Original Article

Skeletal changes of maxillary protraction without rapid maxillary expansion

A comparison of the primary and mixed dentition

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ABSTRACT

Objective: To determine potential differences in treatment efficiencies of face mask therapy without rapid maxillary expansion (RME) at different early dental stages.

Materials and Methods: Forty-nine Class III children who were treated with a face mask without RME were divided into two groups according to their pretreatment dental stage. The primary dentition treatment group consisted of 26 subjects and the mixed dentition treatment group consisted of 23 subjects. Lateral cephalograms before treatment (T0), at the end of treatment (T1), and at least 1 year after the end of treatment (T2) were calculated and analyzed. Fourteen cephalometric variables were evaluated by *t*-test to identify any significant differences in skeletal changes between the two groups during T1-T0, T2-T1, and T2-T0.

Results: The primary dentition group showed not only a greater response to maxillary protraction without RME than did the mixed dentition group during T1-T0, but also a greater relapse tendency during T2-T1. As a result, no significant differences were noted between the two groups in the treatment effects of face masks without RME over the time period T2-T0.

Conclusion: This study suggests that face mask therapy without RME may be postponed to the early to mid mixed dentition period because the therapy induces similar skeletal changes when initiated at primary or mixed dentition. (*Angle Orthod.* 2010;80:692–698.)

KEY WORDS: Skeletal changes; Maxillary protraction; Face mask; Dental age

INTRODUCTION

Class III malocclusions with anterior crossbites are common clinical problems among East Asians, including Koreans.[1] More than half of the preadolescent Korean patients visiting an orthodontist have a Class III malocclusion.[2]

Class III malocclusions can be treated in several ways in growing patients. The chin cup has been used to control mandibular overgrowth, which is one of the main reasons for Class III malocclusions. Many studies have demonstrated that chin cup therapy is effective in improving occlusion in skeletal Class III malocclusion subjects.[3] However, several long-term studies have shown that the orthopedic effects of chin cup therapy are questionable.[4,5] In addition, it has been reported that the orthopedic advantages of chin cup therapy seem to outweigh the disadvantage of occasionally inducing a temporomandibular joint disorder.[6] The recognition that maxillary deficiency is another cause of Class III malocclusion in children has led to an increase in face mask treatment, a therapy used to enhance maxillary forward growth.[1,7] Approximately half of Korean children with a Class III malocclusion have a maxillary deficiency.[7]

One important question is whether there exists an optimal time to start treatment in growing children. A number of authors believe that early face treatment may be more effective in improving the skeletal relationship in Class III malocclusion children,[8–12] but others have found no differences in the treatment of different age groups.[13–15] However, most studies have analyzed the treatment efficiency of maxillary protraction using chronological age rather than developmental stage. This results in a high level of variation, making it difficult to determine treatment efficiency. Evaluating treatment efficiency using developmental stages such

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Table 1. Ages at the Start of Orthodontic Treatment (T0), at the End of Treatment (T1), and after Retention (T2)

	Primary Dentition Group (n = 26)		Mixed Dentition (n = 23)	
	Mean (SD)	Range	Mean (SD)	Range
T0 (y)	6.1 (0.5)	5.1–6.9	8.4 (0.8)	6.4–9.7
T1 (y)	7.2 (0.5)	6.2–8.3	9.7 (0.9)	7.8–11.0
T2 (y)	8.6 (0.6)	7.6–10.1	11.1 (1.0)	9.3–12.9

as dental age is better because it is simple and easy to perform in a clinical setting.

Rapid maxillary expansion (RME) has been used widely with various maxillary protraction devices to expand constricted maxillary arches, as posterior crossbites are relatively common in maxillary deficiency cases.[11,13,14] In addition, RME can produce suture opening within all maxillary bone sutures, which helps maxillary protraction by face mask.[10–13] However, many patients are too young or have a transverse dimension of the maxilla that is too to be fitted with an RME, particularly in the primary dentition.

The purposes of this retrospective investigation were to analyze differences in treatment efficiencies of maxillary protraction without RME between earlier treatment during the primary dentition and later treatment during the early to mid mixed dentition, and to compare skeletal changes during treatment and observation periods. The research protocol was reviewed and approved by the institutional review board of the University Hospital (IRB No: GT0914).

MATERIALS AND METHODS

Forty-nine Class III children (32 girls and 17 boys) who satisfied the following criteria were selected from 176 patients who visited the Department of Orthodontics, Korea University Guro Hospital, from 1999 to 2001, and were treated with a face mask. These patients showed (1) primary or early to mid mixed dentition; (2) Class III skeletal pattern with anteroposterior maxillary deficiency, mesial step, and anterior crossbite; (3) available cephalograms from before the initiation of treatment (T0), at the end of treatment (T1), and at least 1 year after treatment (T2); (4) no retention device, such as a fixed appliance or functional appliance during T2-T1; (5) no RME therapy; (6) no other craniofacial anomalies or skeletal asymmetry; (7) no skeletal transverse problems; and (8) no previous orthodontic treatment.

The sample was divided into two groups according to dental development stage at T0. The primary dentition group (PG) consisted of 26 subjects (18 girls and 8 boys) in the primary dentition stage (from completion of primary dentition to beginning of eruption of permanent first molars; Hellman's developmental stages IIA-IIC[15]). The mixed dentition group (MG) consisted of 23 subjects (14 girls and 9 boys) in the early to mid mixed dentition stage (stage from complete eruption of permanent first molars and permanent incisors to shedding of primary canines and molars and the eruption of successors; Hellman's developmental stages IIIA-IIIB[15]). The mean ages of both groups at T0, T1, and T2 are shown in Table 1. Differences between groups in treatment time (T1-T0), the observation period (T2-T1), and total observation time (T2-T0) are described in Table 2.

Treatment was carried out using a Delaire-type face mask[16] (KJ Meditech, KwangJu, Korea) with a removable intraoral appliance and heavy elastics (Figures 1A and 1B). Adams' clasps and the covered occlusal surface in the intraoral appliance provided retention for the elastics (Figures 1C and 1D). Adams' clasps were placed on the primary molars before eruption of the first molar, and on the permanent first molar in the case of complete eruption of the maxillary first molar. Hooks for the elastics were placed between the primary canine and the primary first molar. Elastics (3M/Unitek, Monrovia, Calif) were attached from the hooks on the appliance to the support bar of the face mask in a downward and forward direction (30 degrees from the occlusal plane), producing an orthopedic force of 350 g per side. To prevent dislodging, the appliances were readjusted by putting acrylic in the area of both upper buccal segments when required. Patients were instructed to wear the face mask for at least 12 hours per day. All patients were treated to a positive dental overjet before discontinuing treatment. Most patients were overcorrected toward a distal step of the primary molars.

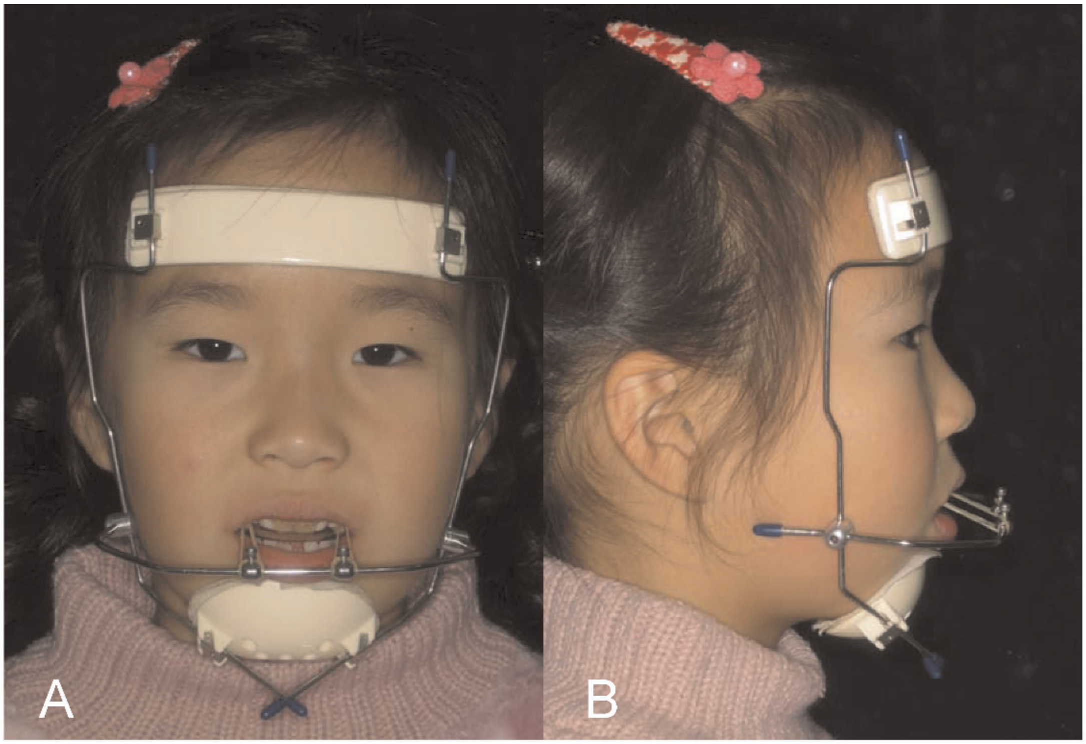
Lateral cephalograms of each patient were taken at T0, T1, and T2 and were traced and analyzed by a single investigator. Thirteen landmarks were digitized on each radiograph (Figure 2), from which 14 variables

Table 2. Comparison of Treatment Time (T1-T0), Retention Time (T2-T1), and Total Observation Time (T2-T0) Between the Primary Dentition Group (PG) and the Mixed Dentition Group (MG)

	PG (n = 26)	MG (n = 23)	Significance[a]
T1-T0 (mo)	13.0 (3.7)	15.1 (5.2)	NS
T2-T1 (mo)	17.2 (6.7)	16.5 (6.4)	NS
T2-T0 (mo)	30.3 (7.8)	31.6 (7.0)	NS

NS indicates not significant.

[a] *t*-test was performed with a significance level of $\alpha = .05$ to compare differences between groups.



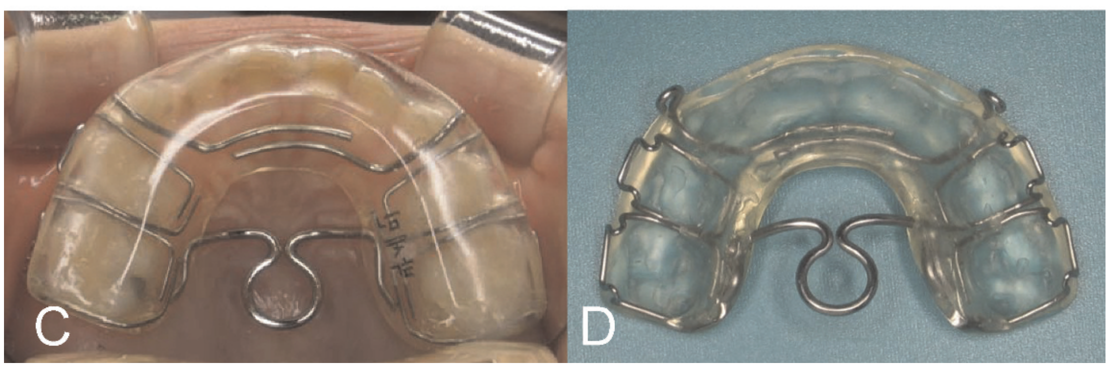


Figure 1. (A) Delaire-type face mask with elastics that delivered 350 g of maxillary protraction force on each side, 30 degrees downward from the occlusal plane. (B) An intraoral removable appliance with hooks at the canine-premolar area.

were selected for evaluation of skeletal changes induced by the face mask treatment (Table 3). Only angular (Figures 3 and 4) and proportional measurements were used to minimize the differences in magnitude between PG and MG according to the patient's developmental stage.

Skeletal changes during treatment, during the observation period, and over the total observation time were found for each variable by subtracting T0 from T1, subtracting posttreatment T1 from T2, and subtracting T0 from T2, respectively (Table 4). Multiple repeated cephalometric measurements at T0, T1, and T2 were correlated or clustered within each subject. Therefore, a multivariate statistical approach was required. After the three basic assumptions were confirmed, the normality of the distribution, the equality of the variance, and the spherical assumption, repeated measure analysis of variance (ANOVA), were performed. In the analysis model, we incorporated gender variable as well as between-group (MG vs PG) variables. All values were considered significant at $P < .05$.

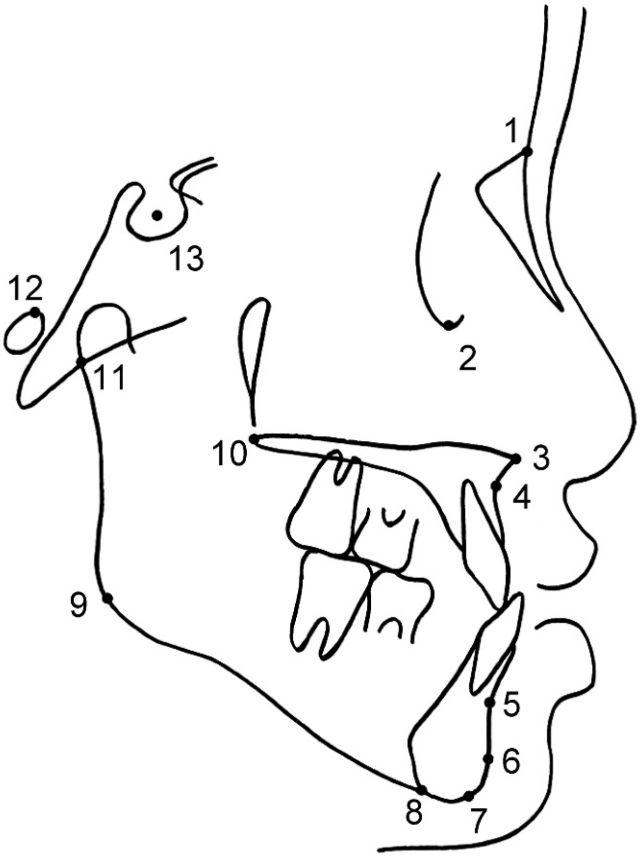


Figure 2. The cephalometric landmarks used in this study. (1) Nasion, (2) orbitale, (3) anterior nasal spine, (4) point A, (5) point B, (6) pogonion, (7) gnathion, (8) menton, (9) gonion, (10) posterior nasal spine, (11) articulare, (12) porion, and (13) sella.

RESULTS

Table 2 shows the differences in treatment time (T1-T0), retention time (T2-T1), and total time (T2-T0) between PG and MG. No significant time difference was noted between the two groups during any time period, indicating that we could eliminate the effects of time on changes in skeletal parameters to determine the treatment efficiency of face mask therapy during any time period.

Table 3 shows the differences in skeletal morphology at T0, T1, and T2. No significant difference in skeletal morphologies was noted between PG and MG, except the mandibular body-to-anterior cranial base ratio at T0. This indicates that the patients in MG had relatively larger mandibles at T0 than did those in PG. Anteroposterior skeletal discrepancies at T1 were greatly improved, although the difference in the mandibular body-to-anterior cranial base ratio still persisted after face mask therapy (Table 3). However, a significant difference in the ANB angle was noted between the two groups at T1. The ANB angle was significantly larger in PG than in MG at the end of treatment. All skeletal differences, including the ANB and the mandibular body-to-anterior cranial base ratio, showed no significant difference between the two groups at T2.

Table 4 shows the changes in skeletal variables of the two groups over T1-T0, T2-T1, and T2-T0, respectively. SNA, ANB, SN-GoGn, and mandibular plane angle increased, while SNB and facial plane angle decreased during treatment, which means that skeletal Class III malocclusions were corrected by forward movement of the maxilla and downward-

Table 3. Cephalometric Comparisons between the Primary Dentition Group (PG) and the Early Mixed Dentition Group (MG) at the Beginning of Treatment (T0), after Treatment (T1), and at Least 1 Year after Treatment (T2)

	T0		T1		T2	
	PG (n = 26)	MG (n = 23)	PG (n = 26)	MG (n = 23)	PG (n = 26)	MG (n = 23)
Variables	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
SNA	78.95 (2.46)	78.13 (2.74)	81.20 (2.30)	80.19 (2.79)	81.03 (2.61)	80.88 (3.04)
SNB	79.42 (2.14)	79.17 (2.90)	77.67 (1.95)	78.39 (2.98)	78.60 (2.23)	79.11 (3.13)
ANB	−0.47 (1.58)	−1.04 (1.78)	3.53 (1.91)**	1.81 (1.95)**	2.43 (1.47)	1.78 (1.19)
Saddle angle	122.78 (3.72)	123.56 (4.65)	123.45 (4.16)	123.55 (4.29)	123.70 (4.03)	123.27 (5.12)
Articular angle	147.82 (4.96)	147.45 (5.54)	149.86 (4.97)	149.09 (5.65)	149.21 (4.78)	148.43 (5.46)
Gonial angle	127.74 (4.25)	129.10 (4.89)	126.85 (4.00)	128.67 (4.55)	126.22 (3.58)	128.24 (5.02)
Sum	398.35 (3.63)	400.12 (4.00)	400.16 (3.46)	401.31 (4.62)	399.13 (3.26)	400.94 (4.27)
SN-GoGn	38.32 (3.63)	40.08 (4.00)	40.13 (3.46)	41.30 (4.63)	39.10 (3.25)	40.92 (4.27)
Facial plane angle	78.77 (1.99)	78.86 (3.23)	77.22 (1.83)	77.91 (3.28)	78.22 (2.16)	78.71 (3.41)
Palatal plane angle	1.77 (2.61)	1.27 (1.89)	1.06 (2.68)	0.91 (2.42)	1.87 (2.34)	1.61 (2.73)
Mandibular plane angle	30.36 (3.37)	31.63 (3.65)	31.95 (3.31)	33.23 (4.06)	31.49 (2.92)	32.49 (4.12)
Mandibular body length-to-anterior cranial base ratio (%)	99.96 (4.02)*	103.30 (6.90)*	101.53 (4.80)*	105.30 (6.22)*	103.44 (5.20)	106.27 (8.13)
Facial height ratio (%)	60.44 (2.84)	59.50 (3.03)	59.65 (2.45)	59.06 (3.57)	60.56 (2.59)	59.77 (3.28)
ANS-Me/Nasion-Me (%)	55.81 (1.40)	55.19 (1.64)	56.59 (1.44)	56.08 (1.69)	56.04 (1.57)	55.33 (1.74)

* $P < .05$; ** $P < .01$.

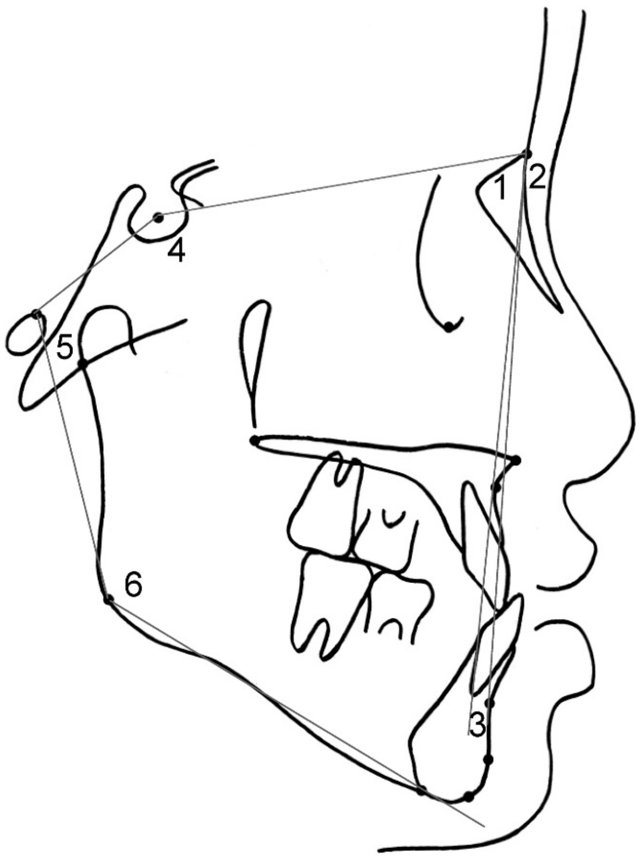


Figure 3. Cephalometric variables used in this study. (1) SNA, (2) SNB, (3) ANB, (4) saddle angle, (5) articular angle, and (6) gonial angle. Sum is the total sum of the saddle angle, articular angle, and gonial angle.

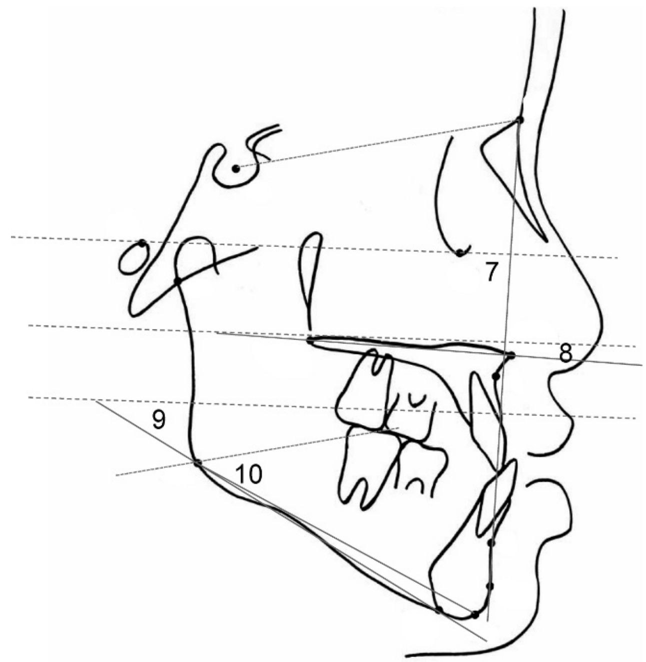


Figure 4. Cephalometric variables used in this study (cont'd). (7) Facial plane angle, (8) palatal plane angle, (9) mandibular plane angle, and (10) SN-GoGn.

backward rotation of the mandible in both groups. However, changes in SNB and ANB were significantly different between the two groups during T1-T0 (Table 4). Changes in the ANB showed a statistically significant difference between the two groups during T2-T1, but no significant difference in skeletal changes was noted during T2-T0 (Table 4).

DISCUSSION

The optimal time to start early face mask therapy in patients with maxillary deficiencies is still controversial. This can be explained in part by the fact that most studies investigating the optimal treatment time for face mask therapy have used chronological age as a classification criterion.[8,10,17] The age ranges of patients in previous studies were fairly wide, meaning that the skeletal effects induced by maxillary protraction might vary with age. Although skeletal age is a more reliable clinical indicator than is chronological age for determining the treatment efficiency of face mask therapy, an additional record, such as a hand-and-wrist radiograph, should be used to measure skeletal age. Therefore, because dental age has been reported to be closely related to skeletal age,[18,19] it can be a useful alternative for determining the most effective timing of maxillary protraction.

Many studies have described the general treatment efficiency of face mask with RME therapy as a combination of effective skeletal and dental modifications.[9–13] Although RME can facilitate effective maxillary forward movement by disrupting the circummaxillary sutural system,[10,11] patients who have a sufficient transverse dimension of the maxilla need only maxillary protraction. In addition, spontaneous improvement of posterior crossbites is observed after maxillary protraction because the protracted maxillary arch fits well with its smaller counterpart of the mandible.

Furthermore, most studies have not investigated the treatment efficiency of face mask treatment in very young patients with primary dentition. Although a previous study compared the treatment effects of maxillary protraction between a deciduous dentition group and an early mixed dentition group, maxillary protraction was performed with RME and data on the observation period were not included.[12] The purpose of this study was to determine the most effective timing for face mask therapy without RME in young growing patients with PG or MG by comparing skeletal changes during T1-T0 and T2-T1 on the basis of dental age.

No significant differences were noted in pretreatment skeletal structures between PG and MG for most variables, except mandibular body-to-anterior cranial

Table 4. Cephalometric Comparisons of Skeletal Changes between the Primary Dentition Group (PG) and the Mixed Dentition Group (MG) during Treatment (T1-T0), the Observation Period (T2-T1), and the Total Period (T2-T0)

	T1-T0		T1		T2	
	PG (n = 26)	MG (n = 23)	PG (n = 26)	MG (n = 23)	PG (n = 26)	MG (n = 23)
Variables	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
SNA	2.24 (1.34)	2.07 (1.77)	−0.17 (1.29)	0.69 (1.86)	2.07 (1.38)	2.75 (1.38)
SNB	−1.75 (1.33)*	−0.78 (1.59)*	0.92 (1.28)	0.72 (1.98)	−0.83 (1.68)	−0.06 (2.32)
ANB	4.00 (1.80)*	2.85 (1.38)*	−1.10 (1.39)*	−0.03 (1.81)*	2.90 (1.58)	2.82 (1.58)
Saddle angle	0.66 (1.49)	−0.02 (2.54)	0.25 (2.19)	−0.28 (2.46)	0.91 (2.09)	−0.29 (2.33)
Articular angle	2.03 (3.29)	1.64 (3.46)	−0.64 (4.57)	−0.66 (3.26)	1.39 (3.37)	0.98 (2.81)
Gonial angle	−0.89 (2.09)	−0.43 (1.65)	−0.64 (2.86)	0.58 (2.07)	−1.53 (2.80)	0.14 (2.54)
Sum	1.81 (1.62)	1.19 (1.61)	−1.03 (1.38)	−0.36 (1.80)	0.77 (1.79)	0.83 (1.73)
SN-GoGn	1.81 (1.63)	1.21 (1.62)	−1.03 (1.37)	−0.38 (1.79)	0.78 (1.79)	0.83 (1.73)
Facial plane angle	−1.54 (1.29)	−0.94 (1.60)	1.00 (1.27)	0.79 (1.99)	−0.55 (1.57)	−0.15 (2.22)
Palatal plane angle	−0.71 (2.00)	−0.36 (1.82)	0.81 (1.97)	0.70 (1.60)	0.09 (2.47)	0.33 (1.97)
Mandibular plane angle	1.58 (1.69)	1.59 (1.58)	−0.45 (1.79)	−0.73 (1.57)	1.12 (2.07)	0.85 (2.15)
Mandibular body length-to-anterior cranial base ratio (%)	1.58 (2.58)	2.02 (4.20)	0.93 (1.61)	0.96 (5.31)	3.49 (3.66)	2.98 (3.49)
Facial height ratio (%)	−0.80 (1.47)	−0.44 (1.09)	0.91 (1.40)	0.72 (1.59)	0.11 (1.62)	0.27 (1.28)
ANS-Me/Nasion-Me (%)	0.78 (1.16)	0.88 (1.10)	−0.55 (0.86)	−0.74 (0.94)	0.22 (1.31)	0.13 (1.22)

* $P < .05$; ** $P < .01$.

base ratio (Table 3). This indicates that at T0, the patients in MG showed a relatively larger mandibular body length than did those in PG. The difference in mandibular body length may be due to the fact that before puberty, the mandible grows at a steadier rate than does the anterior cranial base.[20]

The skeletal Class III malocclusions in the two groups were improved by advancement of the maxilla and backward movement of the mandible (Table 3). Statistical analyses showed the differences in treatment effects between different stages of dental development (Table 4). The magnitudes of maxillary protraction induced by face mask therapy were similar between the two groups, but changes in mandibular position were greater in PG than they were in MG. The different treatment response between PG and MG is consistent with significant differences in ANB at T1 (Table 3). These results are in part consistent with previous studies, which showed that the magnitudes of skeletal changes in the deciduous dentition group were greater than in the early mixed dentition group.[8,12] However, previous studies also showed that both maxillary advancement and mandibular relocation were greater in early treatment groups than in late treatment groups. This may be due to the effects of RME on maxillary protraction, as RME can promote the effects of maxillary protraction by increasing sutural activity around the maxilla.[21] In addition, Delinger[21] has reported that maxillary expansion alone can produce forward movement of the maxilla.

After correction of the Class III malocclusion by face mask treatment, a relapse tendency was noted during the observation period (Tables 3 and 4), with a significant difference in relapse patterns observed between the two groups. The change in ANB during the observation period was greater in the PG than in the MG (Table 4). The ANB difference between the two groups came mostly from the change in SNA during the observation period, which indicates an increased maxillary protraction relapse tendency in PG compared with that in MG during this period. It seems that maxillary protraction induced by face masks without RME may be less stable in very young patients.

Table 4 shows that no significant difference in skeletal changes was seen between the two groups over the total time period. The insignificant differences in skeletal changes may contribute to the similar skeletal patterns noted between the two groups at T2 (Table 3). This can be explained by the fact that the relapse tendency during the observation period was greater in PG than in MG, although face masks induced more favorable corrections of the skeletal Class III pattern in PG. This means that treatment efficiency could not be guaranteed, although the effectiveness of face mask treatment without RME during the primary dentition could be accepted.

When we reclassified patients using the stages in cervical vertebral maturation (CVMS),[23] all patients in PG showed CVMS1. In cases of MG, about half of the patients showed CVMS1 and the remaining showed CVMS2. When we reanalyzed skeletal patterns of the early treatment group (face mask therapy was started in CVMS1) and the late treatment group (treatment was started in CVMS2), the differences in skeletal patterns between early and late treatment groups were not significantly different from those observed between PG and MG at T0, T1, and T2 (data not shown). In addition, results of treatment efficiencies were similar between dental and skeletal groupings. Generally, the early treatment group (CVMS1) showed a more effective orthopedic response in the mandible during T1-T0, and the late treatment group (CVMS2) maintained a more stable result of maxillary protraction during T2-T1.

In this study, the observation period was about 1.5 years. Fixed appliances were usually needed to move each tooth more precisely after maxillary protraction. Individual tooth movement with Class III elastics during fixed appliance therapy can influence skeletal morphology during the retention period. In addition, some patients should wear a functional appliance, a sagittal appliance, or a chin cup to maintain treatment results. Therefore, it was difficult to collect matched samples with sufficient observation time. However, most patients in MG passed through the peak in skeletal growth at T2 based on CVMS, and the patients in PG showed stable results until the postpubertal period. Additional studies using long-term observation data and a control group are needed to better understand the clinical implications of the timing of face mask therapy in growing Class III patients.

CONCLUSIONS

- The primary dentition group showed not only a more effective response to orthopedic correction during the treatment period but also a higher relapse tendency than did the early to mid mixed dentition group after active treatment.
- Similar skeletal effects can be obtained when maxillary protraction is initiated before eruption of the first permanent molar (Hellman's developmental stages IIA-IIC) or after complete eruption of the first permanent molar (Hellman's developmental stages IIIA-IIIB).
- Face mask therapy without RME can be postponed to the early mixed dentition period on the basis of results of this study.

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