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Short-term effects of a modified Alt-RAMEC protocol for early treatment of Class III malocclusion: a controlled study

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Structured Abstract

Objectives – To assess the effects of a modified alternate rapid maxillary expansion and constriction (Alt-RAMEC) protocol in combination with facemask (FM) in Class III growing patients.

Setting and Sample Population – Thirty one Class III patients (17 males, 14 females) were treated with a modified Alt-RAMEC/FM protocol at the Department of Orthodontics of the University of Florence.

Material and Methods – All patients were evaluated at the beginning (T1, mean age 6.4 ± 0.8 years) and at the end of orthopedic therapy (T2, mean age 8.1 ± 0.9 years), and they were compared to a matched sample of 31 Class III patients (16 males and 15 females) treated with rapid maxillary expansion and facemask (RME/FM) and to a matched control group of 21 subjects (9 males and 12 females) with untreated Class III malocclusion. The three groups were compared with ANOVA with Benjamini–Hochberg correction for multiple tests.

Results – Both the Alt-RAMEC/FM and the RME/FM protocols showed significantly favorable effects leading to correction of the Class III malocclusion. The Alt-RAMEC/FM protocol produced a more effective advancement of the maxilla (SNA +1.2°) and greater intermaxillary changes (ANB +1.7°) vs. the RME/FM protocol. No significant differences were recorded as for mandibular skeletal changes and vertical skeletal relationships.

Conclusion – The Alt-RAMEC/FM protocol induced more favorable skeletal short-term effects compared with RME/FM therapy in Class III growing patients.

Key words: Angle Class III malocclusion; cephalometry; interceptive treatment

Introduction

For several years, the use of facemask (FM) in combination with rapid maxillary expansion (RME) represented the most common orthopedic therapy for Class III malocclusion (1). In the long term, 73% of the patients can be treated successfully with this treatment protocol (2). Interestingly, favorable skeletal changes are mainly due to significant improvements in the sagittal position of the mandible while maxillary advancement is almost completely lost in the long term (2).

Several new treatment approaches were recently developed for the correction of Class III dentoskeletal disharmony. Some of them use skeletal anchorage through the application of miniplates (3–5) or miniscrews (6), to protract the maxilla. Cevidanes et al. (4) in 2010 showed that a BAMP (bone-anchored maxillary protraction) protocol is able to produce a significantly larger maxillary advancement than rapid maxillary expansion and facemask (RME/FM) therapy. Other studies (5,6) in the last years compared the effects of the conventional RME/FM protocol with facemask therapy performed in combination with maxillary skeletal anchorage to find the most effective treatment for Class III malocclusion. Conflicting results were reported by Lee et al. (5) who found a greater advancement of the maxilla with maxillary skeletal anchorage with respect to the conventional protocol and by Ge et al. (6) who found no significant differences between the two treatment approaches.

In 2005, Erik Liou (7) proposed an effective orthopedic maxillary protraction performed without any type of skeletal anchorage in young patients. Liou and Tsai (8) described a clinically significant maxillary advancement in cleft patients by means of a weekly sequence of alternate rapid maxillary expansion and constriction (Alt-RAMEC) in combination with intra-oral maxillary protraction springs. The Alt-RAMEC protocol allows opening of the circummaxillary sutures more extensively than conventional rapid maxillary expansion (9), leading to favorable maxillary effects of protraction therapy. Motivated by these favorable results, several authors (10,11) in the last 5 years investigated the outcomes of the Alt-RAMEC protocol combined with facemask (Alt-RAMEC/FM) in Class III patients. The data derived from these surveys are quite inconsistent, with Do-deLatour (10) who reported no significant differences between the two treatment protocols and Isci et al. (11) who found a greater maxillary advancement with the activation–deactivation protocol vs. the conventional RME/FM protocol. These two studies are heterogeneous as for age of the patients at the beginning of treatment, duration of the sequence of Alt-RAMEC [7 weeks (10) vs. 4 weeks (11)] and activation rate of the expansion screw [four activations per day (10) vs. two activations per day (11)]. Both studies included very small samples of subjects [9 patients for each group in the study by Do-deLatour et al. (10) and 15 patients for each group in the study by Isci et al. (11)].

Franchi et al. (12) in 2011 introduced a modified Alt-RAMEC/FM protocol. This protocol consists of 4 weeks of Alt-RAMEC followed by application of a facemask for maxillary protraction. The timing of treatment was shifted from the permanent dentition phase of the original Alt-RAMEC protocol (7) to the deciduous dentition phase for two reasons. First, the forces generated during the repetitive weekly expansion/constriction protocol could produce negative periodontal effects and increase the risk of root resorption on maxillary first premolars and permanent molars (13). These side effects could be avoided if the expansion/constriction forces were applied on the deciduous teeth. Secondly, the deciduous dentition phase coincides with a stage of skeletal development that is considered to be optimal for the correction of dentoskeletal Class III malocclusion as a good response to maxillary protraction is achieved during the prepubertal stage of skeletal maturation (14).

The aim of the present retrospective study, therefore, was to assess the effectiveness of the modified Alt-RAMEC/FM protocol (12) for the correction of Class III dentoskeletal malocclusion in comparison with the RME/FM conventional therapy and with the growth changes in untreated Class III subjects.

Subjects and methods

Ethical approval (#2013/0008564) was obtained from the Ethics Committee of the Careggi University Hospital, Florence, Italy, and informed consent was obtained from patients' parents at the start of treatment.

Patients

A sample of 31 patients (17 males and 14 females, mean age 6.4 ± 0.8 years) with Class III dentoskeletal disharmony was treated consecutively with the modified Alt-RAMEC/FM protocol (12) at the Department of Orthodontics of the University of Florence. Patients of this treatment group started therapy between January 2010 and December 2011. The patients were re-evaluated with a lateral cephalogram 4–5 months after the end of the active phase of treatment with Alt-RAMEC/FM (T2, mean age 8.1 ± 0.9 years), 1.7 ± 0.4 years after the first observation. The Alt-RAMEC/FM group was compared to a sample of 31 patients (16 males and 15 females, mean age 6.9 ± 1.1 years) with Class III dentoskeletal disharmony, treated consecutively with the conventional RME/FM therapy at the Department of Orthodontics of the University of Florence (RME/FM group). Patients of this treatment group started therapy between June 2007 and December 2009. Also in this group, all patients were re-evaluated with a lateral cephalogram 4–5 months after the end of the active phase of treatment (T2, mean age 8.5 ± 1.3 years), 1.6 ± 0.6 years after the first observation.

To be included in this study, all treated patients had to present with the following dentoskeletal features before therapy (at T1) when the pre-treatment lateral cephalogram was taken:

- European ancestry (white);
- Anterior crossbite or edge-to-edge incisor relationship;
- Accentuated mesial step relationships of the primary second molars or Class III relationships of the permanent first molars;
- Wits appraisal (15) of −2.0 mm or less;
- Absence of CO-CR discrepancy (indicating pseudo-Class III malocclusion);
- Deciduous or early mixed phase of dentition;
- Pre-pubertal skeletal maturation (CS1 to CS2) (16).

Controls

Both treated samples were compared to a sample of 21 Caucasian subjects (9 males and 12 females, mean age 6.5 ± 1.0 years) presenting with untreated Class III malocclusion (control group, CG). These subjects were selected from the files of the Department of Orthodontics of the University of Florence and from the AAOF Craniofacial Growth Legacy Collection (http://www.aaoflegacycollection.org, Bolton–Brush Growth Study and Michigan Growth Study). In CG, a second lateral cephalogram (T2) was available for all subjects at a mean age of 8.0 ± 1.1 years, with a mean observation period of 1.5 ± 0.4 years.

Alt-RAMEC/FM protocol

A maxillary acrylic splint expander with soldered hooks for the facemask was bonded to the deciduous canines and the first and second deciduous

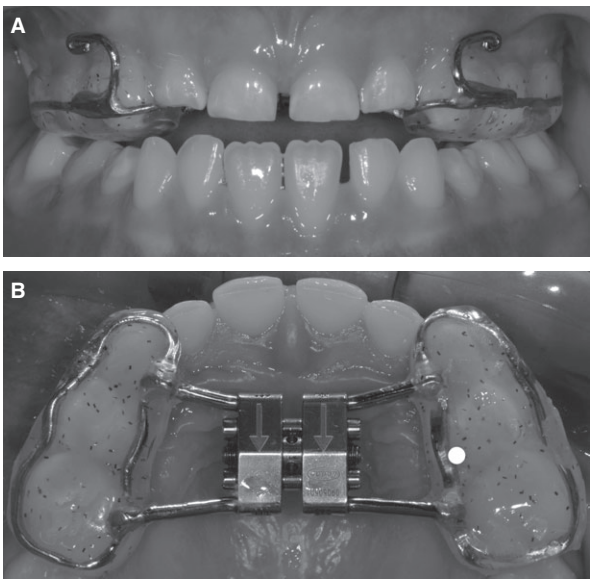

Fig. 1. Acrylic splint maxillary expander with soldered hooks for facial mask. (A) Frontal view. (B) Occlusal view.

molars (1) (Fig. 1). The expansion screw (Leone A2620, Leone Orthodontic Products, Sesto Fiorentino, Firenze, Italy) was activated by the patient's parents twice a day (0.20 mm per turn, one turn in the morning and one turn at night) for 1 week, then it was deactivated twice a day (one turn in the morning and one turn at night) for 1 week. This alternating protocol was repeated twice. After 4 weeks of Alt-RAMEC therapy, an additional twice-daily activation of the expansion screw was performed until overcorrection was achieved (palatal cusps of the upper posterior teeth approximating the buccal cusps of the lower posterior teeth). At the end of the expansion phase, a facemask according to the design of Petit (Dynamic face Mask, Leone Orthodontic Products, Sesto Fiorentino, Firenze, Italy) was placed for maxillary protraction (Fig. 2). Elastics producing orthopedic forces of as much as 400–500 g per side were attached from the hooks on the maxillary expander to the support bar of the facial mask in a downward and forward direction [at least 30° to the occlusal plane (17)]. The patients were instructed to wear the facemask 14 h per day for 6 months, then at night only for another 6 months, after which appliances were removed. All patients were treated at least to a positive dental overjet before discontinuing treatment; most patients were overcorrected toward a Class II occlusal relationship. Average duration of Alt-RAMEC/FM treatment was 1.1 ± 0.1 years.

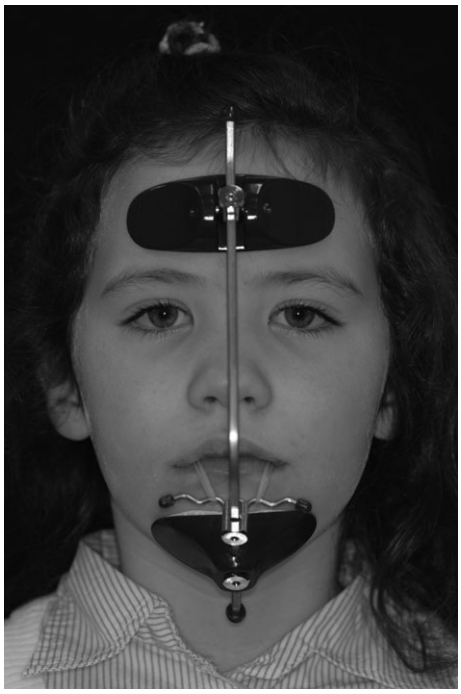

Fig. 2. Facial mask according to the design by Petit (1). Frontal view.

RME/FM protocol

The acrylic splint expander extended from the deciduous canines to the second deciduous molars. When the permanent first molars were erupted, it extended from the first deciduous molars to the permanent first molars. The patients' parents were instructed to activate the expansion screw (Leone A2620, Leone Orthodontic Products, Sesto Fiorentino, Firenze, Italy) 1–2 times per day until overcorrection was achieved as in Alt-RAMEC/FM protocol. Patients were given facemasks immediately after expansion. The clinical management of the facemask therapy was similar to the Alt-RAMEC/FM group. All patients were treated at least to a positive dental overjet before discontinuing treatment; most patients were overcorrected toward a Class II occlusal relationship. Average duration of RME/FM treatment was 1.1 ± 0.2 years. After removal of the expander patients treated with both protocols received a removable mandibular retractor as a retainer (2).

Compliance

As occurs in studies involving any removable device, compliance with the instructions of the orthodontist and staff varied among patients. The clinician asked the patient's parents how regularly and how long each day the facial mask was worn. Compliance was appraised by a means of a 3-point Likert scale (poor, moderate, good) (18). Compliance was recorded by the clinician at each visit (every 5 weeks). Poor compliance occurred when the facial mask was not worn during the day and not regularly at night, moderate compliance when the facial mask was worn regularly only at night, and good compliance when the facial mask was worn 14 h per day (at night and 3 h in the afternoon) for the first 6 months and then at night only for another 6 months.

Cephalometric analysis

A customized digitization regimen and analysis provided by *Viewbox 3.0*. (dHAL Software, Kifissia, Greece) was utilized for the cephalograms that were examined in this study. The cephalometric analysis contained measurements from the analyses of Jacobson (14), McNamara (19) and Steiner (20). Nine variables, seven angular and two linear, were generated for each tracing. Magnification was standardized to a 10% enlargement for all radiographs in the three samples. The magnification factor was standardized to 10% because the majority of the cephalograms (about 90%) had this magnification factor.

Statistical analysis

Chi-square tests were used to assess differences in gender distribution between groups. Descriptive statistics was calculated for age at T1 and T2 time points and for T1–T2 age interval in the examined groups. All cephalometric data at T1 and the T1–T2 changes revealed a normal distribution (Kolmogorov-Smirnov test). Comparisons between the Alt-RAMEC/FM group, the RME/FM group, and CG for the dentoskeletal features at T1 (starting forms) and on the T1–T2 changes were performed with the ANOVA (Statistical Package for the Social Sciences, SPSS, Version 12, Chicago, IL, USA) with Benjamini–Hochberg correction for multiple tests (21).

The power of the study was calculated on the basis of the difference between Alt-RAMEC/FM and RME/FM groups for a relevant cephalometric variable (Wits appraisal) with an effect size f (22) of 1.05 as derived from an investigation of similar nature (23) (Wits appraisal, difference between the means 4.3 mm, standard deviation 1.8 mm) (G*Power 3.1) (24). The power was 0.98 at an alfa level of 0.05.

Method error

Twenty lateral cephalograms, selected randomly, were traced and measured at two times within a week by the same operator (CM). The measurements at both times for each patient were analyzed with the paired t-test for the assessment of the systematic error and with the method of moments'estimator (MME) (25) for the assessment of the random error. No systematic error was detected for any of the variables with the p values ranging from a minimum of 0.059 (FH to palatal plane) to a maximum of 0.871 (palatal plane to mandibular plane). The values for the MME ranged from a minimum of 0.19° (FH to palatal plane) to a maximum of 0.95° (Co-Go-Me).

Results

No significant difference was found as to gender distribution (chi-square tests with Yates correction: Alt-RAMEC/FM group vs. Control group $p = 0.572$ and RME/FM group vs. Control group $p = 0.736$).

Descriptive statistics and comparisons of the dentoskeletal variables at T1 between the 3 groups are reported in Table 1. At T1, there were no statistically significant differences between the Alt-RAMEC/FM group and RME/FM group. The CG showed a significantly larger FH to mandibular plane angle and gonial angle compared with both the Alt-RAMEC/FM group (FH to mandibular plane −3.4° and CoGoMe −6.4°) and RME/FM group (FH to mandibular plane −3.5° and CoGoMe −5.4°).

Treatment effects

In Table 2, the T1–T2 changes in the Alt-RAMEC/FM group vs. the RME/FM group and vs. CG are reported. Both the Alt-RAMEC/FM group and RME/FM group showed significantly greater increments than CG in the sagittal position of the maxilla (SNA +3.1° and +2.0°, respectively). With regard to mandibular sagittal skeletal measures, there was a significant decrease in mandibular projection in the Alt-RAMEC/FM group and in the RME/FM group with respect to CG (SNB −1.9° and −1.3°, respectively). The Alt-RAMEC/FM group and the RME/FM presented with significantly larger improvements in the sagittal

Table 1. **Descriptive statistics and statistical comparisons of dentoskeletal variables at T1 (ANOVA with Benjamini–Hochberg correction for multiple tests)**

	ALT-RAMEC Group (1) (n = 31)		RME/FM Group (2) (n = 31)		Control Group (3) (n = 21)			Multiple test comparisons								
								1vs2			2vs3			1vs3		
Variables	Mean	SD	Mean	SD	Mean	SD	*p*	Diff.	Corr. *p*	95% CI	Diff.	Corr. *p*	95% CI	Diff.	Corr. *p*	95% CI
Sagittal skeletal																
SNA (deg)	81.1	3.9	80.2	3.7	79.4	4.3	0.283	1.0	0.646	−0.9 2.9	0.8	0.706	−1.5 3.0	1.7	0.459	−0.6 4.0
SNB (deg)	79.9	3.4	78.9	3.1	78.5	3.2	0.260	1.0	0.520	−0.7 2.6	0.4	0.689	−1.4 2.2	1.4	0.411	−0.5 3.3
ANB (deg)	1.3	1.9	1.2	1.8	0.9	2.5	0.774	0.1	0.942	−0.9 1.0	0.3	0.707	−0.9 1.5	0.4	0.675	−0.8 1.6
WITS (mm)	−4.8	2.0	−5.0	2.5	−4.3	2.7	0.568	0.3	0.701	−0.9 1.5	−0.7	0.633	−2.2 0.7	−0.4	0.687	−1.7 0.9
Co-Gn (mm)	103.0	6.3	102.2	4.9	104.5	7.6	0.423	0.8	0.697	−2.1 3.6	−2.3	0.466	−5.8 1.2	−1.5	0.686	−5.4 2.4
Vertical skeletal																
FH to palatal plane (deg)	−2.7	2.5	−1.8	2.7	−1.3	2.3	0.126	−0.9	0.467	−2.3 0.4	−0.5	0.741	−2.0 1.0	−1.4	0.198	−2.8 0.0
FH to mandibular plane (deg)	24.6	3.6	24.5	4.1	28.0	3.6	0.002	0.1	0.907	−1.8 2.1	−3.5	**0.014**	−5.7 −1.3	−3.4	**0.009**	−5.4 −1.4
Palatal plane to mandibular plane (deg)	27.3	3.8	26.5	4.1	29.3	4.8	0.059	0.8	0.610	−1.1 3.2	−2.8	0.157	−5.7 −0.3	−2.0	0.413	−4.4 0.4
CoGoMe (deg)	128.8	3.7	129.7	4.8	135.1	3.9	0.000	−1.0	0.638	−3.2 1.2	−5.4	**0.000**	−7.9 −2.8	−6.4	**0.000**	−8.5 −4.2

SD, standard deviation; Diff., difference; Corr. *p*, corrected *p*; 95% CI, 95% confidence interval; RME/FM, rapid maxillary expansion and facemask.
Bold values indicate statistically significant comparisons.

Table 2. **Descriptive statistics and statistical comparisons of T2–T1 changes (ANOVA with Benjamini–Hochberg correction for multiple tests)**

	ALT-RAMEC Group (1) (n = 31)		RME/FM Group (2) (n = 31)		Control Group (3) (n = 21)			Multiple test comparisons								
								1vs2			2vs3			1vs3		
Variables	Mean	SD	Mean	SD	Mean	SD	*p*	Diff.	Corr. *p*	95% CI	Diff.	Corr. *p*	95% CI	Diff.	Corr. *p*	95% CI
Sagittal skeletal																
SNA (deg)	2.7	1.6	1.5	1.4	−0.5	1.3	0.000	1.2	**0.009**	0.4 1.9	2.0	**0.000**	1.2 2.7	3.1	**0.000**	2.3 4.0
SNB (deg)	−1.5	1.6	−0.8	1.4	0.5	0.8	0.000	−0.7	0.119	−1.4 0.1	−1.3	**0.000**	−1.9 −0.6	−1.9	**0.000**	−2.7 −1.2
ANB (deg)	4.0	2.0	2.3	1.7	−0.9	1.3	0.000	1.7	**0.003**	0.8 2.6	3.2	**0.000**	2.3 4.1	4.9	**0.000**	3.9 5.9
WITS (mm)	3.4	2.4	1.9	2.1	−0.7	2.1	0.000	1.6	**0.019**	0.4 2.7	2.6	**0.000**	−1.7 0.5	4.2	**0.000**	−2.1 0.1
Co-Gn (mm)	3.0	1.9	3.4	2.0	4.0	1.9	0.198	−0.4	0.513	−1.4 0.6	−0.6	0.336	1.4 3.8	−1.0	0.110	2.9 5.5
Vertical skeletal																
FH to palatal plane (deg)	−0.5	1.6	−0.6	1.3	0.2	1.1	0.159	0.1	0.914	−0.7 0.8	−0.8	0.086	−1.4 0.0	−0.7	0.155	−1.4 0.2
FH to mandibular plane (deg)	1.1	1.4	1.0	1.7	0.2	1.7	0.151	0.1	0.879	−0.7 0.9	0.8	0.168	−0.2 1.9	0.9	0.110	−0.1 1.8
Palatal plane to mandibular plane (deg)	1.6	2.0	1.6	1.9	0.0	2.1	0.023	0.0	0.989	−1.0 1.0	1.6	**0.037**	0.3 2.8	1.6	**0.038**	0.2 2.8
CoGoMe (deg)	−3.0	2.1	−3.2	2.1	−1.2	1.7	0.001	0.2	0.865	−0.9 1.2	−2.0	**0.003**	−3.1 −0.9	−1.9	**0.002**	−3.0 −0.8

SD, standard deviation; Diff., difference; Corr. *p*, corrected *p*; 95% CI, 95% confidence interval; RME/FM, rapid maxillary expansion and facemask.
Bold values indicate statistically significant comparisons.

maxillo-mandibular skeletal relationships when compared with CG (ANB +4.9° and +3.2°, respectively; Wits +4.2 mm and +2.6 mm, respectively).

As for the vertical skeletal variables both the Alt-RAMEC/FM group and RME/FM group, presented with significantly greater increases than the CG in the palatal plane to mandibular plane angle (pal. pl. to mand. pl. +1.6° and +1.6°, respectively). The gonial angle showed a significantly smaller decrease in the CG than in both the Alt-RAMEC/FM group and the RME/FM group (CoGoMe −1.9° and −2.0°, respectively).

The comparison between the Alt-RAMEC/FM group and the RME/FM group revealed statistically significant differences between these two groups with the Alt-RAMEC/FM group presenting with a significantly larger increase in the sagittal position of the maxilla (SNA +1.2°). No statistically significant differences were reported between the two treated groups as for mandibular sagittal skeletal variables. The Alt-RAMEC group showed a significantly larger improvement in the maxillo-mandibular skeletal relationship (ANB +1.7°; Wits +1.6 mm). There were no statistically significant differences between the two groups as to the vertical skeletal variables.

Appraisal of compliance

The analysis of collaboration showed a similar distribution of 'poor', 'moderate', and 'good' degree of cooperation during the orthopedic therapy (use of the facial mask) in the two treated groups. The Alt-RAMEC group (n = 31) presented 16 patients with a 'good' degree of collaboration, 11 patients with a 'moderate' degree of collaboration, and 4 patients with a 'poor' degree of collaboration. In the RME/FM group (n = 31), there were 18 patients with 'good' degree of collaboration, 10 patients with a 'moderate' degree of collaboration and 3 patients with a 'poor' degree of collaboration. No significant differences were found in the prevalence rates of degree of collaboration between the two treated groups (Fisher's exact probability test $p = 0.818$).

Discussion

The comparison of the T1–T2 changes between the three groups showed that in both the Alt-RAMEC/FM group and the RME/FM group, significantly favorable changes were obtained with respect to the CG in terms of maxillary advancement (SNA +3.1° and +2.0°, respectively). Westwood et al. (23) in a study on the effects of conventional RME/FM therapy for Class III malocclusion found quite similar results with the RME/FM therapy inducing significantly greater increases in the sagittal position of the maxilla (SNA +1.6°) with respect to the changes of growth in a Class III untreated control group. As for the mandibular sagittal skeletal measures, both the Alt-RAMEC/FM group and the RME/FM group revealed significant decreases in mandibular projection with respect to the CG (SNB −1.9° and −1.3°, respectively). Several studies (23, 26) reported quite similar effects in terms of control of mandibular position produced by the RME/FM therapy.

Both the Alt-RAMEC/FM group and the RME/FM groups showed favorable changes when compared with the CG in terms of maxillo-mandibular skeletal relationships(ANB +4.9° and +3.2°, respectively; Wits +4.2 mm and +2.6 mm, respectively). These results showed the efficacy of both treatment protocols in the correction of Class III skeletal relationships, and they are very consistent to those reported by Westwood et al. (23) and by Macdonald et al. (26).

In the present study, both the Alt-RAMEC/FM group and the RME/FM group showed greater increases than the CG in intermaxillary vertical relationships (Pal. Pl to Mand. Pl. +1.6° and +1.6°, respectively). The opening of the intermaxillary angle (Pal. Pl to Mand. Pl.) can be explained by an increase (though not statistically significant) in the FH to mandibular plane angle showed by both the Alt-RAMEC/FM group (FH to mandibular plane 0.9°) and the RME/FM group (FH to mandibular plane 0.8°) with respect to CG. However, the amount of clockwise rotation of the mandible presented by both treated groups was very similar to that reported by Westwood et al. (23) and smaller than that

reported by Macdonald et al. (2.3°) (26). Moreover, the increase in the FH to mandibular plane angle shown in the Alt-RAMEC/FM group and RME/FM group could play an important role in the reduction of the mandibular projection obtained with both treatment protocols (26). The gonial angle was significantly reduced in both the Alt-RAMEC/FM group and the RME/FM group (CoGoMe −2.0° and −1.9°, respectively) when compared with CG. This growth modification has been advocated as a favorable mechanism to control growth excess of the mandible along Co-Gn (27). In the present study, however, this mechanism was not able to produce a significant control of the mandibular growth.

When comparing the two treated groups, the Alt-RAMEC/FM group showed a significantly greater improvement in the sagittal position of the maxilla with respect to the RME/FM group (SNA +1.2°). This effect could be possibly due to the more efficient disarticulation of the circummaxillary sutures achieved with the alternation of the rapid maxillary expansion and constriction (9). Comparable results were reported by Isci et al. (11) in a sample of 11-year-old subjects treated with a very similar expansion/constriction protocol. On the contrary, Do-deLatour et al. (10) found that a sample treated with the conventional RME/FM protocol showed significantly greater improvement in the maxillary position than in a Alt-RAMEC/FM group. These data were explained by the authors (10) with a possible difference in patient compliance during active treatment with the facemask. The amount of T1–T2 change achieved in the Alt-RAMEC/FM group (SNA +2.7°) in the current study is very similar to those reported by Lee et al. (5) and by Ge et al. (6) for two samples of Class III growing patients treated with facemask anchored on miniplates and miniscrews, respectively.

As for the mandibular projection and the mandibular length, the comparison between the Alt-RAMEC/FM group and the RME/FM group did not reveal statistically significant differences, as confirmed by other studies (10,11).

A significant improvement in the sagittal maxillo-mandibular relationships was recorded in the Alt-RAMEC/FM group with respect to the RME/FM group for both ANB angle (ANB +1.7°) and Wits appraisal (Wits +1.6 mm). Isci et al. (11) also found that subjects treated with the Alt-RAMEC approach reached significantly greater increases in the ANB angle as compared to the RME/FM group. These data were not consistent with those reported by Do-deLatour et al. (10) who found a greater increase for the ANB angle in the conventionally treated group when compared with the Alt-RAMEC/FM group. The sagittal intermaxillary correction obtained in the Alt-RAMEC/FM group in the present study during the T1–T2 interval (ANB +4° and Wits +3.4 mm) was greater than that reported by Lee et al. (5) for a sample treated with the miniplates/facemask (ANB +3.8° and Wits +2.8 mm).

As for the vertical relationships, no statistically significant differences were found between the two treated groups. These results were consistent with the vertical skeletal variations reported by the studies from Do-deLatour et al. (10) and Isci et al. (11). The increase in the mandibular plane angle shown by the Alt-RAMEC/FM group in the current study also was smaller than that found by Lee et al. (5) (1.4°) and Ge et al. (6) (1.8°) for the skeletal anchorage treated samples.

The results of the present study indicates that the maxillary protraction with a facemask in association with both the Alt-RAMEC protocol or the conventional RME protocol can be considered a successful therapy for the early correction of Class III malocclusion. The improvement in the maxillo-mandibular skeletal relationships achieved with the Alt-RAMEC/FM protocol and the RME/FM protocol was essentially due to an effective advancement of the maxilla, which was significantly greater in the Alt-RAMEC/FM group. The supplementary amount of maxillary advancement obtained by the Alt-RAMEC protocol vs. the standard RME/FM protocol could contribute potentially to the improvement of the long-term effects of the facemask therapy (2). The limitations of the study are related to the retrospective design and to the short-term evaluation of the treatment effects. Randomized controlled trials and long-term cohort studies would

be required in the future to assess further the efficacy of the modified Alt-RAMEC protocol.

Conclusions

- The use of a facemask in association with both the Alt-RAMEC protocol and the conventional RME protocol can be considered an efficient treatment modality for the early correction of Class III dentoskeletal disharmony in the short term.
- The modified Alt-RAMEC/FM protocol allows obtaining more favorable skeletal effects in terms of maxillary advancement leading to a greater improvement in sagittal skeletal relationships as compared to the conventional RME/FM protocol.
- The Alt-RAMEC/FM protocol and the RME/FM protocol show similar effects as for mandibular skeletal changes and vertical skeletal relationships.

Clinical relevance

This study aimed to assess the effectiveness of a modified Alt-RAMEC/FM protocol in Class III growing patients compared with matched samples of Class III patients treated with the conventional RME/FM protocol and of Class III untreated subjects. The outcomes of this study provide evidence that both the modified Alt-RAMEC/FM protocol and the RME/FM protocol represent very efficient treatment modalities for the early correction of Class III disharmony. Furthermore, the Alt-RAMEC/FM protocol produces more favorable maxillary skeletal effects leading to greater improvements in sagittal skeletal relationships than the RME/FM protocol.

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