Original Article

Long-Term Results of Rapid Maxillary Expansion and Facemask: Long-Term of Regular Protraction

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ABSTRACT

Objective: Evaluation of the long-term skeletal, dental, and soft tissue treatment results of 17 patients who completed their protraction with the facemask.

Materials and Method: Twenty-three Class III patients with a mean age of 12, characterized with maxillary retrognathism, who were treated by facemask protraction therapy, were recalled after 6.08 years following protraction. Only 17 patients presented and their records were renewed. Study was carried out on the initial (T_0), after protraction (T_1), and 6.08 years following protraction (T_2) films. Long-term skeletal, dental, and soft tissue changes were measured.

Results: After 6.08 years, the profile and dental relationships achieved by protraction were found to be well maintained clinically. The cephalometric examination revealed stable sagittal advancement with a mandibular forward positioning. After protraction (T_1) and at 6.08 years of recall (T_2), there were no statistically significant changes found in parameters showing sagittal position of the maxilla (SNA, maxillary depth, and NperA). On the other hand, in the long term, statistically significant increase was noted in the SNB angle, indicating late mandibular growth. In the long term, although the forward positioning of the mandible took place, there was no dental relapse seen, probably because of the significant upper incisor proclination (SN-UI [T_1]: 100.05°; [T_2]: 111.26°), which indicates the dental camouflage.

Conclusion: Advancement achieved by the facemask was found to be stable in the long term. The most important point at which the clinician must pay attention is the late mandibular growth. (*Turkish J Orthod* 2014;27:51–62)

KEY WORDS: Class III, Facemask, Long-term, Stability

INTRODUCTION

Rapid maxillary expansion (RME) and facemask therapy is the most common orthopedic treatment protocol for Class III malocclusion.[1–3] The orthodontic literature includes many articles on the short-term results of RME and facemask therapy in growing subjects with Class III disharmonies.[4] Treatment result with the facemask can be summarized as forward movement of the maxilla, clockwise rotation of the mandible, forward movement of the upper incisors, and retrusion of the lower incisors. Although the main target of this approach is to obtain a forward movement of maxilla, the reported values are not more than 2 mm in 6 to 12 months of treatment time.[4–6] However, short-term improvement does not always mean significant long-term improvement. For patients who had early orthopedic correction, growth at adolescence is a critical indicator for long-term outcomes. Several studies have evaluated the outcomes of the orthopedic treatment protocol at postpubertal observations after fixed appliance therapy, either with[7] or without[8,9] untreated Class III controls. However, in order to evaluate the success of orthodontic treatment, long-term posttreatment analysis is essential. This information is very important for patients being treated with these protocols for at least 2 main reasons: (1) a significant tendency for the reestablishment of the Class III growth pattern has been

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widely demonstrated after active protraction therapy, with a special emphasis during the pubertal growth spurt[7,10] and (2) pubertal growth tends to last longer in Class III subjects compared to Class I subjects.[11] In this study, we aimed to evaluate the short-term and long-term treatment results of maxillary protraction obtained with RME and facemask.

MATERIALS AND METHODS

Twenty-three growing patients with skeletal Class III malocclusion characterized by maxillary retrognathism were selected for RME and maxillary protraction protocol from the clinical intake of the University of Marmara, Department of Orthodontics. Patients were selected according to the following criteria:

(1) Class III skeletal and dental malocclusion,
(2) maxillary retrognathism with normal mandible (maxillary depth: 87.02 ± 3.44; NperA: −3.44 ± 3.05 [Table 1]),
(3) no open bite, and
(4) normal to low angle vertical pattern.

All patients underwent RME with an acrylic-covered hyrax appliance whether or not they had posterior crossbite. Facemask was applied with a one-side 300–500 g force following occurrence of median diastema. Elastics were oriented with a 30° angle to the occlusal plane. Patients were told to wear the facemask nearly 16 hours a day until the achievement of Class II dental relationships. Total treatment time was found to be 8 months. Following the protraction, treatment continued with a multi-bracket system. During fixed treatment in some patients Class II or Class III elastics were used, and in some patients upper first premolars were extracted. There was no standardized protocol for the fixed treatment. At the end of the fixed treatment upper and lower lingual retainers were bonded. At recall time it was seen that some of the retainers were loose or broken but still in place, while the rest were still in the mouth. Patients in this group were recalled after 6.08 ± 0.61 years following the active protraction. Only 17 patients (9 male and 8 female), with a mean initial age of 12.03 ± 2.03 years and mean growth spurt of 3.00 ± 2.37, presented for the follow-up cephalometric study and their records were renewed. At the recall time, the mean age of patients was found to be 18.11 years, and they all completed craniofacial growth. An example of a patient treated by this protocol is shown in Figures 1 through 4.

The study was carried out on the lateral cephalometric films that were taken before treatment (T_0), right after maxillary protraction (T_1), and after 6.08 years of follow-up (T_2) as seen in Figure 5.

Cephalometric method. The horizontal reference plane was drawn at an angle of 7° from the SN plane at point S in clockwise direction (R_1). Then, a perpendicular line was drawn through S point to this horizontal reference plane (R_2).

Twenty-two linear and 11 angular parameters were traced and measured on the lateral cephalograms.

Superimposition of the initial, postprotraction, and recall cephalograms which represents the total skeletal, dental, and soft tissue changes obtained during the protraction and follow-up periods can be seen in Figure 6.

Statistical evaluation. During the assessment of the data, Statistical Package for Social Sciences (SPSS Inc, Chicago, IL, USA) for Windows 15.0 was used. Kolmogorov-Smirnov test was used for the evaluation of the parameters to the normal distribution, and it was found that all parameters were within the normal distribution. Variance analysis was used for repeated measurements for in-group comparisons, to find the differences between the measured values of the parameters of T_0, T_1, and T_2. Paired sample *t* test was used for the in-group comparison of parameters.

RESULTS

Sagittal Changes

Maxillary changes presented by SNA and maxillary depth angle, and NperA, R2-A, and R2-ANS measurements were found to be statistically highly significant (Table 1). All of these parameters exhibited statistically significant increase ($p < 0.01$) from the initial (T_0) to postprotraction (T_1) period and statistically nonsignificant changes between the postprotraction (T_1) and recall (T_2) periods.

SNB and R2-B decreased significantly during protraction ($p < 0.05$ and $p < 0.01$, respectively), while statistically significant increases ($p < 0.01$) were noted between the T_1–T_2 and T_0–T_2 periods.

Dental changes presented by R2-UI tip and R2-UM cusp measurements obtained among all periods were found to be statistically highly significant ($p <$

Table 1. Sagittal changes[a]

Sagittal Changes	Mean ± SD	Post Hoc[a] T_0–T_1	T_0–T_2	T_1–T_2
SNA, degrees				
T_0	79.20 ± 2.27	**	**	NS
T_1	81.23 ± 2.78			
T_2	81.94 ± 3.18			
p	**			
SNB, degrees				
T_0	79.50 ± 2.39	*	**	**
T_1	78.55 ± 2.56			
T_2	82.17 ± 3.26			
p	**			
ANB, degrees				
T_0	−0.29 ± 1.87	**	NS	**
T_1	2.67 ± 1.44			
T_2	−0.23 ± 1.61			
p	**			
Maxillary depth, degrees				
T_0	87.02 ± 3.44	**	NS	NS
T_1	88.82 ± 3.50			
T_2	88.29 ± 3.93			
p	**			
NperA, mm				
T_0	−3.44 ± 3.05	**	**	NS
T_1	−1.17 ± 3.53			
T_2	−1.67 ± 4.22			
p	**			
R2-A, mm				
T_0	66.41 ± 3.95	**	**	NS
T_1	68.88 ± 4.66			
T_2	69.02 ± 4.25			
p	**			
R2-ANS, mm				
T_0	71.67 ± 4.39	**	*	NS
T_1	73.58 ± 5.39			
T_2	73.23 ± 4.41			
p	**			
R2-PNS, mm				
T_0	22.38 ± 2.29	NS	**	NS
T_1	22.94 ± 3.30			
T_2	24.61 ± 3.01			
p	*			
R2-UI tip, mm				
T_0	66.85 ± 4.36	**	**	**
T_1	70.61 ± 4.66			
T_2	74.73 ± 4.46			
p	**			
SN-UI, degrees				
T_0	98.41 ± 4.29	NS	**	**
T_1	100.05 ± 2.76			
T_2	111.26 ± 4.19			
p	**			
R2-UM cusp, mm				
T_0	38.55 ± 5.41	**	**	**
T_1	42.38 ± 5.70			
T_2	44.73 ± 5.00			
p	**			

Table 1. Continued

Sagittal Changes	Mean ± SD	Post Hoc[a] T_0–T_1	T_0–T_2	T_1–T_2
R2-B, mm				
T_0	65.26 ± 5.65	**	**	**
T_1	63.50 ± 5.85			
T_2	69.26 ± 6.30			
p	**			
IMPA, degrees				
T_0	84.00 ± 4.30	**	NS	**
T_1	80.79 ± 4.85			
T_2	85.23 ± 5.83			
p	**			
R2-LI tip, mm				
T_0	69.38 ± 4.14	**	**	**
T_1	67.08 ± 4.59			
T_2	72.67 ± 4.40			
p	**			

[a] T_0 indicates before treatment; T_1, immediately after protraction; and T_2, 6.08 years after protraction.
* $p < 0.05$. ** $p < 0.01$. NS indicates not significant.

0.01), which shows the proclination of upper incisors and mesialization of the upper molars. SN-UI angle measurement increased between the T_0 and T_1 periods, though this increase was found to be statistically nonsignificant ($p > 0.05$); however, highly significant ($p < 0.01$) increases were found between the T_1–T_2 and T_0–T_2 periods. Changes of IMPA and R2-LI tip measurements, except IMPA T_0–T_2 being

Figure 1. Initial extraoral, intraoral pictures.

Figure 2. Postprotraction extraoral, intraoral pictures.

Figure 3. Final extraoral, intraoral pictures.

Figure 4. Recall extraoral and intraoral pictures.

nonsignificant ($p > 0.05$), in all other periods they were found to be highly statistically significant ($p < 0.01$), which shows the retroclination of the lower incisors during protraction and their proclination during the fixed treatment and follow-up period.

Vertical Changes

Changes of maxillary height angle and R1-A, R1-ANS, and N-ANS measurements obtained at all periods were found to be not statistically significant ($p > 0.05$) (Table 2).

Statistically significant decrease of the SN-UOP angle was seen between T_0–T_1 ($p < 0.05$) and T_0–T_2; T_1–T_2 ($p < 0.01$) periods.

SN-MP and ANS-Me measurements were statistically highly increased at all periods ($p < 0.01$).

No statistical change was noted in the SN-PP angle measurement between the T_0–T_1 and T_1–T_2 periods ($p > 0.05$), while decrease obtained during T_0–T_2 was found to be highly statistically significant ($p < 0.01$).

There is highly statistically significant ($p < 0.01$) increase in R1-PNS, N-Me, and R1-UM cusp measurements between the T_0–T_1 and T_0–T_2 periods. No significant change for any of these parameters was observed during the T_1–T_2 period ($p > 0.05$).

Statistically highly significant ($p < 0.01$) increase of ANS-Me/N-Me measurement between the T_0–T_1 and T_0–T_2 periods was noted, while only statistically significant increase was observed during the T_1–T_2 period ($p < 0.05$).

Statistically highly significant ($p < 0.01$) increase of R1-UI tip measurement between T_0 and T_1 and again statistically significant increase ($p < 0.05$) of the same parameter between T_1 and T_2 period was found. No significant change for this parameter was observed during the T_0–T_2 period ($p > 0.05$).

Soft Tissue Changes

The increase of R2-Ls measurement was statistically highly significant at all periods ($p < 0.01$) (Table 3). Again, statistically highly significant ($p < 0.01$) increase of R2-A' measurement between the T_0–T_1 and T_0–T_2 periods was noted, while only statistically significant change was observed during the T_1–T_2 period ($p < 0.05$).

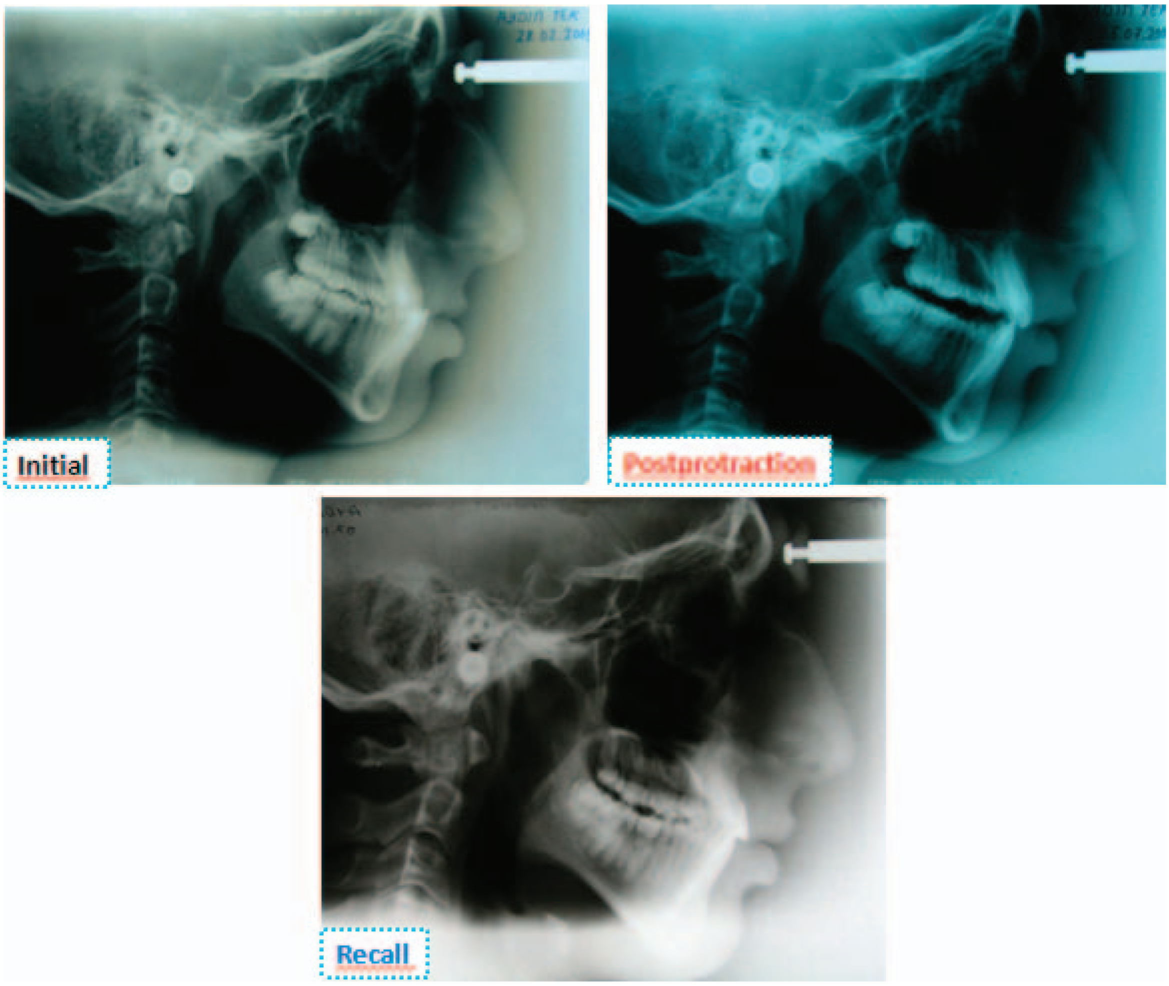

Figure 5. Initial, postprotraction, and recall cephalograms.

Increase of R1-Ls and R1- A' measurements obtained at T_0–T_1 and decrease of the same parameters obtained at T_1–T_2 periods were found to be statistically highly significant ($p < 0.01$), while no significant change for these parameters was observed during the T_0–T_2 period ($p > 0.05$).

Increase of R2-Li measurement between T_0 and T_1 was found to be statistically significant ($p < 0.05$); increase seen in the T_0–T_2 and T_1–T_2 periods was statistically highly significant ($p < 0.01$).

No significant change for NLA was observed during the T_0–T_1 period ($p > 0.05$), while statistically significant ($p < 0.05$) and statistically highly significant ($p < 0.01$) decreases were noted between the T_0–T_2 and T_1–T_2 periods, respectively.

DISCUSSION

Significant improvements in all cephalometric measures for intermaxillary sagittal skeletal relationships were recorded in the treatment group during the T_0–T_1 interval. The SNA and ANB improved by 2.03° and 2.96°, respectively. Both maxillary and mandibular changes contributed to the favorable intermaxillary outcomes in the short term (NperA improved by 2.27°, maxillary depth improved by 1.8°, and SNB angle decreased by 0.95°). At the occlusal level, overjet correction was done, and the Class II canine relationship was established; proclination of the upper and retroclination of the lower incisors along with the mesialization of the upper molars were recorded (R2-UI tip increased by 3.76 mm, R2-UM cusp increased by 3.83 mm, and IMPA and R2-LI tip decreased by 3.21° and 2.3 mm, respectively). No significant changes were recorded in some vertical skeletal relationships, including SN-PP, maxillary height, R1-A, R1-ANS, and N-ANS measurements. On the other hand, increases in skeletal parameters like SN-MP, R1-PNS, ANS-Me, N-Me, and ANS-Me/N-Me and dental parameters like R1-UI tip and R1-UM cusp, indicate the elongation of the face by the downward and backward positioning of the mandible.

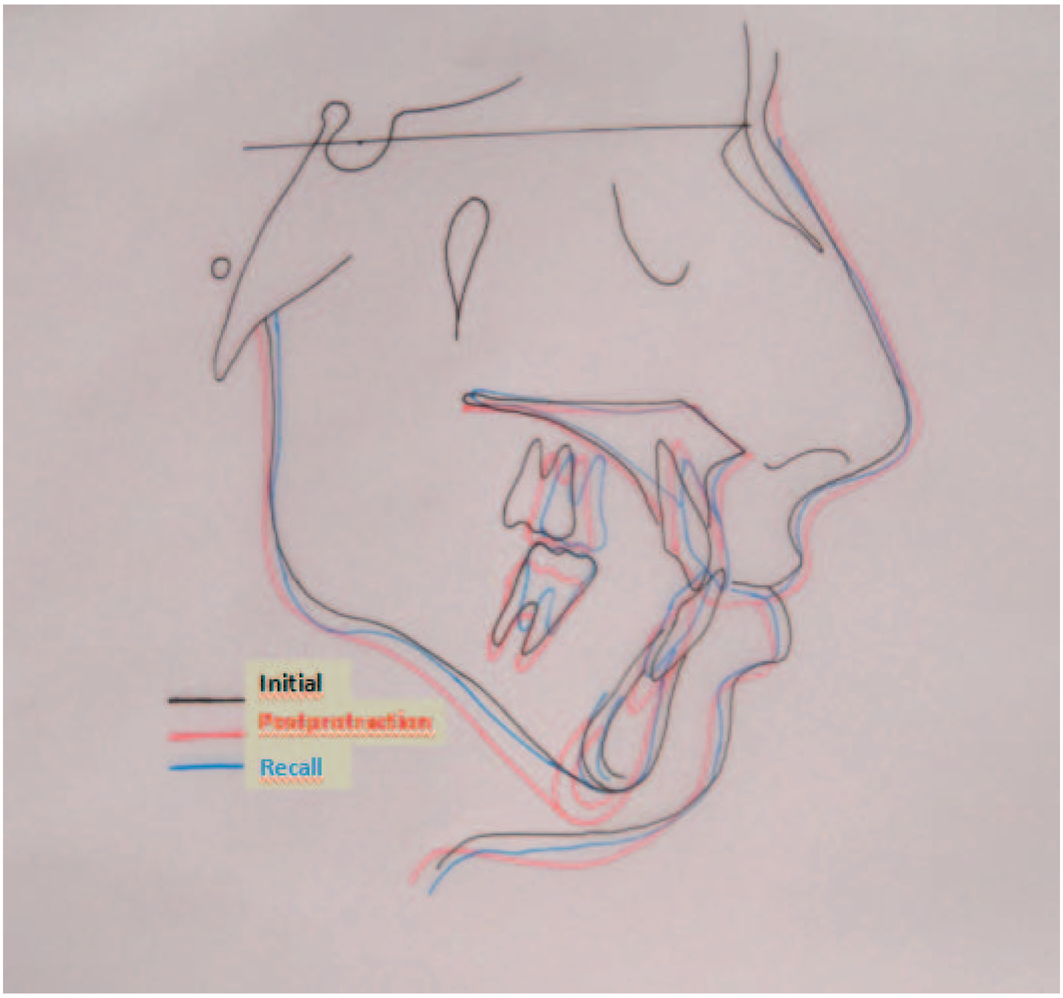

Figure 6. Superimposition showing skeletal, dental, and soft tissue changes of the patient.

Increase in all soft tissue parameters related to the upper lip (R2-A', R2-Ls, R1-A', and R1-Ls improved by 2.67, 2.35, 1.59, and 2 mm, respectively, showing the protrusion and vertical drop of the upper lip) except the nasolabial angle and decrease in parameter related to the lower lip (R2-Li decreased by 1 mm) were found. These short-term treatment outcomes were similar to those reported by Bacetti *et al.*,[3] Da Silva Filho *et al.*,[5] and Alcan *et al.*[6]

On the other hand, the protraction which was observed in the short term was well maintained after 6.08 years. In the long term, between the T_1 and T_2 interval, the cephalometric examination revealed stable maxillary advancement (nonsignificant changes of maxillary depth, NperA, R2-A, and R2-ANS measurements) with no relapse in the sagittal position of the soft tissue. Even though an increases of R2-A' and R2-Ls measurements with the forward positioned mandible (increase in R2-B measurement by 5.76 mm and SNB by 3.62° and decrease of ANB by 2.9°) were noted. At the occlusal level, overjet correction and the Class I canine relationship was maintained mostly, proclination of the upper and lower incisors along with the mesialization of the upper molars were recorded (R2-UI tip and SN-UI increased by 4.12 mm and 11.21°, R2-UM cusp increased by 2.35 mm, IMPA and R2-LI tip increased by 4.44° and 5.59 mm, respectively). These findings are in agreement with findings in other studies of orthodontic literature that report on the long-term maxillary stability of traditional facemask cases.[7,10,12]

Williams *et al.*[13] concluded that the return to a Class III pattern was primarily because of mandibular growth rather than relapse of treatment directed at the maxilla, which is in agreement with our findings.

In the long term, the achieved maxillary sagittal protraction was well maintained, and it was recorded that after the protraction our patients did not exhibit any horizontal growth. Chen *et al.*[14] longitudinally examined 44 untreated subjects from ages 8 to 14

Table 2. Vertical changes

Vertical Changes	Mean ± SD	Post Hoc[a] T_0–T_1	T_0–T_2	T_1–T_2
SN-PP, degrees				
T_0	10.29 ± 3.61	NS	**	NS
T_1	9.20 ± 3.85			
T_2	8.02 ± 4.28			
p	*			
SN-UOP, degrees				
T_0	21.61 ± 2.98	*	**	**
T_1	20.17 ± 3.16			
T_2	12.44 ± 4.74			
p	**			
SN-MP, degrees				
T_0	35.50 ± 4.64	**	**	**
T_1	36.97 ± 4.62			
T_2	31.55 ± 4.60			
p	**			
Maxillary height, degrees				
T_0	61.38 ± 2.48	NS	NS	NS
T_1	60.70 ± 3.27			
T_2	60.52 ± 2.96			
p	*Ns*			
R1-A, mm				
T_0	51.23 ± 3.89	NS	NS	NS
T_1	51.73 ± 4.01			
T_2	51.64 ± 3.28			
p	*Ns*			
R1-ANS, mm				
T_0	44.91 ± 3.93	NS	NS	NS
T_1	45.44 ± 3.79			
T_2	45.26 ± 3.50			
p	*Ns*			
R1-PNS, mm				
T_0	42.29 ± 4.66	**	**	NS
T_1	44.23 ± 5.05			
T_2	43.91 ± 4.55			
p	**			
N-ANS, mm				
T_0	53.88 ± 4.08	NS	NS	NS
T_1	54.64 ± 3.94			
T_2	52.38 ± 5.33			
p	NS			
ANS-Me, mm				
T_0	62.79 ± 4.67	**	**	**
T_1	66.50 ± 5.21			
T_2	67.94 ± 4.85			
p	**			
N-Me, mm				
T_0	116.70 ± 7.26	**	**	NS
T_1	120.91 ± 8.00			
T_2	121.70 ± 6.34			
p	**			
ANS-Me/N-Me, ratio				
T_0	0.53 ± 0.02	**	**	
T_1	0.54 ± 0.01			*
T_2	0.55 ± 0.02			
p	**			

Table 2. Continued

Vertical Changes	Mean ± SD	Post Hoc[a] T_0–T_1	T_0–T_2	T_1–T_2
R1-UI tip, mm				
T_0	71.32 ± 5.00	**	NS	*
T_1	73.20 ± 4.79			
T_2	72.00 ± 3.92			
p	**			
R1-UM cusp, mm				
T_0	63.58 ± 5.66	**	**	NS
T_1	66.47 ± 5.78			
T_2	66.79 ± 7.40			
p	**			

[a] T_0 indicates before treatment; T_1, immediately after protraction; and T_2, 6.08 years after protraction.
* $p < 0.05$; ** $p < 0.01$. NS indicates not significant.

(Class I, 23 girls; Class III, 21 girls) in 2006. They found no significant difference in sagittal intermaxillary relationship in Class III malocclusion from ages 8 to 14. Their results suggested that the sagittal intermaxillary relationships in Class III malocclusions were established before 8 years of age and remained the same throughout puberty. Their findings were consistent with those of Sugawara and Mitani,[15] whose longitudinal studies showed similar maxillary and mandibular growth increments during prepubertal, pubertal, and postpubertal periods when compared to Class I subjects. Therefore, they assumed that the skeletal framework of the Class III malocclusion must have been established before the prepubertal growth period. According to Ochoa and Nanda,[16] the maxillary length increased significantly from ages 6 to 12 and 14 to 20 in female and male Class I subjects, respectively. They reported that the female subjects tended to have the greatest skeletal changes between the ages of 10 and 14, while the male subjects had the greatest changes from ages 12 to 16 and even up to age 18 when considering the mandible. They stated that compared with the maxilla, the mandible grew more than twice as much in length between ages 6 and 20. Their data are conformable with data from Nanda and Ghosh,[17] who have found that the highest rate of growth in the maxilla occurred from ages 6 to 12 in the female and 12 to 18 in the male Class I subjects. The female sample demonstrated a relative deceleration in growth in maxillary length after age 12 and in mandibular length after age 14, whereas the male sample continued to grow significantly until age 16.

The significant increase in R2-UI tip and R2-UM cusp distances indicates that the proclination of the upper incisors and mesialization of the upper posterior dentition took place during treatment, and this increase continues in the follow-up period. Even though the SN-UI angle change was not significant during protraction, it increased significantly later like the other dental measurements, indicating again the proclination in the follow-up period. The lower incisors retroclination, represented by the IMPA and R2-LI tip measurements, was found to be statistically significant during treatment. However, a statistically significant increase of the same parameters, showing the proclination of the lower incisors, took place in the follow-up period. In the clinical examination, there was no discrepancy between the occlusion at finished and recall stages.

The decrease in SN-UOP angle and the increase in R1-PNS, R1-UI, and R1-UM distances can be explained by the extrusion of the posterior part of the maxilla during protraction. All of these parameters were stable during the follow-up period, which indicates that this posterior skeletal and dental extrusion is maintained. Values of the lower facial height (ANS-Me), total facial height (N-Me), and SN-MP angle increased almost in all stages. Increases detected in the follow-up period were probably due to the continuing growth and downward repositioning of the maxilla and mandible. Ochoa and Nanda[16] reported that there were significant increases in the vertical movement of the ANS point between ages 6 and 14 in both sexes combined and in the male subjects alone. They also reported an increase in the vertical movement of point PNS between ages 6 and 16 for both sexes combined and also for male subjects.

Table 3. Soft tissue changes

Soft Tissue Changes	Mean ± SD	Post Hoc[a] T_0-T_1	T_0-T_2	T_1-T_2
R2-A', mm				
T_0	80.88 ± 5.47	**	**	*
T_1	83.55 ± 5.78			
T_2	85.23 ± 5.55			
p	**			
R2-Ls, mm				
T_0	82.76 ± 4.85	**	**	**
T_1	85.11 ± 5.27			
T_2	88.41 ± 5.36			
p	**			
R1-A', mm				
T_0	53.08 ± 4.10	**	NS	**
T_1	54.67 ± 3.97			
T_2	52.00 ± 4.19			
p	**			
R1-Ls, mm				
T_0	63.23 ± 5.04	**	NS	**
T_1	65.23 ± 4.68			
T_2	63.35 ± 4.27			
p	**			
R2-Li, mm				
T_0	83.44 ± 5.51	*	**	**
T_1	82.44 ± 5.75			
T_2	87.47 ± 5.55			
p	**			
NLA, degrees				
T_0	107.85 ± 14.76	NS	*	**
T_1	110.41 ± 12.76			
T_2	100.52 ± 9.65			
p	**			

[a] T_0 indicates before treatment; T_1, immediately after protraction; and T_2, 6.08 years after protraction.
* $p < 0.05$; ** $p < 0.01$. NS indicates not significant.

The advancement of soft tissue A point (A') and upper lip position achieved during treatment continued throughout the follow-up period.

In the short term, significant improvement in skeletal and soft tissue profile was obtained by the means of regular RME and facemask therapy. After 6.08 years of follow-up, the clinical examinations revealed well-maintained profile along with stable dental and soft tissue relationships; the cephalometric measurements showed also well-maintained sagittal relationships with a continuing mandibular growth. Significant upper incisor proclination and molar mesialization took place during all stages, which represents the dental camouflage. Long-term results revealed that the late mandibular growth must be considered as an important factor contributing to the long-term stability of the orthopedically treated Class III patients.

CONCLUSION

Advancement achieved by the facemask was found to be stable in the long term. The most important point to which the clinician must pay attention is the late mandibular growth that contributes to the relapse of Class III in the long term.

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