Stability of rapid maxillary expansion and facemask therapy: A long-term controlled study

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Introduction: The aim of this prospective controlled study was to evaluate the long-term effects of rapid maxillary expansion and facemask therapy in Class III subjects. **Methods:** Twenty-two subjects (9 boys, 13 girls; mean age, 9.2 years ± 1.6) with Class III disharmony were treated consecutively with rapid maxillary expansion and facemask therapy followed by fixed appliances. The patients were reevaluated at the end of the 2-phase treatment (mean age, 14.5 years ± 1.9) and then recalled about 8.5 years after the end of rapid maxillary expansion and facemask treatment (mean age, 18.7 years ± 2.1). Two groups of controls with untreated Class III malocclusion were used for statistical comparisons of the short-term and long-term intervals. Statistical comparisons were performed with the Mann-Whitney U test. **Results:** In the long term, no significant differences in maxillary changes were recorded, whereas the treatment group showed significantly smaller increases in mandibular protrusion. The sagittal maxillomandibular skeletal variables maintained significant improvements in the treatment group vs the control groups. **Conclusions:** In the long term, rapid maxillary expansion and facemask therapy led to successful outcomes in about 73% of the Class III patients. Favorable skeletal changes were mainly due to significant improvements in the sagittal position of the mandible. (Am J Orthod Dentofacial Orthop 2011;140:493-500)

Rapid maxillary expansion and facial mask (RME/FM) therapy is the most common orthopedic treatment protocol for Class III malocclusion.[1,2] The literature includes many articles on the short-term results of RME/FM therapy in growing subjects with Class III disharmonies, as described in a recent systematic review.[3] Several studies have also evaluated the outcomes of the orthopedic treatment protocol at postpubertal observations after fixed appliance therapy, either with[4] or without[5,6] untreated Class III controls. Both short-term and postpubertal observations indicated a fair-to-good effectiveness of RME/FM therapy, with about 70% to 80% of the patients showing favorable results after puberty. The dentoskeletal changes induced by therapy consist of a combined effect of the protocol on both maxillary and mandibular components. Optimal timing for the orthopedic approach to Class III malocclusion is related to early treatment, at either a prepubertal or a pubertal phase of development.[7]

No data are available in the literature with regard to the outcomes of RME/FM therapy revaluated at the end of active craniofacial growth—ie, after the circumpubertal developmental period. This information is vital for the appraisal of orthopedic treatment results in patients with Class III malocclusion for at least 2 main reasons. First, a significant tendency for the reestablishment of the Class III growth pattern has been widely demonstrated after active protraction therapy, with special emphasis during the pubertal growth spurt.[4,8-10] Second, pubertal growth tends to last longer in Class III subjects compared with Class I subjects.[11] On the other end, long-term observations at the end of active craniofacial growth are available for different orthopedic and orthodontic approaches: chincup therapy, with favorable short-term changes often not maintained at the end of growth,[12] and mandibular cervical headgear, with greater long-term stability of favorable mandibular modifications.[13]

The aim of this study was to analyze the long-term outcomes of RME/FM therapy in Class III subjects. The

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study included Class III subjects treated consecutively with the orthopedic protocol in a prospective design and subjects with untreated Class III malocclusions as controls.

MATERIAL AND METHODS

A sample of 30 subjects with Class III dentoskeletal disharmony were treated consecutively with RME/FM therapy followed by comprehensive preadjusted edgewise therapy at the Departments of Orthodontics of the University of Florence and the University of Rome Tor Vergata. All patients had the following dentoskeletal features before therapy (T1) when the pretreatment lateral cephalogram was taken: European ancestry (white), anterior crossbite or edge-to-edge incisor relationship, Class III molar relationship, Wits appraisal of −2.0 mm or less, no discrepancy between centric occlusion and centric relation (indicating pseudo-Class III malocclusion), and prepubertal skeletal maturation (CS 1-CS 3).[14]

The patients were reevaluated with a lateral cephalogram at the end of the 2-phase treatment (T2) and then recalled at an average of 4 years after T2 (T3, about 8.5 years from the end of RME/FM treatment). Eight of the 30 initial subjects could not be located at T3 or did not agree to be reevaluated radiographically in the long term. Therefore, a lateral cephalogram at T3 was taken in the 22 subjects (9 male, 13 female) who represented the final sample of the study. The T3 cephalograms were taken at least 2 years after the attainment of stage 6 in cervical vertebral maturation (completion of circumpubertal active craniofacial growth) for all treated subjects.

Two samples of controls with untreated Class III malocclusions were used for statistical comparisons of the short-term (T1-T2) and long-term (T1-T3) observation intervals. All subjects in the control groups had been followed longitudinally at the Department of Orthodontics of the University of Florence, and they matched the treated group according to ancestry, dentoskeletal Class III characteristics, age, skeletal maturation at all observation periods, duration of observation intervals, and sex distribution.

The 3 components of the RME/FM therapy used in this study were a maxillary expansion appliance, a facemask, and heavy elastics.[1,15] Treatment began with the placement of a bonded or banded maxillary expander to which were attached vestibular hooks extending in a superior and anterior direction. The patients were instructed to activate the expander once or twice a day until the desired transverse width was achieved.

The patients were given facemasks with pads fitted to the chin and forehead for support either during or immediately after expansion. Elastics were attached from the soldered hooks on the expander to the support bar of the facemask in a downward and forward vector, producing orthopedic force levels up to 400 to 500 g per side. The patients were instructed to wear the facemask for a minimum of 14 hours per day. All patients were treated at least to a positive dental overjet before discontinuing treatment; most patients were overcorrected toward a Class II occlusal relationship. The average duration of the RME/FM treatment was 1.1 years ± 5 months.

As occurs in studies involving any removable device, compliance with the instructions of the orthodontist and staff varied among patients. Therefore, compliance was appraised with a 3-point Likert scale (poor, moderate, good).[16] Nineteen of the 22 subjects (86.3%) underwent a second phase of preadjusted edgewise therapy after an interim period, during which a removable mandibular retractor typically was worn or, in a few instances, immediately after the rapid maxillary expansion and protraction treatment.[17] On average, fixed appliance therapy lasted 18 months. During the T2-T3 period, the patients wore a standard Hawley retainer at night for about 2 years, and thereafter they wore no retention appliance.

A customized digitization regimen and cephalometric analysis provided by Viewbox (version 3.0, dHAL Software, Kifissia, Greece) was used for all cephalograms examined in this study. The customized cephalometric analysis, containing measurements from the analyses of Jacobson,[18] McNamara,[19] and Steiner,[20] generated 19 variables, 9 angular and 10 linear, for each tracing. Magnification was standardized to an 8% enlargement for all radiographs in both treated and control samples.

Statistical analysis

Descriptive statistics were calculated for age at T1, T2, and T3, and for the T1-T2 and T1-T3 age intervals in all groups. Statistical comparisons on these data were performed with the Mann-Whitney U test. Chi-square tests were used to assess differences in sex distributions between groups. The comparison between the treated group and the controls on the dentoskeletal features at T1 (starting forms) was performed with Kruskal-Wallis and Tukey post-hoc tests.

The following statistical comparisons were carried out with the Mann-Whitney U test: (1) treatment effects (T1-T2: T1-T2 changes in the treatment group vs T1-T2 changes in the T1-T2 control group; and (2) overall long-term effects (T1-T3: T1-T3 changes in the treatment group vs T1-T3 changes in the T1-T3 control group.

The prevalence rate of successful patients in the long term (at T3) was calculated in the treatment group. As reported earlier, an unsuccessful outcome of treatment was defined as a concurrent Class III permanent molar relationship and a negative overjet.[21] The prevalence

Table I. Demographics for the treated and the control groups

Treated group (9 male, 13 female)				*Control group T1-T2 (9 male, 7 female)*				*Control group T1-T3 (8 male, 5 female)*			
Period/ interval	*n*	*Mean (y)*	*SD (y)*	*Period/ interval*	*n*	*Mean (y)*	*SD (y)*	*Period/ interval*	*n*	*Mean (y)*	*SD (y)*
T1	22	9.2	1.6	T1	16	8.6	1.8	T1	13	8.4	0.9
T2	22	14.5	1.9	T2	16	14.8	2.1				
T3	22	18.7	2.1					T3	13	17.5	1.1
T1-T2	22	5.3	1.9	T1-T2	16	6.2	2.0				
T1-T3	22	9.4	2.5					T1-T3	13	9.5	1.8

There were no significant differences either between the treated group and the respective control group at any age period or observation interval (Mann-Whitney U test, $P < 0.05$), or sex distribution (z test on proportions, $P < 0.05$).

rate of compliance was calculated in treatment group, and the association with the long-term outcome of treatment was appraised with the chi-square test.

The power of the study was calculated on the basis of the difference between the treated and control groups for a relevant cephalometric variable (ANB angle) as reported in a previous longitudinal investigation of similar nature and on the basis of the standard deviation of this difference.[4] The power exceeded 0.90 at an α level of 0.05.

The method error was determined with 15 lateral cephalograms, selected randomly, traced and measured twice within a week by the same operator (C.M.). The measurements at both times for each patient were analyzed with the intraclass correlation coefficient, which varied between 0.966 for the SNB angle and 0.995 for the inclination of the maxillary incisor to the SN line. These values indicated a high level of intraobserver agreement. Linear measurement errors averaged 0.3 mm (SD, 0.8 mm), and angular measurement errors averaged 0.4° (SD, 0.6°).

The stage of cervical vertebral maturation was assessed for each film in a patient's series by using the method described by Baccetti et al.[14] Staging of cervical vertebrae for each cephalogram was performed by the senior author (T.B.) and then verified by 2 independent investigators (C.M., L.F.) experienced in this method.

RESULTS

The demographic data of the treated group and the control groups (T1-T2 and T1-T3) are reported in the Table I, along with the statistical comparisons showing no significant difference for age at observation periods, age intervals, or sex distribution. The comparisons of the starting forms of the treated group vs the control group T1-T2 and the control group T1-T3 (Table II) showed no significant differences with the exception of a smaller inclination of the maxillary incisors to SN in the control group T1-T2 with respect to the control group T1-T3.

The success rate in the long term (at T3) in the treated group was 16 of 22 patients, or 72.7%.

Table III reports the treatment effects when comparing the T1-T2 changes in the treated group vs the control group T1-T2. These effects comprise the outcomes of active RME/FM therapy followed by fixed appliances in a 2-phase treatment protocol. The treated group showed a significantly greater amount of maxillary advancement (Point A to nasion perp, 1.4 mm), along with significant decrements in the size and sagittal position of the mandible (Co-Gn, −4.2 mm; SNB, −1.6°; Pg to nasion perp, −2.8 mm). The sagittal maxillomandibular skeletal variables all showed highly significant improvements in the treated group vs the control group (Wits appraisal, 3.9 mm; max/mand differential, −5.2 mm; ANB angle, 2.1°).

Overjet and molar relationship improved significantly in the treated group vs the control groups (2.5 and −4.9 mm, respectively), with a significantly reduced amount of maxillary incisor proclination in the treated group (U1 to SN, −6.5°).

Table IV reports the overall long-term treatment and posttreatment effects when comparing the T1-T3 changes in the treated group vs the control group T1-T3. These effects comprised the outcomes of the 2-phase treatment protocol followed by an average of 5 years of posttreatment observation. The T3 observation was taken approximately 8 years after the completion of the orthopedic portion of therapy (RME/FM).

In the long term, no significant differences in maxillary changes were recorded, whereas the treated group still showed a significant decrement in the sagittal position of the mandible (SNB, −2.0°). The sagittal maxillomandibular skeletal variables all maintained significant improvements in the treated group vs the control group (Wits, 3.0 mm; max/mand differential, −3.7 mm; ANB angle, 1.4°). The molar relationship improved significantly in the treated group (3.2 mm more than the T1-T3 control group).

The analysis of compliance of the treated subjects during the orthopedic therapy (use of the facial mask) showed that none had a "poor" degree of cooperation;

Table II. Analysis of starting forms

Cephalometric measures	Treated group (TG) n = 22 Mean	SD	Control group (CG T1-T2) n = 16 Mean	SD	Control group (CG T1-T3) n = 13 Mean	SD	TG vs CG T1-T2	TG vs CG T1-T3	CG T1-T2 vs CG T1-T3
Cranial base									
Cranial flexure (°)	130.5	5.8	127.2	4.9	126.3	3.6	NS	NS	NS
Maxillary skeletal									
Co-point A (mm)	81.6	4.9	80.2	5.4	79.5	4.8	NS	NS	NS
SNA (°)	79.8	4.3	79.7	3.5	80.1	2.8	NS	NS	NS
Point A to nasion perp (mm)	0.0	3.0	−1.4	2.1	−1.5	1.9	NS	NS	NS
Mandibular skeletal									
Co-Gn (mm)	109.3	7.6	108.9	8.7	106.5	7.7	NS	NS	NS
SNB (°)	79.5	3.7	80.2	3.9	79.7	3.5	NS	NS	NS
Pg to nasion perp (mm)	−1.0	5.2	−1.6	7.1	−2.9	7.2	NS	NS	NS
Gonial angle (°)	127.1	4.3	131.2	6.0	129.3	6.3	NS	NS	NS
Maxillary/mandibular									
Wits appraisal (mm)	−6.1	2.2	−7.0	3.1	−6.6	3.8	NS	NS	NS
Max/mand differential (mm)	27.8	4.7	28.6	6.0	27.0	6.2	NS	NS	NS
ANB (°)	0.4	1.8	−0.5	2.7	0.4	2.6	NS	NS	NS
Vertical skeletal									
FH to palatal plane (°)	−1.7	2.2	−2.0	3.4	−0.7	4.0	NS	NS	NS
MPA (°)	25.5	4.5	28.7	5.6	27.9	6.1	NS	NS	NS
ANS to Me (mm)	63.2	5.4	61.1	4.2	60.9	4.4	NS	NS	NS
Interdental									
Overjet (mm)	0.1	1.6	−0.8	1.7	−0.6	1.8	NS	NS	NS
Overbite (mm)	0.3	1.6	0.5	1.8	−0.4	1.8	NS	NS	NS
Molar relationship (mm)	4.1	1.7	5.4	1.6	5.2	2.0	NS	NS	NS
Dentoalveolar									
U1 to SN (°)	107.0	10.6	99.9	8.7	118.7	19.7	NS	NS	*
L1 to MPA (°)	84.2	5.3	82.5	7.6	85.2	8.0	NS	NS	NS

Statistical comparisons were performed with Kruskal-Wallis and Tukey post-hoc tests ($P < 0.05$).
NS, Not significant.
*$P < 0.05$.

7 had "moderate" compliance, and the remaining 15 patients had "good" compliance. As a result, therefore, cooperation was good in 68.2% of the patients.

When compliance was evaluated in association with the long-term outcomes of therapy (at T3), 5 patients with moderate compliance had long-term unfavorable results, whereas only 2 patients with moderate compliance had a successful outcome of treatment at T3. The association between the degree of compliance and the long-term clinical success of therapy was highly significant (chi-square, 7.061; $P = 0.008$).

DISCUSSION

We analyzed for the first time the long-term effects of RME/FM therapy in growing subjects with Class III malocclusion. The main features of our longitudinal study were the following.

1. Patients were treated with RME/FM consecutively and enrolled in the study regardless of successful outcomes. A posttreatment observation (T2) was taken approximately 4 years after the end of RME/FM therapy, and the long-term appraisal (T3) was approximately 8 years after the end of the orthopedic treatment.
2. The Class III patients were treated with the orthopedic protocol at a prepubertal stage of skeletal maturity (CS 1 or CS 2). All patients were postpubertal at T2 (CS 4-CS 6), and they had completed the active circumpubertal growth at the T3 observation (at least 2 years in CS 6).
3. The control samples consisted of subjects with untreated Class III malocclusion followed longitudinally, and they matched the treated group as to dentoskeletal Class III disharmony, age intervals, skeletal maturations at different time points, and sex distribution (Tables I and II).

The results of the T1-T2 longitudinal observation (Table III) can be regarded as the short-term outcomes

Table III. Analysis of treatment effects (T1-T2) and comparisons (Mann-Whitney U test, $P < 0.05$) of T1-T2 changes in the treated group vs T1-T2 changes in the control group T1-T2

	Treated group (TG) n = 22		*Control group (CG T1-T2) n = 16*		*TGvs CG T1-T2*		
Cephalometric measurement	*Mean*	*SD*	*Mean*	*SD*	*Net difference*	P *value*	
Cranial base							
Cranial flexure (°)	−0.2	2.8	−0.2	2.0	0.0	0.919	NS
Maxillary skeletal							
Co-point A (mm)	8.3	4.1	7.3	2.6	1.0	0.438	NS
SNA (°)	1.9	2.9	1.5	1.8	0.4	0.965	NS
Point A to nasion perp (mm)	1.7	1.8	0.3	1.6	1.4	0.036	*
Mandibular skeletal							
Co-Gn (mm)	14.1	4.8	18.3	5.3	−4.2	0.021	*
SNB (°)	2.0	3.1	3.6	2.3	−1.6	0.042	*
Pg to nasion perp (mm)	4.2	4.0	7.0	4.0	−2.8	0.048	*
Gonial angle (°)	−3.0	3.3	−2.5	3.5	−0.5	0.827	NS
Maxillary/mandibular							
Wits appraisal (mm)	1.1	2.6	−2.8	1.8	3.9	0.000	†
Max/mand differential (mm)	5.8	3.3	11.0	3.3	−5.2	0.000	†
ANB (°)	0.0	1.4	−2.1	1.6	2.1	0.000	†
Vertical skeletal							
FH to palatal plane (°)	0.0	1.9	−0.5	1.9	0.5	0.137	NS
MPA (°)	−2.2	3.0	−2.3	3.4	0.1	0.849	NS
ANS to Me (mm)	6.5	2.3	8.2	3.8	−1.7	0.060	NS
Interdental							
Overjet (mm)	1.8	2.6	−0.7	3.1	2.5	0.037	*
Overbite (mm)	1.4	1.4	0.6	1.9	0.8	0.161	NS
Molar relationship (mm)	−0.5	1.8	4.4	2.5	−4.9	0.000	†
Dentoalveolar							
U1 to SN (°)	2.4	8.9	8.9	6.1	−6.5	0.024	*
L1 to MPA (°)	−0.5	3.9	−1.0	5.7	0.5	0.589	NS

NS, Not significant.
*$P < 0.05$; †$P < 0.001$.

of a 2-phase treatment protocol incorporating an orthopedic treatment phase (RME/FM) followed by fixed appliances in the permanent dentition. Significant improvements in all cephalometric measures for intermaxillary sagittal skeletal relationships were recorded in the treatment group during the T1-T2 interval. When they were compared with the untreated controls, the Wits appraisal improved by 3.9 mm, the maxillomandibular differential improved by 5.2 mm, and the ANB angle improved by 2.1°. Both maxillary and mandibular changes contributed to the favorable intermaxillary outcomes in the short term (Point A to nasion perp improved by 1.4 mm, and Co-Gn decreased by 4.2 mm, SNB angle decreased by 1.6°, and Pg to nasion perp decreased by 2.8 mm over the controls). At the occlusal level, overjet correction was 2.5 mm, and the correction in molar relationships was 4.9 mm. No significant changes were recorded in the vertical skeletal or dental relationships. These short-term postpubertal treatment outcomes were similar to those reported by Westwood et al,[4] who implemented a comparable methodology of investigation.

The analysis of the T1-T3 results (Table IV) after active circumpubertal growth (average age, 18.5 years) showed that intermaxillary sagittal skeletal relationships still exhibited favorable changes compared with the untreated Class III controls. Substantial favorable modifications were recorded in the mandible (−3.9 mm for Co-Gn in the treated subjects vs the controls, −1.8 mm for Pg to nasion perp, and −2° for SNB). These mandibular changes accounted for most of the intermaxillary outcomes. No significant improvements in the maxillary measurements were found in the treated sample in the long term. More than 3 mm of molar correction was still assessed during the T1-T3 interval.

The long-term appraisal of the outcomes of RME/FM therapy failed to show some of the craniofacial changes that have been described in previous controlled trials reporting the short-term changes with the same treatment protocol.[4,22] From T1 to T3, the treatment group did not show a significant amount of closure of the gonial angle (a growth modification that has been advocated as a favorable mechanism to limit linear increases of the mandible along Co-Gn[23]) or any

Table IV. Analysis of overall long-term effects (T1-T3) and comparisons (Mann-Whitney U test, $P < 0.05$) of T1-T3 changes in the treated group vs T1-T3 changes in the control group T1-T3

	Treated group (TG) n = 22		*Control group (CG T1-T3) n = 13*		*TG vs CG T1-T3*		
Cephalometric measurement	*Mean*	*SD*	*Mean*	*SD*	*Net difference*	P *value*	
Cranial base							
Cranial flexure (°)	−0.2	2.9	−0.9	2.1	0.7	0.339	NS
Maxillary skeletal							
Co-point A (mm)	10.8	3.9	10.9	4.8	−0.1	0.891	NS
SNA (°)	1.9	2.6	2.1	2.8	−0.2	0.413	NS
Point A to nasion perp (mm)	1.1	2.6	0.9	2.8	0.2	0.891	NS
Mandibular skeletal							
Co-Gn (mm)	20.6	6.3	24.5	6.9	−3.9	0.172	NS
SNB (°)	2.3	3.0	4.3	2.7	−2.0	0.048	*
Pg to nasion perp (mm)	5.8	6.0	7.6	5.1	−1.8	0.322	NS
Gonial angle (°)	−4.7	3.8	−4.3	3.7	−0.4	0.609	NS
Maxillary/mandibular							
Wits appraisal (mm)	0.1	3.7	−2.9	3.7	3.0	0.017	*
Max/mand differential (mm)	9.8	4.7	13.5	4.5	−3.7	0.024	*
ANB (°)	−0.8	1.7	−2.2	2.0	1.4	0.044	*
Vertical skeletal							
FH to palatal plane (°)	0.9	2.5	0.9	3.1	0.0	0.707	NS
MPA (°)	−3.2	3.6	−2.4	4.1	−0.8	0.657	NS
ANS to Me (mm)	9.8	3.0	12.5	3.8	−2.7	0.052	NS
Interdental							
Overjet (mm)	1.1	3.2	−0.1	2.6	1.2	0.527	NS
Overbite (mm)	1.2	1.5	0.7	2.2	0.5	0.388	NS
Molar relationship (mm)	0.7	2.3	3.9	2.4	−3.2	0.000	†
Dentoalveolar							
U1 to SN (°)	3.1	9.8	8.8	8.8	−5.7	0.095	NS
L1 to MPA (°)	0.6	4.4	−1.7	5.0	2.3	0.227	NS

NS, Not significant.
*$P < 0.05$; †$P < 0.001$.

significant improvement in the sagittal position of the maxilla, as described by Westwood et al[4] and Pangrazio-Kulbersh et al.[22] However, Franchi et al[7] showed that both of these craniofacial changes are induced by early, prepubertal orthopedic treatment of Class III disharmony, but they are not associated with later treatment, during or after puberty. Our study included patients who underwent orthopedic treatment before puberty (14 patients) and at puberty (8 patients). Therefore, the lack of a specific prepubertal treatment in this study might explain the lack of significant results in terms of maxillary or gonial angle changes in the long term.

The favorable long-term outcomes in terms of mandibular position in the patients treated with the orthopedic protocol could be associated with changes in the glenoid fossa that have been described previously for chincap therapy[24] and miniplates and Class III elastics protocol.[25] A laminagraphic evaluation of temporomandibular joint changes after chincap therapy showed deepening and widening of the mandibular fossa, and narrowing of the clearance between the condyle and the fossa.[24] No tendency to an increase in the vertical skeletal relationships was recorded in the treated group at either the T2 or T3 observations, in contrast with previous findings by Macdonald et al.[8] The use of a correct downward inclination of the extraoral elastics of the facial mask might have accounted for the lack of a bite opening tendency in the treated group.[26]

When individual patient data were analyzed, we found that over 70% of the patients (16 of 22) could be considered clinically successful in the long term, whereas less than 30% of them (6 of 22) were unsuccessful at T3 because of relapse in the occlusal relationships. The prevalence rate for the long-term success of RME/FM therapy of Class III malocclusion appears as a favorable result, and it is similar to the success rates reported in other studies on orthopedic Class III treatment that included a posttreatment interval (76% according to Westwood et al[4]; 75% according to Ngan et al[9] and Wells et al[6]; 67% according to Hägg et al[5]).

During the posttreatment interval, the outcomes of RME/FM therapy did not show a notable trend of relapse, with the exception of the maxillary measures. It

appears that the immediate posttreatment changes during the pubertal growth spurt (when the mandible has a longer and more intense period of growth in Class III vs Class I subjects[11,27]) have the greatest unfavorable impact on treatment outcomes in the mandibular and intermaxillary measurements. More evidence it this regard can be derived from the study by Westwood et al.[4] Once the pubertal growth spurt is over, the relapse tendency after orthopedic Class III treatment becomes more modest.

Since the facial mask is a removable appliance, the issue of patient compliance deserves to be investigated in relation to the long-term treatment outcomes. Interestingly, 5 of the 6 patients with unsuccessful results at T3 had a modest degree of compliance during active therapy with the facial mask, whereas just 2 of the 16 successful patients had poor compliance. However, significant differences were found in the pretreatment craniofacial features of unsuccessful vs successful patients that can explain further the failure of therapy on the basis of the severity and specific characteristics of the initial dentoskeletal disharmony. The unsuccessful patients showed a significantly greater gonial angle (+3.8°), a downward inclination of the mandibular plane to Frankfort horizontal (+4.1°), and a mesial molar relationship (+1.5 mm). Therefore, both patient compliance and pretreatment dentoskeletal features can be regarded as significant factors influencing the long-term results of RME/FM treatment.

The outcomes of this study can be compared with those of other long-term controlled studies on orthopedic treatment of Class III malocclusion in the literature. The results of the RME/FM study by Pangrazio-Kulbersh et al[22] are similar to those reported here, with the exception of less posttreatment relapse tendency in the skeletal sagittal position of the maxilla. The results of the long-term study on the FR-3 appliance indicated that the treated group showed a significant increase in midfacial length compared with the controls, without any significant change in the sagittal position of the maxilla or in the mandibular dimensions.[28] Sugawara et al[12] found that most of the favorable changes induced by chincaps reverted completely in the long term. With respect to both the FR-3 and chincap therapies, however, the RME/FM protocol has a significantly shorter duration of active treatment. Whereas chincap wear was on average 4.5 years (range, 1-9.5 years)[12] and FR-3 wear consisted of about 2.5 years of active full-time appliance wear followed by at least 3 years of part-time wear,[28] the RME/FM protocol entails a much smaller "burden of treatment." The analysis of active treatment duration in this study showed that the orthopedic appliance was worn for an average of 1.1 years (range, 4 months-2 years). Only 1 patient resumed facial mask wear during phase 2 treatment. Therefore, RME/FM treatment is an efficient orthopedic protocol even when considering the possibility of adding a second phase of treatment with comprehensive fixed appliance therapy.

CONCLUSIONS

1. In the long term, RME/FM therapy of subjects with Class III dentoskeletal disharmony led to successful outcomes in about 73% of the patients.
2. Approximately 8 years after the end of RME/FM therapy, the patients still showed significantly improved sagittal dentoskeletal relationships. These favorable changes were mainly due to significant improvements in the sagittal position of the mandible, but the maxillary changes reverted completely in the long term.
3. RME/FM therapy of Class III malocclusion did not induce a tendency of bite opening or increased vertical relationship.
4. The long-term results of RME/FM therapy are influenced by the patient's compliance and pretreatment dentoskeletal features (Class III disharmony associated with increased facial divergence).

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