Analysis of maxillary arch expansion in growing patients treated with early Class III protocol versus RME



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Abstract

Aim To evaluate and compare the maxillary arch expansion obtained in growing patients treated with Class III early treatment protocol (the modified SEC III protocol), or rapid maxillary expansion (RME).

Methods This retrospective observational study included patients in the mixed dentition with maxillary constriction and/or dental crowding. The first group consisted of 30 patients (11 males and 19 females, mean age 9.4 ±1.7 years) with dentoskeletal Class III malocclusion treated with the modified SEC III protocol. The second group of 30 patients (14 males and 16 females, mean age 9.3 ±1.5 years) with Class I or II malocclusion was treated with a Hyrax-type expander applied to bands on the first upper molars. For each subject, initial (T0) and post expansion (T1) digital dental casts were collected. The intermolar and intercanine widths, the arch lengths at both cusp and gingival levels, the anteroposterior length and the palatal depth were measured at T0 and T1.

Results At T1 there were statistically significant differences for 3-3 occlusal (OC) ($P < 0.009$), arch-length OC ($P < 0.030$), anteroposterior arch-length (AP) ($P < 0.003$), Depth ($P < 0.030$) and Ap ($P < 0.000$). No statistically significant T0-T1 changes were found between the modified SEC III and Hyrax groups except for Depth ($P < 0.011$) with a mean difference of 2.3 mm between the two groups.

Conclusions Both bonded and banded expanders, used in the modified SEC III protocol and RME treatment respectively, produced similar changes in the upper arch. The different initial dentoskeletal malocclusions of the two sample groups were not relevant to the post-expansion arch changes.

KEYWORDS Maxillary expansion, modified SEC III protocols, rapid maxillary expansion, bonded expander, Hyrax expander

Introduction

Dentoskeletal Class III malocclusions are often characterized by mandibular prognathism, maxillary deficiency or combinations of both [Perillo et al., 2016a; Toffol et al., 2008]. Specifically, they show significant narrower skeletal and dentoalveolar widths of the upper arch in comparison to Class I malocclusions [Uysal et al., 2005]. In addition, subjects with Class III malocclusion show significant increments of facial divergence related to constricted and high palate during growth [Paoloni et al., 2020; d'Apuzzo et al., 2021; Nucci et al., 2021; Perillo et al., 2021b; Eslami et al., 2018; Grippaudo et al., 2020].

Thus, the correction of the transverse occlusal relationships with maxillary expansion is suggested being the transverse deficiency of the maxilla as one of the typical features of Class III malocclusions in the mixed dentition together with crowding that can also cause tooth impactions in the permanent dentition [Ferro R et al., 2016; Dekel et al., 2021]. Early maxillary expansion is further supported by current investigations showing that subjects treated before the pubertal growth peak present significant and more effective and stable long-term skeletal modifications in both maxillary and circumaxillary structures [Franchi and Baccetti, 2005].

Among the various therapeutic alternatives proposed over the years, many protocols including intraoral and extraoral appliances have been assessed through short- and long-term evaluations [Eslami et al., 2018; Ferro A et al., 2003; Baccetti et al., 2004; Masucci et al., 2011; Quinzi et al., 2021; Primozic et al., 2021; Fischer et al., 2018; Fabozzi et al., 2021]. Currently, it has also been proposed the use of clear aligners as early treatment in patients with Class III malocclusion. However, evidence about treatment outcomes of this new protocol is still very low [d'Apuzzo et al., 2019; De Felice et al., 2020; Staderini et al., 2020].

A recent study showed that treatment with rapid maxillary expansion (RME) and face mask (FM) increased the arch length of patients with Class III malocclusion [Uzuner et al., 2017]. The RME/FM protocol compared to treatment with Transverse Sagittal Maxillary Expander (TSME) produced similar skeletal and dentoalveolar corrections in Class III patients with maxillary retrusion [Maspero et al., 2012].

Another early treatment alternative for growing Class III patients is the modified SEC III (Splints, Elastics and Chin cup) protocol that includes an expansion screw in the upper splint to allow the maxillary expansion. The occlusal planes of the acrylic splints facilitate both the sagittal and transversal corrections by

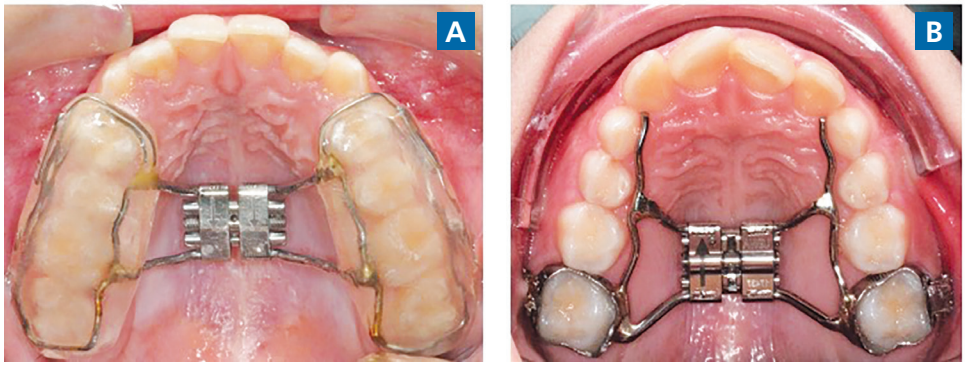


FIG. 1
Bonded (A) versus Banded (B) Maxillary Expander

removing the occlusal intercuspation and the tongue thrust [d'Apuzzo et al., 2019; Montinaro et al., 2021].

Several studies demonstrated the efficacy of increasing the upper transversal widths in growing patients through different maxillary expansion devices both banded or bonded [Quinzi et al., 2021; Fischer et al., 2018; Baccetti et al., 2000b; Kama et al., 2006; Pavoni et al., 2015; Lione et al., 2016] but there is still a lack of knowledge on the peculiar effects of the maxillary expansion in patients with Class III malocclusion compared to the expansion performed in other types of malocclusions. First, usually the expansion in patients with Class III malocclusion is achieved through bonded expander that avoid any occlusal interference during treatment thus facilitating the sagittal correction. Moreover, it can be hypothesized that the use of the Class III elastics in the SEC III protocol could have an inhibitory effect on transverse expansion as they are anchored in the mandibular arch to the resin hooks in the anterior area. Moreover, the chin cup could have a hindering effect on maxillary expansion due to its pressure on the cheeks, which could be transferred to the alveolar processes.

Thus, the purpose of this retrospective observational clinical study was to assess the maxillary arch expansion obtained in children treated with bonded expander included in the modified SEC III protocol versus RME in the mixed dentition phase.

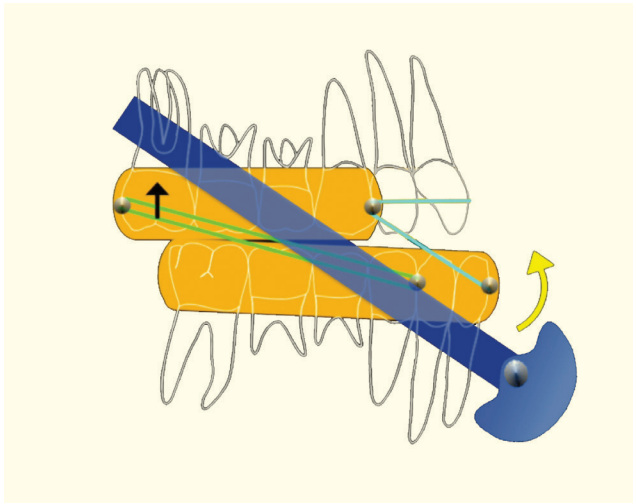


FIG. 2 Modified SEC III protocol design: - upper splint with expander screw to create a wedge effect with a single contact point on the last molars; - lateral Class III sand anterior elastics placed on three hooks (two located in the upper arch, between the cuspids and the lateral incisors, and one in the lower arch on the midline)

Methods

Approval for this study was granted by the Ethical Committee of the University of Campania Luigi Vanvitelli (N° 148). Patients' parents signed the authorization for the use of personal data stored in the archives of the Orthodontic Program at the University of Campania Luigi Vanvitelli where they had been previously treated.

For an effect size of 1 for the primary outcome variable 6-6 OC (mm), a minimum sample size of 17 patients per group was required for a type I error rate of 5% and a power of 80%.

Diagnostic records from patients ranged between 9 and 12 years of age consecutively treated with a bonded expander, in the modified SEC III protocol or with a banded Hyrax appliance were gathered from the files of the University of Campania Luigi Vanvitelli Naples, Italy, from January 2009 to February 2021.

Inclusion criteria were as follows: mixed dentition with fully erupted upper permanent molars; maxillary constriction and/or mild to moderate upper dental crowding; cervical vertebral skeletal maturation stages between CS1 and CS3; good quality dental casts taken before and after maxillary expansion treatment and clinical chart. Exclusion criteria were previous orthopedic treatment and craniofacial anomalies or related syndrome (cleft lip and palate).

The first group treated with the modified SEC III protocol showed a dentoskeletal Class III malocclusion at the initial evaluation (T0). Specifically, this protocol included a lower removable acrylic splint, Class III and anterior elastics and extraoral chincup together with the maxillary arch expansion with a bonded appliance with acrylic splints from the upper deciduous canines to the first permanent molars (Fig. 1 a). Specifically, the Class III elastics were applied from hooks distal to the last molar in the upper arch to hooks distal to the lateral incisors in the lower arch; an anterior elastic was applied from two hooks located mesial to the canines in the upper arch to a single hook located between the central lower incisors (Fig. 2) [d'Apuzzo et al., 2019; Montinaro et al., 2021]. Conversely, the second group of patients treated with a Hyrax-type expander applied to bands on the first upper molars (Fig. 1 b) showed a Class I or II malocclusion.

For each subject, the dental casts collected before (T0) and after active expansion followed by retention phase (T1) were digitalized using the 3shapeTRIOS® by a single operator, then exported in STL surface mesh and imported in Viewbox 4 (dHal Software, Greece). The study casts reported a manufacturing accuracy of less than 20 microns (www.3shape.com). The recent literature confirms that the assessment of the treatment outcomes on dental casts might be performed accurately on digital 3D models with a higher validity and repeatability when compared to direct measurement on cast models [Fleming et

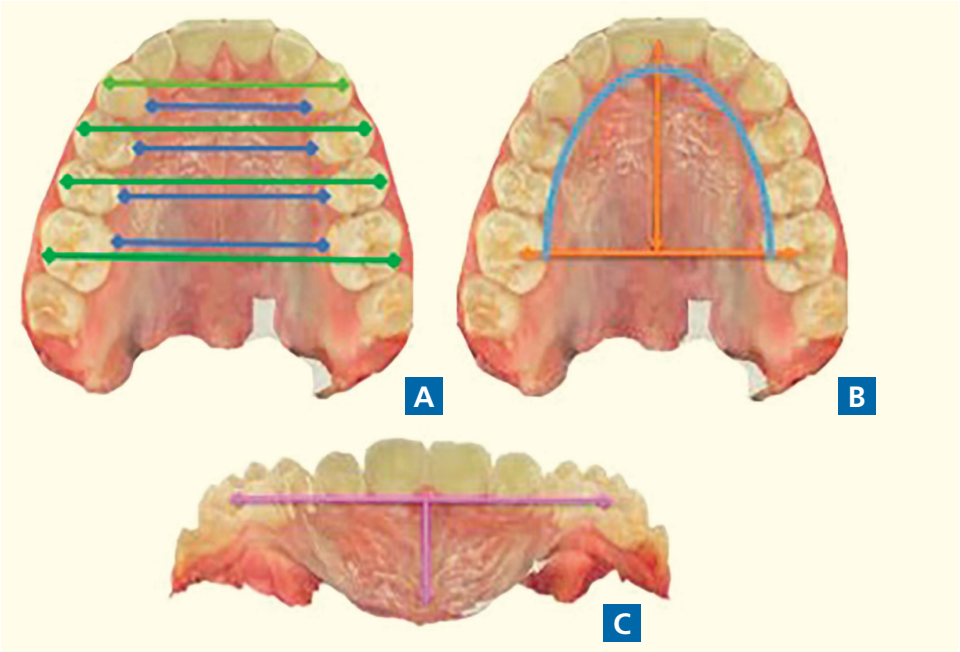


FIG. 3
Measurements on upper arch of digital dental casts: intercanine, interpremolar, intermolar widths (a) at occlusal (green lines) and gingival (blue lines) levels; arch length (orange lines) and arch perimeter (azure line) (b); palatal depth (pink lines) (c).

Mid-incisal	Point lies at the middle of right and left maxillary centrals incisal edge
3 OC	Buccal cusp tip of right and left maxillary canines
4 OC	Buccal cusp tip of right and left maxillary first premolars or its predecessor
5 OC	Buccal cusp tip of right and left maxillary second premolars or mesiobuccal cusp of deciduous
6 OC	Distobuccal cusp tip of right and left maxillary first molars
1 AP	Most gingival points of palatal surface of clinical crown of right and left maxillary centrals
2 AP	Most gingival points of palatal surface of clinical crown of right and left maxillary laterals or its predecessor
3 AP	Most gingival points of palatal surface of clinical crown of right and left maxillary canines or its predecessor
4 AP	Most gingival points of palatal surface of clinical crown of right and left maxillary first premolars or its predecessor
5 AP	Most gingival points of palatal surface of clinical crown of right and left maxillary second premolars or mesiopalatal cusp of its predecessor
6 AP	Most gingival points of palatal surface of clinical crown of right and left maxillary first molars
6 Mid	Midway point on the line between right and left 6 OC
Pv (Palatal Vault)	6 Midway point projection on palatal surface from occlusal view

SUPPLEMENTAL TABLE 1 Landmark definitions

3-3 OC	Linear distance between right and left 3 Occlusal
3-3 AP	Linear distance between right and left 3 Gingival
4-4 OC	Linear distance between right and left 4 Occlusal
4-4 AP	Linear distance between right and left 4 Gingival
5-5 OC	Linear distance between right and left 5 Occlusal
5-5 AP	Linear distance between right and left 5 Gingival
6-6 OC	Linear distance between right and left 6 Occlusal
6-6 AP	Linear distance between right and left 6 Gingival
Arch length AP	Length of curve connecting incisors mid-incisal and premolars and first molar Gingival points
Arch length OC	Length of curve connecting incisors mid-incisal and premolars and first molar Occlusal points
Ap	Perpendicular anteroposterior length between mid-incisal and the line connecting 6 Occlusal
Depth	Linear distance between 6 Mid and Pv

SUPPLEMENTAL TABLE 2 Measurement definitions

al., 2011; De Luca Canto et al., 2015; Lo Giudice et al., 2020]. For the measurements, 13 reference points (Supplemental Table 1) were identified to carry out 12 linear measurements (Supplemental Table 2) in order to calculate the intermolar and intercanine widths, the arch lengths measured at both cusp and gingival levels, the anteroposterior arch length and palatal depth. (Fig. 3 a-c) The examiner who made the measurements was blinded to the type of treatment performed for each patient.

Details about the modified SEC III protocol (i.e. type of elastics, chin-cup and biomechanics) can be found in previous publications [Perillo et al., 2016a; Nucci et al., 2021; d'Apuzzo et al.,

2019; Montinaro et al., 2021]. In both groups, the activation of the maxillary expander had been performed first at the chair-side with two turns of the expansion screw (0.5 mm), then at home with two turns per day. All patients were monitored once every 2 weeks and the active phase of expansion lasted until the palatal cusps of the upper posterior teeth approximated the buccal cusps of the lower ones [Lione et al., 2016]. Then, the appliance was maintained in situ for at least 6 months to stabilize the outcomes [Grassia et al., 2014a; Grassia et al., 2014b; Grassia et al., 2015]. The dental casts were taken after this phase of retention post-expansion (T1).

Statistical Analysis

Descriptive statistics were evaluated for all the measurements in each group. Significant between-group differences for continuous variables were tested with independent sample t-tests, whereas the Mann-Whitney test was used for the variables non-normally distributed. The level of significance was set at P <0.05 for all statistical tests. All statistical computations were performed by using specific software (Statistical Package for the Social Sciences, SPSS, Version 12).

Method error

To determine the method error, measurements were performed twice in a week interval by the same trained examiner on fifteen randomly selected digital models. The intraobserver reproducibility was calculated with the interclass correlation coefficient (ICC), while the error was evaluated with the method of moments' estimator (MME).

Results

The total sample included 60 patients (25 males and 35 females, mean age 9.35 years SD: 1.6 years). The modified SEC III group consisted of 30 patients (11 males and 19 females, mean age 9.4 years SD: 1.7 years), while the Hyrax group comprised 30 patients (14 males and 16 females, mean age 9.3 years SD: 1.5 years). The length of the active expansion phase lasted between 4 and 5 months (mean 4.0 months; SD: 0.2 months for the bonded expander and mean 4.5 months; SD: 0.3 months for the Hyrax expander). The length of the modified SEC III protocol, including the use of chincup and elastics, ranged between 6 and 20 months (mean: 12.0 years; SD: 4.2 years), while the Hyrax protocol lasted between 8 and 21 months (mean: 13.1 years; SD: 2.6 years). After treatment at T1, the modified SEC III group showed a mean age of 10.6 years (SD: 1.6 years) and the Hyrax group a mean age of 10.6 years (SD: 1.7 years). The error values varied from 0.13 mm to 0.28 mm, while the values for the ICC varied from 0.988 to 0.999.

No statistically significant differences for any of the variables describing the baseline dental features were revealed between the two groups except for a significantly smaller arch length OC and Ap in the modified SEC III group (P <0.007 and P <0.000, respectively) (Table 1).

At T1 there were statistically significant differences for 3-3 OC (P < 0.009), arch length OC (P <0.030), arch length AP (P <0.003), Depth (P <0.030) and Ap (P <0.000) (Table 2).

No statistically significant for the T0-T1 modifications were detected between the modified SEC III and Hyrax groups except for Depth (P <0.011), with a difference of 2.3 mm between the two groups (Table 3).

Discussion

This study was performed to compare the dental effects of the bonded maxillary expander used in the modified SEC III protocol for early treatment of Class III malocclusions and a banded expander during RME treatment in patients with other dentoskeletal malocclusions during growth. The use of tridimensional digital casts allowed an accurate evaluation of the parameters used to check the efficacy of the different expansion appliances. The sample showed differences at baseline for the arch length OC and Ap measurements that can be ascribed to the different malocclusions before the expansion treatment. In particular, these measurements were smaller at T0 in patients with Class III malocclusions, confirming the higher prevalence of reduced anteroposterior and transverse maxillary relationships in this group of subjects before puberty that could worsen during the adolescent growth period if not treated early [Baccetti et al., 2004b].

Variables	Mod SEC III	RME	Diff.	P value	95% CI of the difference			
	Mean	SD	Mean	SD			Lower	Upper
Age (years)	9.4	1.7	9.3	1.5	0.1	0.762		
3-3 OC (mm)	31.3	2.5	32.5	2.6	-1.2	0.084	-2.5	0.2
3-3 AP (mm)	25.5	2.6	25.7	2.1	-0.2	0.815	-1.4	1.1
4-4 OC (mm)	39.6	2.8	39.5	3.0	0.1	0.996	-1.5	1.5
4-4 AP (mm)	27.1	3.1	27.5	2.1	-0.4	0.607	-1.7	1.0
5-5 OC (mm)	44.3	3.3	44.6	2.7	-0.3	0.654	-1.9	1.2
5-5 AP (mm)	29.9	3.6	29.8	2.5	0.1	0.842	-1.4	1.8
6-6 OC (mm)	52.9	3.9	52.5	2.8	0.4	0.575	-1.2	2.2
6-6 AP (mm)	33.6	3.3	32.5	2.8	1.1	0.186	-0.5	2.6
Arch length OC (mm)	94.8	4.7	98.5	6.3	-3.7	0.007*		
Arch length AP (mm)	76.4	3.6	79.0	5.8	-2.6	0.076		
Depth (mm)	13.0	3.7	13.8	2.4	-0.8	0.371		
Ap (mm)	33.1	2.2	36.3	2.7	-3.2	0.000*	-4.4	-1.9

**P < 0.05*
SD= Standard Deviations; Diff.= Differences; CI= Confidence interval; OC= occlusal; AP= anteroposterior
Independent sample t test or Mann Whitney test were used. 95% confidence interval was not reported when the non-parametric Mann-Whitney test was applied.

TABLE 1 Descriptive statistics and statistical comparisons at T0 (starting forms).

Variables	Mod SEC III	RME	Diff.	P value	95% CI of the difference			
	Mean	SD	Mean	SD			Lower	Upper
Age (years)	10.6	1.6	10.6	1.7	0.0	0.652		
3-3 OC (mm)	35.6	2.1	37.0	1.9	-1.4	0.009*	-2.4	-0.4
3-3 AP (mm)	29.8	2.5	29.7	2.3	0.1	0.877	-1.1	1.3
4-4 OC (mm)	46.1	3.2	46.9	2.3	-0.8	0.285	-2.2	0.7
4-4 AP (mm)	33.3	2.9	33.9	2.2	-0.6	0.335	-2.0	0.7
5-5 OC (mm)	51.6	3.3	52.5	2.1	-0.9	0.193	-2.4	0.5
5-5 AP (mm)	37.5	3.0	37.5	1.6	0.0	1.000	-1.3	1.3
6-6 OC (mm)	60.3	4.0	60.1	2.4	0.2	0.789	-1.5	1.9
6-6 AP (mm)	41.1	3.7	40.4	2.1	0.7	0.330	-0.8	2.3
Arch length OC (mm)	99.7	6.4	103.3	6.3	-3.6	0.030*	-6.9	-0.4
Arch length AP (mm)	76.9	4.6	81.2	7.0	-4.3	0.003*		
Depth (mm)	12.6	3.5	11.0	3.7	1.6	0.030*		
Ap (mm)	31.9	3.0	36.2	3.2	-4.3	0.000*	-5.8	-2.6

**P < 0.05*
SD= Standard Deviations; Diff.= Differences; CI= Confidence interval; OC= occlusal; AP= anteroposterior
Independent sample t test or Mann Whitney test were used. 95% confidence interval was not reported when the non-parametric Mann-Whitney test was applied.

TABLE 2 Descriptive statistics and statistical comparisons at T1.

Variables	Mod SEC III	RME	Diff.	P value	95% CI of the difference			
	Mean	SD	Mean	SD			Lower	Upper
Age (years)	1.1	0.3	1.3	0.6	-0.2	0.165	-0.4	0.1
3-3 OC (mm)	4.3	2.5	4.5	1.9	-0.2	0.687	-1.4	0.9
3-3 AP (mm)	4.2	3.0	4.0	2.5	0.2	0.740	-1.2	1.7
4-4 OC (mm)	6.6	2.9	7.4	2.6	-0.8	0.270	-2.2	0.6
4-4 AP (mm)	6.2	3.1	6.5	3.0	-0.3	0.711	-1.9	1.3
5-5 OC (mm)	7.3	2.6	7.9	2.5	-0.6	0.119		
5-5 AP (mm)	7.6	2.7	7.8	2.4	-0.2	0.530		
6-6 OC (mm)	7.4	3.3	7.7	2.9	-0.3	0.773		
6-6 AP (mm)	7.5	3.2	7.8	3.3	-0.3	0.679		
Arch length OC (mm)	4.9	4.5	4.8	5.1	0.1	0.983	-2.5	2.5
Arch length AP (mm)	0.5	4.4	2.2	3.9	-1.7	0.111	-3.9	0.4
Depth (mm)	-0.5	3.8	-2.8	5.0	2.3	0.011*		
Ap (mm)	-1.2	2.0	-0.1	2.4	-1.1	0.067	-2.2	0.1

**P < 0.05*
SD= Standard Deviations; Diff.= Differences; CI= Confidence interval; OC= occlusal; AP= anteroposterior
Independent sample t test or Mann Whitney test were used. 95% confidence interval was not reported when the non-parametric Mann-Whitney test was applied.

TABLE 3 Descriptive statistics and statistical comparisons on the T1-T0 changes.

When analyzing the post-treatment outcomes in each group of patients (T1), the 3-3 OC widths and arch lengths both at the occlusal and gingival level and Ap distance resulted statistically significant. In particular, the increase of the occlusal intercanine width was greater in the RME group. This could be explained by the different geometry of the bonded and banded appliances used in the two groups: the RME consisted of two bands on the first molars and anterior arms extended to the canines with a consequent greater expansion at the crown level, favoring greater increases in intercanine width. On the other hand, a decrease in the palatal depth was recorded in both groups after expansion treatment. These results are in agreement with the outcomes of a previous study of Uzuner et al. [2017]. The authors evaluated the effects of RME/FM therapy during the mixed dentition period on the dental arch length in patients with skeletal Class III malocclusion. They found that inter-molar, inter-premolar, and inter-canine widths and the arch length showed increases after therapy, whereas the arch depth showed a significant decrease (p <0.001) [Uzuner et al., 2017].

The increases of the intermolar arch widths did not show any significant differences between the bonded and banded expander, in agreement with the results reported by Lione et al. after early Class III treatment with RME/FM [Lione et al., 2016].

The comparison of treatment T0-T1 changes in the two groups did not show any statistical significance for any of the examined variables except for the Depth value. This may be explained by the different conformation of the two expanders that favored a smaller inclination of the upper posterior teeth and of the maxillary processes in the group with bonded expander thanks to the resin capping of the anchoring teeth.

Contrary to the initial hypothesis, these results showed that the use of the modified SEC III protocol did not interfere with either transversal or anteroposterior expansion of the upper

arch. Specifically, the Class III elastics did not create any inhibitory effects on transverse expansion, and the chincup did not show effects on dental occlusion.

Moreover, it was confirmed that the use of bonded or banded expanders did not influence maxillary expansion, even when using a different protocol for the early treatment of Class III malocclusion [Primozic et al., 2021; Lione et al., 2016].

Limitations of this study were its retrospective nature and the lack of evaluation of long-term treatment changes (assessment of the stability of the results at a follow-up observation). A further point to be consider in the next future is the assessment of a short-term phase of treatment after fixed appliances and make a prospective clinical trial including cephalometric and also periodontal [Quinzi et al., 2019] evaluations pre- and post- early treatment with maxillary expansion in growing patients.

Conclusions

Both bonded expander in the modified SEC III protocol and the banded expander in the RME treatment produced similar modifications in the upper arch of patients in mixed dentition. The use of intraoral Class III and anterior elastics in the modified SEC III did not influence the sagittal or anteroposterior maxillary increases. The different initial dentoskeletal malocclusion of the two sample groups was not relevant to the arch changes after maxillary expansions.

References

- Baccetti T, Franchi L, McNamara JA Jr. Treatment and posttreatment craniofacial changes after rapid maxillary expansion and facemask therapy. Am J Orthod Dentofacial Orthop. 2000;118 (4):404-13.
- Baccetti T, Franchi L, McNamara JA Jr. Cephalometric variables predicting the long-term success or failure of combined rapid maxillary expansion and facial mask therapy. Am J Orthod Dentofacial Orthop. 2004;126(1):16-22.
- d'Apuzzo F, Minervini G. Grassia V, Rotolo RP, Nucci L. Mandibular coronoid process hypertrophy: Diagnosis and 20-year follow-up with CBCT, MRI and EMG evaluations. Appl Sci. 2021;11(10):4504.
- d'Apuzzo F, Perillo L, Carrico CK, Castroflorio T, Grassia V, Lindauer SJ, et al. Clear aligner treatment: different perspectives between orthodontists and general dentists. Prog Orthod. 2019;20:10.
- d'Apuzzo F, Grassia V, Quinzi V, Vitale M, Marzo G, Perillo L. Pediatric Orthodontics - Part 4: SEC III protocol in Class III malocclusion. Eur J Paed Dent. 2019;20(4):330-4.
- De Felice ME, Nucci L, Fiori A, Mir CF, Perillo L, Grassia V. Accuracy of interproximal enamel reduction during clear aligner treatment. Progr in Orthod. 2020;21(1):28.
- De Luca Canto G, Pachêco-Pereira C, Lagravere MO, Flores-Mir C, Major PW. Intra-arch dimensional measurement validity of laser scanned digital dental models compared with the original plaster models: a systematic review. Orthod Craniofac. 2015;18(2):65-76.
- Dekel E, Nucci L, Weill T, et al. Impaction of maxillary canines and its effect on the position of adjacent teeth and canine development: A cone-beam computed tomography study. Am J Orthod Dentofacial Orthop 2021;159(2):e135-47.
- Eslami S, Faber J, Fateh A, Sheikholaemmeh F, Grassia V, Jamilian A. Treatment decision in adult patients with class III malocclusion: surgery versus orthodontics. Prog Orthod. 2018;19(1):28.
- Fabozzi FF, Nucci L, Correra A, d'Apuzzo F, Franchi L, Perillo L. Comparison of two protocols for early treatment of dentoskeletal Class III malocclusion: Modified SEC III versus RME/FM. Orthod Craniofac Res. 2021;24(3):344-350.
- Fischer B, Masucci C, Ruellas A, et al. Three-dimensional evaluation of the maxillary effects of two orthopaedic protocols for the treatment of Class III malocclusion: A prospective study. Orthod Craniofac Res. 2018; 21(4):248-57.
- Ferro A, Perillo L, Ferro F, Gallo C. Long-term stability of skeletal Class III patients treated with splints, Class III elastics, and chincup. Am J Orthod Dentofacial Orthop. 2003;123(4):423-34.
- Ferro R, Besostri A, Olivieri A, Quinzi V, Scibetta D. Prevalence of cross-bite in a sample of Italian preschoolers. Eur J Paediatr Dent. 2016;17(4):307-9.
- Fleming PS, Marinho V, Johal A. Orthodontic measurements on digital study models compared with plaster models: a systematic review. Orthod Craniofac. 2011;14(1):1-16.
- Franchi L, Baccetti T. Transverse maxillary deficiency in Class II and Class III malocclusions: a cephalometric and morphometric study on postero-anterior films. Orthod Craniofac Res. 2005;8(1):21-8.
- Grassia V, d'Apuzzo F, Di Stasio D, Jamilian A, Lucchese A, Perillo L. Upper and lower arch changes after Mixed Palatal Expansion protocol. Eur J Paediatr Dent. 2014;15(4):375-80.
- Grassia V, D'Apuzzo F, Ferrulli VE, Matarese G, Femiano F, Perillo L. Dento-skeletal effects of mixed palatal expansion evaluated by postero-anterior cephalometric analysis. Eur J Paed Dent. 2014;15(1):59-62.
- Grassia V, d'Apuzzo F, Jamilian A, Femiano F, Favero L, Perillo L. Comparison between rapid and mixed maxillary expansion through an assessment of arch changes on dental casts. Prog Orthod. 2015;16:20.
- Grippaudo MM, Quinzi V, Manai A, Paolantonio EG, Valente F, La Torre G, Marzo G. Orthodontic treatment need and timing: Assessment of evolutive malocclusion conditions and associated risk factors. Eur J Paediatr Dent. 2020;21(3):203-8.
- Kama JD, Ozer T, Baran S. Orthodontic and orthopaedic changes associated with treatment in subjects with Class III malocclusions. Eur J Orthod. 2006;28(5):496-502.
- Lione R, Huanca Ghislanzoni LT, Defraia E, Franchi L, Cozza P. Bonded versus banded rapid palatal expander followed by facial mask therapy: analysis on digital dental casts. Eur J Orthod. 2016;38(2):217-22.
- Lo Giudice A, Nucera R, Ronsivalle V, Di Grazia C, Rugeri M, Quinzi V. Enhancing the diagnosis of maxillary transverse discrepancy through 3-D technology and surface-to-surface superimposition. Description of the digital workflow with a documented case report. Eur J Paediatr Dent. 2020;21(3):213-8.
- Maspero C, Galbiati G, Perillo L, Favero L, Giannini L. Orthopaedic treatment efficiency in skeletal Class III malocclusions in young patients: RME-face mask versus TSME. Eur J Paediatr Dent. 2012;13(3):225-30.
- Masucci C, Franchi L, Defraia E, Mucedero M, Cozza P, Baccetti T. Stability of rapid maxillary expansion and facemask therapy: a long-term controlled study. Am J Orthod Dentofacial Orthop. 2011;140(4):493-500.
- Montinaro F, Nucci L, Carfora M, d'Apuzzo F, Franchi L, Perillo L. Modified SEC III protocol: vertical control related to patients' compliance with chincup. Eur J Orthod. 2021;43(1):80-85.
- Nucci L, Costanzo C, Carfora M, d'Apuzzo F, Franchi L, Perillo L. Dentoskeletal effects of early Class III treatment protocol based on timing of intervention in children. Prog Orthod. 2021; 22:49.
- Paoloni V, Gastaldi G, Franchi L, De Razza FC, Cozza P. Evaluation of the morphometric covariation between palatal and craniofacial skeletal morphology in class III malocclusion growing subjects. BMC Oral Health. 2020;20(1):152.
- Pavoni C, Masucci C, Cerroni S, Franchi L, Cozza P. Short-term effects produced by rapid maxillary expansion and facemask therapy in Class III patients with different vertical skeletal relationships. Angle Orthod. 2015;85(6):927-33.
- Perillo L, Vitale M, Masucci C, D'Apuzzo F, Cozza P, Franchi L. Comparisons of two protocols for the early treatment of Class III dentoskeletal disharmony. Eur J Orthod. 2016;38(1):51-6.
- Perillo L, Auconi P, d'Apuzzo F, et al. Machine learning in the prognostic appraisal of Class III growth. Semin Orthod. 2021;27:96-108
- Primozic J, Federici Canova F, Rizzo FA, Marzo G, Quinzi V. Diagnostic ability of the primary second molar crown-to-root length ratio and the corresponding underlying premolar position in estimating future expander anchoring teeth exfoliation. Orthod Craniofac Res. 2021;24(4):561-7.
- Quinzi V, Rossi O, Paglia L, Marzo G, Caprioglio A. Paediatric Orthodontics Part 2: Periodontal effects of maxillary expansion. Eur J Paediatr Dent. 2019;20(2):164-6.
- Quinzi V, Federici Canova F, Rizzo FA, Marzo G, Rosa M, Primozic J. Factors related to maxillary expander loss due to anchoring deciduous molars exfoliation during treatment in the mixed dentition phase. Eur J Orthod. 2021;43(3):332-7.
- Staderini E, Patini R, Meuli S, Camodeca A, Guglielmi F, Gallenzi P. Indication of clear aligners in the early treatment of anterior crossbite: a case series. Dental Press J Orthod. 2020;25(4):33-43.
- Toffol LD, Pavoni C, Baccetti T, Franchi L, Cozza P. Orthopedic treatment outcomes in Class III malocclusion. A systematic review. Angle Orthod 2008;78(3):561-73.
- Uysal T, Usumez S, Memili B, Sari Z. Dental and alveolar arch widths in normal occlusion and Class III malocclusion. Angle Orthod. 2005;75(5):809-13.
- Uzuner FD, Öztürk D, Varlık SK. Effects of Combined Bonded Maxillary Expansion and Face Mask on Dental Arch Length in Patients with Skeletal Class III Malocclusions. J Clin Pediatr Dent. 2017;41(1):75-81.