional tooth-borne anchorage.

Materials and Methods: This retrospective study included 20 patients who received facemask (FM) therapy with miniplates as anchorage for maxillary protraction (Miniplate/FM group, 10.6 ± 1.1 years old [mean ± SD]) and 23 patients who were treated with facemask with rapid maxillary expander (RME/FM group, 10.0 ± 1.5 years old [mean ± SD]). Dentoskeletal changes were evaluated using lateral cephalograms at pretreatment (T1), after facemask therapy (T2), and at the post-pubertal stage (T3). Cephalometric changes were compared between groups and clinical success rates at T3 were evaluated.

Results: SNA and A to N perpendicular to FH increased significantly more in the Miniplate/FM group than in the RME/FM group when comparing short-term effects of facemask therapy (T1–T2). ANB, Wits appraisal, Angle of convexity, mandibular plane angle, and overjet decreased significantly more in the RME/FM group than in the Miniplate/FM group after facemask therapy (T2–T3). A more favorable intermaxillary relationship was observed in the Miniplate/FM group than in the RME/FM group in long-term observations (T1–T3). Clinical success rate at T3 was 95% in the Miniplate/FM group and 85% in the RME/FM group.

Conclusions: Facemask therapy with skeletal anchorage showed a greater advancement of the maxilla and more favorable stability for correction of Class III malocclusion in the long-term than conventional facemask therapy with tooth-borne anchorage. (*Angle Orthod.* 2022;92:307–314.)

KEY WORDS: Class III malocclusion; Facemask; Skeletal anchorage; Miniplate; Rapid maxillary expander

INTRODUCTION

Early intervention for Class III malocclusion is one of the most challenging endeavors in orthodontics due to uncertain stability after pubertal growth.[1] Despite the difficulty in predicting growth, orthopedic therapy may offer a favorable growth environment and decrease the chances of later orthognathic surgery.

Rapid maxillary expansion (RME) and facemask therapy is a widely used treatment protocol for the correction of Class III malocclusion with maxillary deficiency. The short- and long-term effects of conventional facemask therapy are well documented in earlier reports.[1–11] A combination of the advancement of the maxilla, clockwise rotation of the mandible, and mesial displacement of the maxillary dentition has been reported to contribute to the improvement of Class III malocclusion after treatment.[2–4] In long-term observation, the treated group exhibited relatively successful outcomes. However, favorable dentoskeletal relationships induced by early orthopedic treatment

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Table 1. Descriptive Statistics for the Miniplate/FM Group and the RME/FM Group[a]

		Age (y)						Interval (y)					
		T1		T2		T3		T1–T2		T2–T3		T1–T3	
Groups	n	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Miniplate/FM	20	10.6	1.1	11.7	1.2	18.4	1.8	1.1	0.4	6.5	1.6	7.7	1.6
RME/FM	23	10.0	1.5	11.1	1.5	18.8	1.8	1.0	0.3	7.5	2.7	8.8	2.7

[a] FM indicates facemask; RME, rapid maxillary expansion; SD, standard deviation.

showed a tendency to be re-established with Class III characteristics during the pubertal growth period.[1,5,7–11]

Indirect force transmission through the maxillary dentition may limit skeletal changes and cause unwanted dental movement. Therefore, facemask therapy using skeletal anchorage with miniplates placed in the zygomatic buttress area was previously introduced.[12–15] In short-term observation, the skeletal anchorage group showed more significant advancement of the maxilla, prevention of mesial movement of maxillary dentition, and control of vertical changes compared to the conventional tooth-borne anchorage group after the first phase treatment with facemask therapy.[14] Other investigators proposed several modifications of skeletal anchorage for maxillary protraction, such as miniplates on the lateral nasal walls of the maxilla,[16,17] bimaxillary miniplates for the application of protraction force by intraoral Class III elastics,[18,19] or miniscrew-assisted RME.[20]

However, there have been no reports on the long-term effects of facemask therapy with skeletal anchorage. The aims of this study were to investigate the long-term outcomes of dentoskeletal changes induced by facemask therapy using miniplate anchorage in Class III patients and to compare them to those of conventional tooth-borne anchorage.

MATERIALS AND METHODS

This study was approved by the ethics committee of Gangneung-Wonju National University Dental Hospital (IRB 2019-008). The sample was collected retrospectively from the records of patients who first visited the Department of Orthodontics, Gangneung-Wonju National University Dental Hospital, between 1998 and 2011. The inclusion criteria were: (1) patients who received facemask (FM) therapy with RME appliances (RME/FM group) or miniplates as anchorage (Miniplate/FM group); (2) anterior crossbite or an edge-to-edge incisor relationship with a Class III molar relationship, and Wits appraisal of -2.5 mm or less at pretreatment (T1); and (3) lateral cephalograms available at T1, after facemask therapy (T2), and at the final observation (T3) at a post-pubertal stage according to the cervical vertebral maturation method.[21] Patients who had prior orthopedic or orthodontic treatment, craniofacial deformities, poor compliance, or cosmetic surgery were excluded from the study.

The Miniplate/FM group consisted of 20 patients (14 girls and 6 boys), and 23 patients (15 girls and 8 boys) with ages matching those of the Miniplate/FM group were included in the RME/FM group (Table 1). No significant difference was found in age, time intervals of T1, T2, and T3, and gender distribution between the groups ($P > .05$). Cervical vertebral maturity at T3 was stage 5 (Miniplate/FM; four patients, RME/FM; five patients) or stage 6 (Miniplate/FM; 16 patients, RME/FM; 18 patients), indicating the end of circumpubertal growth. The long-term clinical success rates were evaluated in patients who had received the second phase of orthodontic treatment using fixed appliances. An unsuccessful outcome was defined as an incisor edge-to-edge bite or a negative overjet with a Class III molar relationship at T3.

RME/FM Group

Bonded or banded maxillary expanders with protraction hooks were applied to the maxillary teeth. The patients were instructed to activate the expanders once or twice a day until the desired transverse width was achieved. After expansion, a protraction force of 300 g to 400 g per side was applied and the patients were instructed to wear the facemask for at least 14 hours per day. Protraction was continued until at least a positive overjet and a Class I or Class II molar relationship was achieved. The mean duration of facemask therapy in the RME/FM group was 9.0 $\pm$ 0.3 months. After facemask therapy, two patients used a functional regulator-III or a chin cup for retention, and another two patients used removable acrylic plates in the maxilla for space preservation. After the pubertal growth spurt, the patients underwent a second phase of orthodontic treatment with fixed appliances for an average of 2.3 years, except for three patients who were satisfied with their occlusion. After the second phase of orthodontic treatment, the patients used wraparound retainers or fixed retainers.

Miniplate/FM Group

The surgical procedures for placing the miniplates were described previously.[12–15] The end of the miniplate

Figure 1. Intraoral photograph of elastics applied from miniplates to the facemask.

was exposed to the oral cavity between the maxillary canine and the first premolar area and modified into a hook for elastics (Figure 1). The patients were instructed to wear the facemask for at least 14 hours per day with 300 to 400 g of force per side as in the RME/FM group. Space regaining or maxillary expansion were performed with additional intraoral appliances such as a pendulum, removable acrylic plate, or RME while wearing the facemask. Protraction was continued until at least a positive overjet and a Class I or Class II molar relationship was achieved. The mean duration of active protraction was 9.7 ± 0.3 months. The patients were instructed to wear the facemask at night for retention and 14 patients showed favorable cooperation of wear. The mean duration of nightwear was 1.3 years and the total duration of protraction in the Miniplate/FM group was 2.2 years. The patients underwent a second phase of treatment for an average of 2.3 years, except for one patient who was satisfied with the first phase treatment outcome. After the second phase of treatment, the patients used wrap-around retainers or fixed retainers.

Cephalometric Analysis

Lateral cephalometric radiographs were taken in maximum intercuspal occlusion using the Cranex 3+ (Soredex Orion Corporation, Helsinki, Finland) or the CX-90SP (Asahi Roentgen, Kyoto, Japan). The cephalograms were traced by one investigator on acetate paper using a 0.5 mm pencil. Subsequently, the linear and angular variables were measured using Quick Ceph Studio software (Quick Ceph Systems, San Diego, CA, USA). The magnification factor of each cephalogram was standardized at 8%. Fifteen lateral cephalograms were arbitrarily selected and remeasured by the same investigator at a 2-week interval to assess measuring errors. The method error was calculated by Dahlberg's formula. The mean error was 0.5 mm for linear measurements, and 0.6° for angular measurements.

Statistical Analysis

Because several measurements did not show a normal distribution by Shapiro-Wilk test, nonparametric tests were performed. The cephalometric measurements were compared between the groups using the Mann-Whitney *U*-test. The intragroup differences in T1-T2, T2-T3, and T1-T3 were evaluated with the Bonferroni-corrected Wilcoxon signed-rank test. The statistical comparisons were performed using SPSS software version 18.0 (SPSS, Inc., Chicago, IL, USA). Post-hoc power analyses (β) were conducted for all variables that exhibited statistically significant differences ($P < .05$).

RESULTS

The dentoskeletal characteristics at T1 did not significantly differ between the groups, except for SNA, Wits appraisal, and L1 to MP, which were greater in the RME/FM group than in the Miniplate/FM group (Table 2). Table 3 presents the cephalometric measurements at T1, T2, and T3, and the intragroup differences of each group. SNA, ANB, A to N perpendicular FH, and the angle of convexity, Wits appraisal, and mandibular plane angle (FMA) significantly increased at T2 in both groups. However, during the T2–T3 period, the angle of convexity decreased significantly in both groups.

In comparing the short-term outcomes of facemask therapy (T1–T2) between the groups (Table 4), the Miniplate/FM group showed a significantly greater increase in SNA ($\beta = 0.52$) and A to N perpendicular to FH ($\beta = 0.45$) than the RME/FM group. There was no significant difference in changes in overjet and in the mean duration of protraction between the groups ($P > .05$).

Table 5 shows a comparison of the changes during the pubertal growth period after active facemask therapy (T2–T3) in both groups. Changes in SNA, SNB, A to N perpendicular to FH, mandibular length, and the lower anterior facial height at T2-T3, did not significantly differ between the groups. However, ANB ($\beta = 0.35$), Wits appraisal ($\beta = 0.46$), Angle of convexity ($\beta = 0.47$), FMA ($\beta = 0.61$), and overjet ($\beta = 0.33$) decreased more in the RME/FM group than in the Miniplate/FM group.

As summarized in Table 6, the Miniplate/FM group showed a significantly greater increase in SNA ($\beta = 0.47$), ANB ($\beta = 0.46$), Wits appraisal ($\beta = 0.55$), A to N perpendicular FH ($\beta = 0.46$), and Angle of convexity (β

Table 2. Comparison of Dentoskeletal Features at Pre-Treatment (T1) Between the Miniplate/FM Group and the RME/FM Group[a]

	Miniplate/FM (n = 20)		RME/FM (n = 23)			
Cephalometric Measurements	Mean	SD	Mean	SD	*P* Value	Sig
Cranial base						
Saddle angle (°)	133.9	3.5	131.9	3.2	.075	NS
Maxillary skeletal						
SNA (°)	77.4	2.5	79.2	3.4	.032	*
Midfacial length (Co-A) (mm)	79.2	4.6	79.3	4.0	.865	NS
A to N perpendicular FH (mm)	-3.4	1.9	-3.2	3.7	.526	NS
SNO (°)	59.3	4.3	61.7	5.1	.056	NS
Mandibular skeletal						
SNB (°)	79.3	3.1	80.1	3.6	.394	NS
Mandibular length (Co-Gn) (mm)	111.9	7.1	111.0	6.5	.865	NS
Gonial angle (°)	129.0	5.1	126.6	4.9	.100	NS
Maxillary/mandibular						
ANB (°)	-1.8	1.8	-0.9	1.8	.071	NS
Wits appraisal (mm)	-9.5	2.8	-7.5	2.8	.027	*
Maxillo-mandibular differential (mm)	32.6	4.7	31.7	3.9	.635	NS
Angle of convexity (°)	-4.2	3.7	-2.0	4.4	.119	NS
Vertical skeletal						
Palatal plane angle (°)	0.5	2.6	1.6	3.0	.263	NS
FMA (°)	30.0	3.8	29.5	3.9	.635	NS
Lower anterior facial height (mm)	64.8	4.3	64.8	4.4	.981	NS
Dentoalveolar						
U1 to FH (°)	112.3	6.3	111.9	7.6	.961	NS
L1 to MP (°)	81.5	4.5	85.6	5.8	.016	*
Overbite (mm)	2.0	2.3	2.0	2.6	.798	NS
Overjet (mm)	-1.6	2.0	-1.6	1.6	.826	NS

* $P < .05$ (Mann-Whitney *U*-test).
[a] FM indicates facemask; NS, Not significant; RME, rapid maxillary expansion; SD, standard deviation.

= 0.81) than the RME/FM group in the long-term observation (T1–T3). In contrast, no significant differences were found in mandibular length, FMA, and lower anterior facial height between the groups.

Eighteen out of the 19 subjects in the Miniplate/FM group maintained positive overjet, and only one patient showed an edge-to-edge incisal relationship at T3 (success rate: 95%). In the RME/FM group, 17 out of the 20 patients maintained positive overjet, but two patients showed an edge-to-edge relationship and one patient showed an anterior crossbite at T3 (success rate: 85%).

DISCUSSION

This was a longitudinal study of facemask therapy with skeletal anchorage in Class III children from 8 to 18 years of age, and the final observation was done at or near the cessation of pubertal growth. By matching the mean age between the groups, which may affect the success of facemask therapy, an attempt was made to remove bias due to age differences (Table 1). The Miniplate/FM group showed more skeletal discrepancy than the RME/FM group before facemask therapy (Table 2). However, it did not seem to affect the long-term treatment outcome, and the stability of facemask therapy was even more favorable in the Miniplate/FM group longitudinally.

Changes From Facemask Therapy (T1–T2)

Significant advancement of the maxilla and clockwise rotation of the mandible improved the intermaxillary relationship after protraction therapy in both groups. The increase in SNA (+3.1° vs +2.1°) and A to N perpendicular FH (+3.3 mm vs +2.1 mm) was greater in the Miniplate/FM group than in the RME/FM group, which was probably related to the direct transmission of the orthopedic force to the circumaxillary sutures in the Miniplate/FM group. The results were consistent with those reported by investigators using skeletal anchorage for facemask therapy.[14,19,22,23] Şar et al.[22] placed miniplates on a more anterior part of the maxilla than in the current study. They also found more maxillary advancement in the miniplate group than in the RME/FM group (SNA, +2.53° vs +1.83°; A to N perpendicular FH, +2.53 mm vs +1.76 mm) and the differences between the groups were less than in the current results. Cevidanes et al.,[19] who used intraoral Class III elastics and bimaxillary application of miniplates for maxillary protraction, found that the increase in the midfacial length (Co-A, +5.3 mm vs +2.4 mm) was greater in the miniplate group than in the conventional tooth-borne anchorage group. Hino et al.[23] also reported significant protraction of the maxilla and zygomatic area when using intraoral Class III elastics to bone anchors.

Table 3. Descriptive Statistics and Intragroup Differences of Each Group; Pre-Treatment (T1), After Facemask Therapy (T2), at the Final Observation (T3)[a]

	Miniplate/FM Group									RME/FM Group								
	T1		T2		T3		Intragroup Difference			T1		T2		T3		Intragroup Difference		
Cephalometric Measurements	Mean	SD	Mean	SD	Mean	SD	T1–T2	T2–T3	T1–T3	Mean	SD	Mean	SD	Mean	SD	T1–T2	T2–T3	T1–T3
Cranial base																		
Saddle angle (°)	133.9	3.5	134.1	3.6	133.4	3.7	NS	*	*	131.9	3.2	131.8	3.0	131.2	3.1	NS	*	*
Maxillary skeletal																		
SNA (°)	77.4	2.5	80.5	3.1	81.3	3.6	*	*	*	79.2	3.4	81.3	3.4	81.9	3.6	*	NS	*
Midfacial length (Co-A) (mm)	79.2	4.6	84.7	4.3	87.4	5.4	*	*	*	79.3	4.0	83.8	3.9	88.3	3.8	*	*	*
A to N perpendicular FH (mm)	-3.4	1.9	-0.1	2.7	0.3	2.8	*	NS	*	-3.2	3.7	-1.1	3.8	-0.8	4.2	*	NS	*
SNO (°)	59.3	4.3	61.8	4.9	61.7	4.9	*	NS	*	61.7	5.1	63.4	5.7	63.7	5.0	*	NS	*
Mandibular skeletal																		
SNB (°)	79.3	3.1	78.0	3.2	79.9	3.7	*	*	NS	80.1	3.6	78.4	3.5	81.4	4.5	*	*	NS
Mandibular length (Co-Gn) (mm)	111.9	7.1	115.5	6.8	124.7	6.4	*	*	*	111.0	6.5	114.1	6.7	127.0	7.1	*	*	*
Gonial angle (°)	129.0	5.1	127.4	5.0	126.0	6.0	*	*	*	126.6	4.9	125.6	4.9	123.1	6.4	*	*	*
Maxillary/mandibular																		
ANB (°)	-1.8	1.8	2.5	2.0	1.4	1.8	*	NS	*	-0.9	1.8	2.9	1.4	0.5	2.4	*	*	NS
Wits appraisal (mm)	-9.5	2.8	-3.8	3.4	-3.8	2.2	*	NS	*	-7.5	2.8	-2.3	2.4	-4.4	3.2	*	*	*
Maxillo-mandibular differential (mm)	32.6	4.7	30.8	5.4	37.3	5.2	*	*	*	31.7	3.9	30.3	4.3	38.7	4.9	*	*	*
Angle of convexity (°)	-4.2	3.7	4.3	4.3	1.2	4.1	*	*	*	-2.0	4.4	5.0	3.6	-1.1	5.7	*	*	NS
Vertical skeletal																		
Palatal plane angle (°)	0.5	2.6	-0.9	2.7	-0.9	2.7	*	NS	*	1.6	3.0	0.6	3.1	1.3	2.8	*	*	NS
FMA (°)	30.0	3.8	30.9	4.0	29.7	5.6	*	NS	NS	29.5	3.9	31.1	4.4	27.6	5.4	*	*	*
Lower anterior facial height (mm)	64.8	4.3	68.2	4.6	73.8	5.3	*	*	*	64.8	4.4	68.7	5.4	73.9	4.8	*	*	*
Dentoalveolar																		
U1 to FH (°)	112.3	6.3	114.4	5.9	119.6	6.9	NS	*	*	111.9	7.6	114.7	5.6	119.8	6.9	NS	*	*
L1 to MP (°)	81.5	4.5	80.6	7.2	85.5	7.1	NS	*	*	85.6	5.8	83.6	5.0	88.3	6.9	*	*	NS
Overbite (mm)	2.0	2.3	1.4	1.6	1.3	1.0	NS	NS	NS	2.0	2.6	1.8	1.9	0.7	1.0	NS	NS	NS
Overjet (mm)	-1.6	2.0	4.1	2.1	3.2	1.3	*	NS	*	-1.6	1.6	4.7	1.4	2.2	1.8	*	*	*

* $P < .016$ (Wilcoxon signed rank test with Bonferroni correction).
[a] FM indicates facemask; NS, not significant; RME, rapid maxillary expansion; SD, standard deviation.

Previous studies[14,20] showed less increase in lower facial height in bone-anchored groups, which might have been the result of more extrusion of the maxillary molars during conventional tooth-anchored facemask therapy. However, in the present study, changes in the vertical skeletal measurements at the short-term observation timepoint did not show significant differences between the groups.

Changes After Active Protraction (T2–T3)

Definite forward displacement of the maxilla was not determined after active protraction therapy (T2–T3), but mandibular growth was considerable with a significant increase in SNB and mandibular length in both groups. Macdonald et al.[7] found that the Class III untreated group showed significantly less forward growth of the maxilla but greater forward movement of the mandible compared to the Class I control group. Turley[9] reported that maxillary growth after RME/FM therapy was similar to that of untreated Class III children during the post-protraction observation period. Changes at the post-protraction period were mainly caused by deficient maxillary growth and normal to excessive mandibular growth compared to the Class I control group.[7,9] Direct comparisons with untreated Class I or III controls could not be made in the present study. However, anterior growth of the maxilla in the RME/FM group was similar with that reported previously[7,9] and the stability of the protracted maxilla in the Miniplate/FM group was also well-maintained.

Interestingly, the decrease of ANB, angle of convexity, and FMA was less in the Miniplate/FM group compared to the RME/FM group, and the Wits appraisal and overjet were well-maintained in the miniplate group during the post-protraction period (Table 5). This may be partly explained by the fact that a majority of the Miniplate/FM group used a facemask for an extra year after active protraction therapy at night for retention. The removal of RME appliances is usually recommended after the first phase treatment to prevent the possible risk of microleakage and decalcification of teeth.[24] In contrast, miniplates can remain without any special risk and, thus, are used for further protraction. The decrease in FMA was more evident (-3.5°) in the RME/FM group than in the Miniplate/FM group (-1.2°). Nightwear of the

Table 4. Comparison of Dentoskeletal Changes at T2–T1 Between the Miniplate/FM Group and the RME/FM Group[a]

	Miniplate/FM (n = 20)		RME/FM (n = 23)			
Cephalometric Measurements	Mean	SD	Mean	SD	*P* Value	Sig
Cranial base						
Saddle angle (°)	0.2	0.6	-0.1	0.6	.059	NS
Maxillary skeletal						
SNA (°)	3.1	1.6	2.1	1.0	.024	*
Midfacial length (Co-A) (mm)	5.5	2.8	4.5	1.6	.214	NS
A to N perpendicular FH (mm)	3.3	1.8	2.1	1.0	.008	*
SNO (°)	2.5	1.8	1.7	2.1	.064	NS
Mandibular skeletal						
SNB (°)	-1.3	0.9	-1.7	1.1	.218	NS
Mandibular length (Co-Gn) (mm)	3.6	3.1	3.1	1.4	.961	NS
Gonial angle (°)	-1.6	1.5	-1.0	1.2	.295	NS
Maxillary/mandibular						
ANB (°)	4.4	1.4	3.8	1.4	.223	NS
Wits appraisal (mm)	5.7	2.7	5.2	2.0	.429	NS
Maxillo-mandibular differential (mm)	-1.9	2.1	-1.4	1.4	.278	NS
Angle of convexity (°)	8.5	3.1	7.0	2.8	.128	NS
Vertical skeletal						
Palatal plane angle (°)	-1.4	1.6	-1.0	1.1	.584	NS
FMA (°)	0.9	1.0	1.6	1.6	.079	NS
Lower anterior facial height (mm)	3.4	1.8	3.9	2.6	.380	NS
Dentoalveolar						
U1 to FH (°)	2.1	5.6	2.8	5.6	.592	NS
L1 to MP (°)	-0.9	5.5	-2.0	3.3	.289	NS
Overbite (mm)	-0.6	2.0	-0.2	2.7	.752	NS
Overjet (mm)	5.7	2.4	6.3	1.7	.312	NS

* $P < .05$ (Mann-Whitney *U*-test).
[a] FM indicates facemask; NS, not significant; RME, rapid maxillary expansion; SD, standard deviation.

Table 5. Comparison of Dentoskeletal Changes at T3–T2 Between the Miniplate/FM Group and the RME/FM Group[a]

	Miniplate/FM (n = 20)		RME/FM (n = 23)			
Cephalometric Measurements	Mean	SD	Mean	SD	*P* Value	Sig
Cranial base						
Saddle angle (°)	-0.7	0.8	-0.6	0.9	.660	NS
Maxillary skeletal						
SNA (°)	0.8	1.2	0.6	1.3	.414	NS
Midfacial length (Co-A) (mm)	2.7	2.5	4.5	3.8	.210	NS
A to N perpendicular FH (mm)	0.4	1.3	0.3	1.4	.884	NS
SNO (°)	-0.1	1.6	0.3	3.1	.990	NS
Mandibular skeletal						
SNB (°)	1.9	1.7	3.0	2.6	.125	NS
Mandibular length (Co-Gn) (mm)	9.2	4.2	12.9	8.2	.268	NS
Gonial angle (°)	-1.4	2.0	-2.5	3.2	.257	NS
Maxillary/mandibular						
ANB (°)	-1.1	1.6	-2.4	2.4	.019	*
Wits appraisal (mm)	0.0	3.0	-2.1	2.9	.022	*
Maxillo-mandibular differential (mm)	6.5	2.6	8.4	4.9	.312	NS
Angle of convexity (°)	-3.1	3.4	-6.1	5.1	.027	*
Vertical skeletal						
Palatal plane angle (°)	0.0	1.6	0.7	1.3	.157	NS
FMA (°)	-1.2	2.3	-3.5	2.7	.011	*
Lower anterior facial height (mm)	5.6	3.6	5.2	3.4	.836	NS
Dentoalveolar						
U1 to FH (°)	5.2	8.1	5.1	7.2	.752	NS
L1 to MP (°)	4.9	8.0	4.7	7.6	.913	NS
Overbite (mm)	-0.1	1.4	-1.1	2.0	.079	NS
Overjet (mm)	-0.9	1.5	-2.5	2.0	.012	*

* $P < .05$ (Mann-Whitney *U*-test).
[a] FM indicates facemask; NS, not significant; RME, rapid maxillary expansion; SD, standard deviation.

Table 6. Comparison of Dentoskeletal Changes at T3–T1 Between the Miniplate/FM Group and the RME/FM Group[a]

	Miniplate/FM (n = 20)		RME/FM (n = 23)			
Cephalometric Measurements	Mean	SD	Mean	SD	*P* Value	Sig
Cranial base						
Saddle angle (°)	-0.5	0.9	-0.7	0.9	.367	NS
Maxillary skeletal						
SNA (°)	3.9	2.1	2.7	1.1	.022	*
Midfacial length (Co-A) (mm)	8.2	4.4	9.0	4.1	.465	NS
A to N perpendicular FH (mm)	3.7	2.1	2.4	1.4	.019	*
SNO (°)	2.4	1.7	2.0	3.1	.306	NS
Mandibular skeletal						
SNB (°)	0.6	1.9	1.3	2.7	.247	NS
Mandibular length (Co-Gn) (mm)	12.8	6.0	16.0	8.1	.223	NS
Gonial angle (°)	-3.0	2.0	-3.5	2.6	.487	NS
Maxillary/mandibular						
ANB (°)	3.3	1.5	1.4	2.5	.004	*
Wits appraisal (mm)	5.7	2.8	3.1	2.8	.007	*
Maxillo-mandibular differential (mm)	4.6	3.0	7.0	4.6	.051	NS
Angle of convexity (°)	5.4	3.1	0.9	5.3	.022	*
Vertical skeletal						
Palatal plane angle (°)	-1.4	1.8	-0.3	1.6	.024	*
FMA (°)	-0.3	2.6	-1.9	3.2	.061	NS
Lower anterior facial height (mm)	9.0	4.2	9.1	3.3	.626	NS
Dentoalveolar						
U1 to FH (°)	7.3	9.0	7.9	8.9	.798	NS
L1 to MP (°)	4.0	4.8	2.7	8.2	.575	NS
Overbite (mm)	-0.7	2.2	-1.3	2.6	.503	NS
Overjet (mm)	4.8	2.3	3.8	1.9	.137	NS

* $P < .05$ (Mann-Whitney *U*-test).
[a] FM indicates facemask; NS, not significant; RME, rapid maxillary expansion; SD, standard deviation.

facemask for retention might have inhibited the counterclockwise rotation of the mandible during pubertal growth as a chin cup effect,[6] and minimized the relapse tendency of the Class III intermaxillary relationship.

Overall Long-Term Changes (T1–T3)

The current results were in agreement with those reported by Westwood et al.[1] and Masucci et al.[10] that the forward movement of the maxilla after RME/FM therapy was relatively modest in long-term observation, contrary to short-term observation. In the present study, the Miniplate/FM group showed significantly greater advancement of the maxilla and a more favorable intermaxillary relationship compared to the RME/FM group at T1–T3 (Table 6). However, it remains unclear whether Miniplate/FM therapy has a long-term effect on growth modification of the mandible, and further studies are needed.

Desirable dentoskeletal changes occurred in both groups, allowing for a positive occlusal relationship at T3. Skeletal changes from facemask therapy helped to maintain an improved dental relationship for about 3 to 4 years after the second phase of treatment. The clinical success rate of the RME/FM group (85%) in the current study was a little higher than in previous reports.[1,5,8,10,11] The Miniplate/FM group had a 95% clinical success rate after attaining post-pubertal skeletal maturity, and only one patient had an edge-to-edge incisor relationship. Based on these results, facemask therapy with miniplates is expected to achieve more predictable outcomes than conventional therapy.

This retrospective study had several limitations, including a small sample size and no objective evaluation of patient compliance. Several patients showed poor cooperation during the retention period. Additionally, the retention protocol was different between groups because the RME/FM group could not keep wearing the facemask after RME removal. A definite overcorrection with nightwear in the Miniplate/FM group might have contributed to more favorable long-term outcomes.

CONCLUSIONS

- The Miniplate/FM group showed superiority in maxillary advancement compared to the RME/FM group during the active treatment period, and maxillary growth during the post-protraction period was similar in both groups.
- After facemask therapy, the intermaxillary relationship was better maintained in the Miniplate/FM group compared to the RME/FM group.

- After attaining post-pubertal skeletal maturity, the Miniplate/FM group showed more favorable dentoskeletal changes and higher clinical success rates than the RME/FM group.

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