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Original article

Comparisons of two protocols for the early treatment of Class III dentoskeletal disharmony

Letizia Perillo*, Maddalena Vitale*, Caterina Masucci, Fabrizia D'Apuzzo*, Paola Cozza*** and Lorenzo Franchi****

*Department of Orthodontics, Seconda Università degli Studi di Napoli, **Department of Surgery and Translational Medicine, Università degli Studi di Firenze, ***Department of Orthodontics, Università degli Studi di Roma Tor Vergata, Italy

Correspondence to: Lorenzo Franchi, Department of Surgery and Translational Medicine, University of Florence, Via del Ponte di Mezzo, 46–48, Florence 50127, Italy. E-mail: lorenzo.franchi@unifi.it

Summary

Objective: To assess the short-term outcomes of splints, Class III elastics, and chincup (SEC III) and rapid maxillary expansion and facial mask (RME/FM) protocols.

Materials and methods: 25 patients with Class III dentoskeletal disharmony (10 males, 15 females) treated with the SEC III protocol were evaluated at the beginning (T1, mean age 7.5 ± 1.4 years) and at the end of treatment (T2, mean age 8.7 ± 1.4 years). The SEC III group was compared to a matched sample of 32 Class III patients (16 males, 16 females) treated with the RME/FM protocol and to a matched control group (CG) consisting of 23 subjects (12 males, 11 females) with untreated Class III dentoskeletal disharmony. The statistical comparisons between the three groups were performed with analysis of variance with Tukey's *post hoc* tests.

Results: With respect to the CG the SEC III and the RME/FM groups showed significantly favourable effects in terms of maxillary advancement (SNA +1.2 and +1.4 degrees, respectively), control of mandibular projection (SNB –1.3 and –1.4 degrees, respectively), and intermaxillary relationships (ANB +2.6 and +2.9 degrees, respectively; WITS +3.7 and +2.6 mm, respectively). The RME/FM group showed a significantly greater increase in the intermaxillary divergency than the SEC III group (+1.8 degrees) and the CG (+2.0 degrees).

Limitations: A limitation of this study is its short-term nature.

Conclusions: Both SEC III and RME/FM protocols are efficient treatments for Class III dentoskeletal disharmony. The SEC III protocol produces more favourable control in intermaxillary vertical relationships than the RME/FM therapy.

Introduction

Early treatment of Class III disharmonies in growing patients is a topic widely discussed in the literature, mainly due to the uncertainty of stable long-term results after the active growth period (1–4). Several therapeutic alternatives have been developed to treat Class III dentoskeletal disharmony at an early stage, including intraoral and extraoral appliances, such as the rapid maxillary expansion along with the facial mask (RME/FM) and two occlusal acrylic splints combined with Class III elastics and chincup (SEC III) (2–7). Two recent systematic reviews and meta analyses on the short-term effects of chincup protocol showed that there are insufficient data to make definitive recommendations about the early treatment with chincup alone (8, 9).

During the past decades, short- and long-term studies described favourable dentoskeletal changes induced by RME/FM treatment on maxillary and mandibular components (1, 4, 10). SEC III protocol (2) was proposed to facilitate Class III dentoskeletal correction by eliminating the intercuspation and the tongue thrust with the flat occlusal plane of the acrylic splints. This protocol also induced no

clockwise mandibular rotation with minimal dentoalveolar compensation. The favourable outcomes of this approach were stable at the end of growth (2).

However, in the literature there are no studies comparing the effects of the SEC III treatment with those of different approaches or with the changes of untreated Class III subjects. On the contrary, previous studies described the effectiveness of RME/FM with respect to other Class III protocols (6, 11). Baccetti *et al.* (6) comparing RME/FM and mandibular cervical headgear (MCH) followed by fixed appliances, showed a greater enhancement of maxillary growth associated with RME/FM protocol, whereas mandibular length increases were smaller in patients treated with MCH.

Cevidanes *et al.* (11) evaluating the dentoskeletal changes with RME/FM and bone-anchored maxillary protraction (BAMP) found that the BAMP protocol produced significantly larger maxillary advancement than the RME/FM therapy. Mandibular effects were similar in the two treatment protocols with no mandibular clockwise rotation.

The aim of the present retrospective study was to compare the short-term effects produced by SEC III protocol and RME/FM treatment in patients with Class III dentoskeletal disharmony with respect to growth changes in an untreated Class III control group (CG).

Subjects and methods

The study was approved by the Ethics Committee of the XXXXXXXX (n° 889), and informed consent was obtained from patients' parents before treatment.

All subjects included in this study had European ancestry (white), were either in deciduous or mixed dentition phases and showed a Class III dentoskeletal malocclusion with the following dentoskeletal features at the start of the treatment when a lateral cephalogram was taken (T1):

- Anterior crossbite or edge-to-edge incisor relationship;
- Class III molar relationship;
- WITS appraisal (12) of –2.0 mm or less;
- Absence of CO-CR discrepancy (indicating pseudo-Class III malocclusion);
- Prepubertal skeletal maturation (CS1 or CS2) (13).

The sample treated consecutively with the SEC III protocol (2) at the Unit of Orthodontics of the XXXXXXX (SEC III group) included 25 patients (10 males and 15 females, mean age 7.5 ± 1.4 years).

The SEC III group was compared to a sample of 32 patients (16 males and 16 females, mean age 7.5 ± 1.7 years) treated consecutively with RME/FM approach (RME/FM group) at the Departments of Orthodontics of the University of XXXXXX (21 patients) and of the University of XXXXXXX (11 patients).

Both SEC III (T2, mean age 8.7 ± 1.4 years), and RME/FM groups (T2, mean age 8.8 ± 1.6 years) were re-evaluated with a lateral cephalogram at the end of orthopaedic phase, respectively 1.2 ± 0.3 and 1.3 ± 0.3 years after the first observation.

These two groups were compared to a CG consisting of 23 untreated Class III subjects (12 males and 11 females, mean age at T1 7.0 ± 1.0 years) retrieved from the electronic archive of the Department of Orthodontics of the University of XXXXXXX and from the files of AAOF Craniofacial Growth Legacy Collection (http://www.aaoflegacycollection.org, Bolton–Brush Growth Study and Michigan Growth Study). All subjects of the CG presented with a second lateral cephalogram (T2, mean age 8.4 ± 0.9 years) taken after 1.4 ± 0.4 years.

SEC III protocol

The SEC III protocol (2) included two occlusal splints, Class III elastics, and chincup.

The two removable acrylic splints (Figure 1) had a flat occlusal plane. The Class III elastics with a force of 200–300 g per side, were attached to vestibular hooks placed on each side of the splint, distal to the maxillary last molars and between the mandibular canines and lateral incisors. Force levels depended mainly on splint stability. Patients were instructed to wear the splints and the elastics for a minimum of 16 hours per day and to change the elastics at least twice a week.

The chincup (Figure 2) used in combination with the splints and the Class III elastics developed a force ranging from 400 to 600 g per side with the force vector passing through the maxillary first molars to avoid their extrusion and consequent clockwise mandibular rotation. Patients were asked to wear the chincup for a minimum of 14

Figure 1. (A–C) Splints with Class III elastics.

Figure 2. Chincup.

hours per day. The active phase was performed until a positive overjet (2–3 mm) was reached. The average SEC III treatment duration was about 1 year.

RME/FM protocol

The RME/FM therapy included three components: maxillary expansion appliance, facial mask, and heavy elastics (14). The acrylic splint expander, with vestibular hooks for protraction with the facial mask, was bonded on the deciduous canines and the first and second deciduous molars. When the permanent first molars were erupted, the expander was bonded on the first and second deciduous molars and the permanent first molars. The expansion screw (Leone A2620; Leone Orthodontic Products, Sesto Fiorentino, Firenze, Italy) was activated by the patients' parents one or two times per day until overcorrection of transverse occlusal relationships was achieved (palatal cusps of the upper posterior teeth approximating the buccal cusps of the lower posterior teeth). Immediately after the conclusion of the expansion phase the patients were instructed to wear a facial mask according to the design of Petit (Dynamic Face Mask; Leone Orthodontic Products) in order to perform the maxillary protraction. Elastics were attached from the vestibular hooks of the expander to the horizontal bar of the facial mask and they were inclined downward and forward at about 30 degrees to the occlusal plane (15). The extraoral elastics generated forces of 400–500 g per side. Patients were asked to wear the facial mask for a minimum of 14 hours per day for 6 months, then only at night for another 6 months. The active orthopaedic phase was discontinued when the patient showed at least a positive overjet. An overcorrection towards Class II occlusal relationships was achieved in most of the patients. The average duration of the RME/FM therapy was about 1 year.

Compliance appraisal

Patient compliance was assessed by a means of a 3-point Likert scale (poor, moderate, good) (16). As for the SEC III therapy poor compliance was reported when the patient wore the splints with elastics less than 12 hours and the chincup less than 10 hours per day; moderate compliance occurred when the patient wore the appliances more than 12 and 10 hours per day, respectively, and good compliance when the patient wore the SEC III regularly as suggested by the clinician.

As for the RME/FM therapy poor compliance was reported when the patient did not wear the facial mask during the day and not regularly at night, moderate compliance when the patient wore the facial mask regularly only at night, and good compliance when the patient wore the facial mask 14 hours per day (at night and 3 hours in the afternoon) for the first 6 months and then only at night for another 6 months.

Cephalometric analysis

All the cephalograms were assessed by means of a customized digitization regimen and cephalometric analysis provided by *Viewbox 3.0*. (dHAL Software, Kifissia, Greece). Seven variables, five angular and two linear, were generated for each tracing. The majority of the lateral cephalograms were taken with a 10 per cent enlargement. In order to compare the results of the present studies with previous investigations, enlargement factor was standardized to a 10 per cent for all radiographs in the three samples during digitization.

Statistical analysis

The differences in gender distribution between the three groups and in the degree of collaboration between the two treated groups were assessed by means of chi-square tests.

All cephalometric variables at T1 and the T1-T2 changes showed normal distribution (Kolmogorov–Smirnov test). The analysis of variance (ANOVA) (Statistical Package for the Social Sciences, SPSS, Version 12, Chicago, IL, USA) with Tukey's *post hoc* tests were applied to perform between-group statistical comparisons on the dentoskeletal features at T1 (baseline characteristics) and on the T1-T2 changes.

The power of the study (17) was calculated for the ANOVA on the basis of a minimum sample size of 23 subjects and of a minimal clinically relevant difference between RME/FM and CG for a relevant cephalometric variable (ANB angle) of 2.0 degrees with a standard deviation of 1.5 degrees as derived from an investigation of similar nature (18). At an alpha level of 0.05 the power of the study was 0.99 (SigmaStat™ version 3.5; Systat Software, Point Richmond, CA, USA).

Method error

One operator (CM) traced and digitized 20 lateral cephalograms, selected randomly, two times in a week interval. The paired *t*-test and the method of moments'estimator (19) were used to assess the systematic error and the random error, respectively. No systematic error was detected for any of the variables. The values for the random error were reported in Table 1.

Results

The three groups were similar as to gender distribution (chi-square test = 0.85; $P = 0.654$). Table 2 reported the descriptive statistics and the comparisons of the baseline characteristics of the three groups.

Table 1. Values for the random error assessed with the method of moments'estimator (MME).

Variables	MME values
Sagittal skeletal	
SNA (deg)	0.33
SNB (deg)	0.21
ANB (deg)	0.30
WITS (mm)	0.92
Co-Gn (mm)	0.88
Vertical skeletal	
Pal. Pl. to Mand. Pl. (deg)	0.41
CoGoMe (deg)	0.88

Mand. Pl., mandibular plane; Pal. Pl., palatal plane.

No significant differences were found between the three groups with the exception of the SEC III group that showed a significantly smaller mandibular angle (CoGoMe –4.9 degrees) with respect to CG.

Treatment effects

The between-group comparisons on the T1-T2 changes are reported in Table 3.

Both treated groups showed significant differences with respect to CG. Both SEC III and RME/FM groups presented significantly greater forward sagittal displacement of the maxilla (SNA +1.2 and +1.4 degrees, respectively), significant reduction of mandibular projection (SNB –1.3 and –1.4 degrees, respectively) and significantly greater improvements in the intermaxillary sagittal relationships (ANB +2.6 and +2.9 degrees, respectively; WITS +3.7 and +2.6 mm, respectively) when compared to CG.

Moreover, the RME/FM group revealed a significant increase in the palatal plane to mandibular plane angle with respect to CG (+2.0 degrees).

The comparison between SEC III and RME/FM groups showed no significant differences with the exception of the intermaxillary vertical relationships. The RME/FM group showed a significantly greater increase of the palatal plane to mandibular plane angle with respect to the SEC III group (–1.8 degrees).

Appraisal of compliance

The analysis of compliance revealed a similar distribution of 'poor', 'moderate', and 'good' degree of collaboration during the active phase of therapy (use of the SEC III and use of the facial mask) in the two treated groups. In the SEC III group 11 patients showed 'good' degree of collaboration, 8 patients 'moderate' degree of collaboration, and 6 patients 'poor' degree of collaboration. In the RME/FM group 18 patients presented with 'good' degree of collaboration, 10 patients with 'moderate' degree of collaboration, and 4 patients with 'poor' degree of collaboration. The prevalence rates of degree of collaboration were similar in the two treated groups (chi-square = 1.47; $P = 0.479$).

Discussion

The present retrospective study was designed to evaluate the effectiveness of the SEC III protocol for the correction of Class III dentoskeletal disharmony in comparison with the RME/FM treatment and with the growth changes in untreated Class III subjects.

The SEC III group presented significant favourable sagittal skeletal effects such as maxillary advancement (SNA +1.2 degrees), control of mandibular position (SNB –1.3 degrees) and intermaxillary sagittal relationship (ANB +2.6 degrees and WITS +3.7 mm) when compared to CG. These findings are consistent with the data reported by Ferro *et al.* (2) who found an increase in SNA angle (+1.2 degrees), a reduction in SNB angle (–0.7 degrees) and an improvement of ANB angle (+2 degrees) and WITS appraisal (+4.4 mm) after SEC III treatment.

Conversely, the SEC III group revealed no significant vertical skeletal differences when compared to CG. Intermaxillary divergency did not change during the active phase of SEC III treatment (palatal plane to mandibular plane +0.3 degrees). This outcome is similar to that reported by Ferro *et al.* (2) (SN to palatal plane –0.4 degrees and SN to Go-Me –0.7 degrees). A limitation of this study is represented by the fact that the SEC III group was not perfectly matched with the control sample in terms of baseline characteristics. However, the main objective of this study was to compare the dentoskeletal effects produced by the SEC III protocol versus the RME/FM protocol.

Also the RME/FM group showed significant favourable skeletal changes at the end of the orthopaedic treatment with respect to CG. The maxillary advancement (SNA +1.4 degrees) and the control of mandibular projection (SNB –1.4 degrees) produced a favourable improvement in the intermaxillary sagittal relationship (ANB +2.9 degrees and WITS +2.6 mm). Similar findings were reported by Westwood *et al.* (1) in a sample of 34 patients treated with RME/FM therapy and compared to an untreated CG (SNA +1.6 degrees; SNB –1.8 degrees and ANB +3.6 degrees). Cordasco *et al.* (10) in a recent meta-analysis on the effects of facial mask treatment in Class III malocclusion showed that the RME/FM protocol induced favourable skeletal sagittal changes (SNA +1.8 degrees; SNB –1.3 degrees), leading to the improvement of the intermaxillary sagittal relationship (ANB +3.0 degrees). In the present study the favourable skeletal sagittal effects induced by the RME/FM treatment were associated with an increase in the skeletal vertical relationships. The RME/FM group showed a significant increase in intermaxillary divergency (palatal plane to mandibular plane +2.0 degrees) with respect to CG. This outcome is consistent with data reported by several studies (20–22) on the effects of RME/FM therapy versus growth changes. Ngan *et al.* (20) and Vaughn *et al.* (21) showed that the RME/FM samples presented at the end of therapy an increase in intermaxillary divergency angle of 2.0 and 2.2 degrees, respectively, when compared with untreated Class III CG. Macdonald *et al.* (22) showed a greater increase in the skeletal vertical relationships of the sample treated with RME/FM versus the CG (SN palatal plane –1.4 degrees and FMA +2.3 degrees). On the other hand, Westwood *et al.* (1) reported in their RME/FM sample a reduction in the intermaxillary divergency (palatal plane to mandibular plane –1 degree).

The comparison between SEC III and RME/FM groups showed no significant differences as for the skeletal sagittal variables (SNA –0.2 degree and SNB +0.1 degree). The absence of RME in the SEC III protocol does not seem to represent a disadvantage in terms of maxillary protraction with respect to the RME/FM protocol as indicated by Vaughn *et al.* (21) who found that facemask therapy with or without palatal expansion produced equivalent changes in the dentofacial complex. The effects of the two treatment protocols were also very similar in terms of improvement in the intermaxillary sagittal relationships (ANB –0.3 degree and WITS +1.1 mm). The RME/FM group induced significantly greater increase in the intermaxillary divergency with respect to the SEC III group (palatal plane to mandibular plane +1.8 degrees). This more favourable control of the vertical skeletal relationships produced by the SEC III protocol with

Table 2. Descriptive statistics and statistical comparisons of baseline characteristics (ANOVA with Tukey's *post hoc* tests).

	SEC III group (1) (n = 25)		RME/FM group (2) (n = 32)		Control group (3) (n = 23)			Multiple test comparisons								
Variables	Mean	SD	Mean	SD	Mean	SD	P	1 versus 2			2 versus 3			1 versus 3		
Sagittal skeletal								Diff.	P	95% CI	Diff.	P	95% CI	Diff.	P	95% CI
SNA (deg)	80.4	2.9	80.1	3.2	80.1	3.4	0.912	0.3	0.918	−1.7 to 2.4	0.0	1.000	−2.1 to 2.1	0.3	0.936	−1.9 to 2.5
SNB (deg)	79.0	2.8	78.7	3.1	78.5	3.0	0.854	0.2	0.957	−1.7 to 2.1	0.3	0.946	−1.7 to 2.2	0.5	0.840	−1.6 to 2.5
ANB (deg)	1.4	1.8	1.3	2.0	1.6	2.8	0.904	0.1	0.981	−1.3 to 1.5	−0.3	0.894	−1.7 to 1.2	−0.2	0.965	−1.7 to 1.4
WITS (mm)	−3.9	2.6	−5.6	2.9	−4.4	2.7	0.055	1.8	0.051	0.0 to 3.5	−1.2	0.265	−3.0 to 0.6	0.6	0.757	−1.3 to 2.5
Co-Gn (mm)	105.1	4.9	104.7	5.6	106.5	7.0	0.533	0.4	0.962	−3.3 to 4.1	−1.8	0.515	−5.6 to 2.1	−1.3	0.705	−5.4 to 2.7
Vertical skeletal																
Pal. Pl. to Mand. Pl. (deg)	26.9	3.9	26.6	4.6	28.5	4.8	0.321	0.3	0.962	−2.5 to 3.2	−1.8	0.295	−4.8 to 1.1	−1.5	0.470	−4.6 to 1.6
CoGoMe (deg)	127.7	5.1	129.6	4.9	132.6	5.5	**0.006**	−1.9	0.367	−5.2 to 1.4	−3.0	0.088	−6.4 to 0.3	**−4.9**	**0.004**	−8.4 to −1.3

Bold values indicate $P < 0.05$. ANOVA, analysis of variance; CI, confidence interval; Diff., Difference; Mand. Pl., mandibular plane; Pal. Pl., palatal plane; RME/FM, rapid maxillary expansion and facial mask; SEC III, splints, Class III elastics, and chincup.

Table 3. Descriptive statistics and statistical comparisons of the T2-T1 changes (ANOVA with Tukey's *post hoc* tests).

	SEC III group (1) (n = 25)		RME/FM group (2) (n = 32)		Control group (3) (n = 23)			Multiple test comparisons								
Variables	Mean	SD	Mean	SD	Mean	SD	P	1 versus 2			2 versus 3			1 versus 3		
Sagittal skeletal								Diff.	P	95% CI	Diff.	P	95% CI	Diff.	P	95% CI
SNA (deg)	1.0	1.7	1.2	1.4	−0.2	1.2	**0.002**	−0.2	0.876	−1.1 to 0.7	1.4	**0.002**	0.5 to 2.4	1.2	**0.014**	0.2 to 2.2
SNB (deg)	−0.8	1.1	−0.9	1.3	0.6	0.9	**0.000**	0.1	0.948	−0.7 to 0.8	−1.4	**0.000**	−2.2 to −0.7	−1.3	**0.000**	−2.1 to −0.5
ANB (deg)	1.8	1.5	2.1	1.4	−0.8	1.2	**0.000**	−0.3	0.721	−1.2 to 0.6	2.9	**0.000**	1.9 to 3.8	2.6	**0.000**	1.6 to 3.5
WITS (mm)	3.1	2.6	2.0	2.3	−0.6	2.3	**0.000**	1.1	0.199	−0.4 to 2.6	2.6	**0.001**	1.0 to 4.1	3.7	**0.000**	2.0 to 5.3
Co-Gn (mm)	3.4	2.0	3.0	1.8	3.9	2.1	0.249	0.4	0.692	−0.8 to 1.7	−0.9	0.219	−2.2 to 0.4	−0.5	0.684	−1.9 to 0.9
Vertical skeletal																
Pal. Pl. to Mand. Pl. (deg)	0.3	1.7	2.0	1.9	0.0	2.3	**0.000**	−1.8	**0.004**	−3.0 to −0.5	2.0	**0.001**	0.7 to 3.3	0.3	0.871	−1.1 to 1.7
CoGoMe (deg)	−1.1	1.7	−1.8	2.9	−0.9	2.1	0.273	0.8	0.458	−0.8 to 2.3	−1.0	0.294	−2.5 to 0.6	−0.2	0.946	−1.9 to 1.4

Bold values indicate $P < 0.05$. ANOVA, analysis of variance; CI, confidence interval; Diff., Difference; Mand. Pl., mandibular plane; Pal. Pl., palatal plane; RME/FM, rapid maxillary expansion and facial mask; SEC III, splints, Class III elastics, and chincup.

respect to RME/FM therapy has to be ascribed most probably to the use of the chincup.

The findings of the present investigations confirm that both SEC III and RME/FM protocols can be considered effective for the correction of Class III dentoskeletal disharmony. The values for standard deviations of both sagittal and vertical skeletal variables point out that individual variation in treatment response to both protocols has to be expected. Such individual variation can be ascribed, at least in part, to the different degree of compliance. The SEC III protocol showed a more favourable control of the vertical skeletal relationships with respect to the RME/FM therapy that produced a significant increase in the intermaxillary divergency angle. Although this outcome is very consistent with the data reported in the literature for the RME/FM treatment (20–22), it can be considered an unfavourable side-effect particularly in hyperdivergent Class III patients. However, a long-term study (4) on the effects of RME/FM compared with growth changes in untreated Class III subjects demonstrated that at the end of active growth no significant differences were observed between groups in terms of vertical skeletal changes. A limitation of this study is its short-term nature. Therefore, further long-term studies are needed to assess the stability of the dentoskeletal effects produced by the two treatment protocols.

Conclusions

- Early treatment of Class III dentoskeletal disharmony with both SEC III and RME/FM protocols produce favourable maxillary and mandibular skeletal changes.
- The RME/FM protocol induces a significant increase of the intermaxillary vertical relationships with respect to the SEC III protocol and to the growth changes.
- The SEC III protocol is able to produce more favourable control in intermaxillary vertical relationships with respect to RME/FM therapy.

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