Orthopedic treatment of Class III malocclusion with rapid maxillary expansion combined with a face mask: A cephalometric assessment of craniofacial growth patterns

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Objective: The aim of this prospective study was to assess potential changes in the cephalometric craniofacial growth pattern of 17 children presenting Angle Class III malocclusion treated with a Haas-type expander combined with a face mask.

Methods: Lateral cephalometric radiographs were taken at beginning (T_1) and immediately after removal of the appliances (T_2), average of 11 months of treatment. Linear and angular measurements were used to evaluate the cranial base, dentoskeletal changes and facial growth pattern.

Results: The length of the anterior cranial base experienced a reduction while the posterior cranial base assumed a more vertical position at T_1. Some maxillary movement occurred, there was no rotation of the palatal plane, there was a slight clockwise rotation of the mandible, although not significant. The ANB angle increased, thereby improving the relationship between the jaws; dentoalveolar compensation was more evident in the lower incisors. Five out of 12 cases (29.41%) showed the following changes: In one case the pattern became more horizontal and in four cases more vertical.

Conclusions: It was concluded after a short-term assessment that treatment with rapid maxillary expansion (RME) associated with a face mask was effective in the correction of Class III malocclusion despite the changes in facial growth pattern observed in a few cases.

Keywords: Angle Class III malocclusion. Cephalometrics. Headgear appliances. Maxillary expansion.

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INTRODUCTION

Class III malocclusion defined as a facial skeletal discrepancy, may result from a variety of morphological combinations between maxilla and mandible, both in the sagittal direction (mandibular prognathism, maxillary retraction, or a combination thereof) and in the vertical direction (excess or decrease in lower anterior facial height).[1,2,9,27,30]

It has been estimated that the prevalence of Class III malocclusion among Japanese and Chinese is around 14% of the population.[19] In 1994, an epidemiological study conducted in the region of Bauru, Brazil, found that this malocclusion is prevalent in 3% of all patients assessed.[22]

Before 1970, the orthodontic literature treated all Class III malocclusions as mandibular prognathism. Therefore, many authors were reluctant to discuss maxillary protraction as a viable treatment method, resorting only to the use of a chin cup to prevent mandibular growth.[17]

The finding that maxillary deficiency is often a component of skeletal Class III enhanced the potential of orthodontic-orthopedic treatment in promoting maxillary growth.[3,5,6,18,27] However, by the time most of this growth is completed, treatment options become limited.[1,4,13]

Angle Class III with maxillary deficiency, with a well positioned or retruded mandible and a reduced anterior facial height, provides the best treatment prognosis.[13,16,27,28] It should be emphasized, however, that this does not mean that one should not tackle Angle Class III with maxillary deficiency and mild mandibular prognathism.[28]

Early orthodontic-orthopedic therapy has proven effective from a skeletal standpoint, thus favouring the establishment of growth patterns and normal relationships between facial components.[1,3,23] Although still controversial,[7,20] rapid maxillary expansion (RME) combined with reverse pull maxillary headgear may be beneficial in early treatment of Class III malocclusion, even in the absence of posterior crossbite[4,13,19,23,27]. RME might disarticulate the maxilla and trigger cellular responses in the sutures, thereby strengthening the effects of maxillary protraction.[13,27]

The purpose of this study was to evaluate potential changes in craniofacial growth pattern by means of lateral radiographs in Class III children treated with RME and face mask.

MATERIAL AND METHODS

Material

This prospective study involved 17 Brazilian children with mixed dentition (7 male and 10 female), mean age 8 years and 7 months ± 1 year and 8 months (ranging from 6 years and 1 month to 11 years old), who were treated with a Haas-type expander combined with a Petit face mask to correct Class III malocclusion.

The patients presented the following characteristics:

1 – Angle Class III malocclusion.

2 – A facial Class III pattern due to maxillary deficiency, mandibular excess or a combination of both factors.

3 – Mixed dentition stage.

4 – Good oral health.

This study was approved by the Ethics Committee of Santa Cecília.

Methods

All patients were treated with a modified Haas-type expander[8] (Fig 1) and followed a protocol comprising one full turn on the first day and a half turn in the subsequent days until overcorrection of the case. In order to facilitate intraoral elastic placement, the hooks of the expander were positioned between the canines and first molars, in a horizontal direction parallel to the occlusal plane.[11,27] After screw fixation, a Petit face mask (Orthosource, Brazil) was placed with initial force of 350 grams (Fig 2), ultimately reaching 500 grams on each side. The patients were instructed to wear the mask for at least 14 hours/day.[12] The mean treatment time with the face mask was 11 months ± 3 months (ranging from 6 to 18 months).

Patients were evaluated using lateral cephalometric radiographs at the beginning of treatment (T_1) and immediately after removal of the appliances, with a mean treatment time of 11 months (T_2). The lateral cephalometric radiographs were performed in the same cephalostat, using Ortophos unit (Siemens, Germany) laterally and in centric occlusion. Cephalograms were traced over the radiographs using acetate paper. All anatomical details of interest to this study were highlighted and the variables were measured with a cephalometric protractor (Desetec) and a millimeter ruler (Desetec) with subdivisions of 0.5° and 0.5 mm, respectively. The following cephalometric variables were used:

1. Linear Variables (Fig 3): S-N, S-Ar, Ar-Goc, Me-Goc, S-Goc, N-Me, S-Gnc, N-Goc, Co-A, Co-Gn and ANS-Me.
2. Angular Variables (Fig 4): Sella angle, articulare angle, gonial angle, superior gonial angle, inferior gonial angle, SNA, SNB, 1.PP, IMPA, SN.PP angle.

The quotient of Siriwat and Jarabak[25] was used to describe facial morphology: The ratio between the posterior facial height (S-Goc) and the anterior facial height (N -Me) multiplied by one hundred (100). Any percentage lower than 59% was classified as a hyperdivergent growth pattern, between 59 and 63% a neutral pattern, and above 63% a hypodivergent pattern (Fig 3).

Statistical Method

To assess data normality, the Kolmogorov Smirnov test was initially applied. After verifying that the distribution of the measured values was symmetrical, the parametric test (t-test) was employed to evaluate potential differences between the linear and angular measures studied at T_1 and T_2. A 5% significance level was used.

Method Error

To assess method accuracy, radiographs of nine patients from the study sample (n = 17) were randomly selected. All radiographs were traced and measured again by a single operator after a period of one month counted from the original tracing. The paired t-test was applied to evaluate

Figure 1 - Modified Haas-type expander.

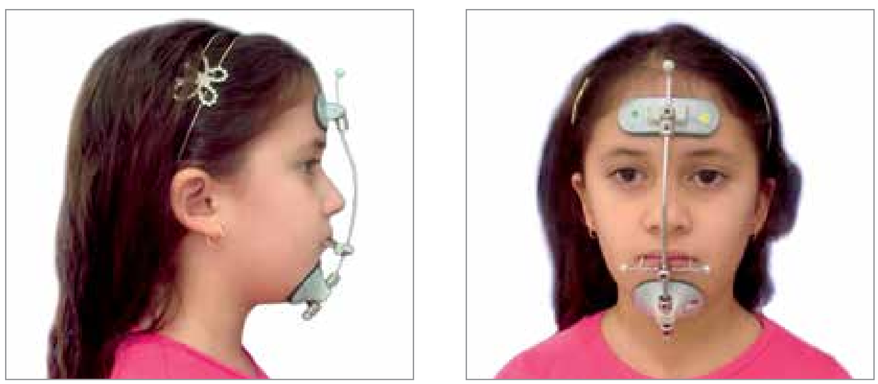

Figure 2 - Frontal and lateral facial photographs with Petit face mask.

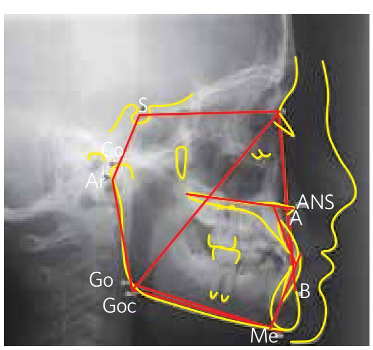

Figure 3 - Linear cephalometric variables.

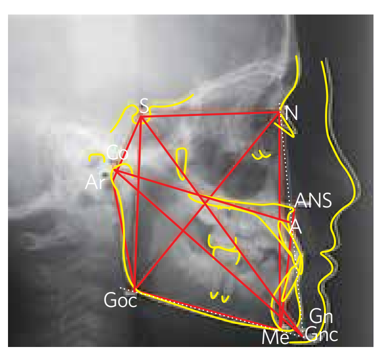

Figure 4 - Angular cephalometric variables.

systematic error. Once the difference between the first and second measurements had been obtained for each cephalogram, Dahlberg's formula was applied to estimate random error.

RESULTS

All cases evolved into a Class I correction or a class II overcorrection. Systematic error (bias) was not significant in any of the cases. Random error is depicted in Tables 1 and 2. Ar-Goc was the only linear cephalometric variable that showed no statistically significant difference between T_1 and T_2 (Table 1). Among the angular variables, the superior and inferior Gonial angles SNA, ANB and IMPA showed statistically significant differences between T_1 and T_2. In the remaining angular measures no significant changes occurred (Table 2).

At T_1, 9 cases showed hypodivergent patterns (52.94%), 5 cases neutral patterns (29.41%) and 3 cases hyperdivergent patterns (17.64%). In 12 cases (70.58%) there were no changes in facial pattern between T_1 and T2. In 5 cases (29.41%) the following changes occurred: Case 2 displayed a hyperdivergent pattern, which became neutral, 2 cases (3 and 8) exhibited neutral patterns, which became hyperdivergent, and 2 cases (10 and 17) had hypodivergent patterns which ultimately became neutral.

DISCUSSION

Given the difficulty of restraining the mandibular growth and the plasticity of the maxillary growth, the combination of RME and reverse pull maxillary headgear is a treatment protocol often used in the correction of Angle Class III malocclusion.[3,6,13,18,21,27] Prognosis of this type of malocclusion will depend on variables such as etiology and location of the skeletal problem.[4] In this study, patients were clinically evaluated and facially classified as

Table 1 - Mean and standard deviation (SD) of linear cephalometric measurements (in mm) and random error at T_1 and T_2.

		T_1	T_2	Significance (p)	Random error T_1	Random error T_2
S-N	Mean	65.12	65.97	**	0.22	0.43
	s.d.	3.46	3.40			
S-Ar	Mean	29.79	30.97	**	0.47	0.33
	s.d.	3.18	2.99			
Ar-Goc	Mean	40.50	41.09	0.157	0.72	0.33
	s.d.	5.25	6.09			
Goc-Me	Mean	65.03	66.82	**	0.71	1.10
	s.d.	5.32	4.69			
S-Goc	Mean	67.29	68.94	**	0.63	0.56
	s.d.	6.36	7.16			
N-Me	Mean	106.06	109.94	**	0.47	0.57
	s.d.	5.78	5.98			
S-Gnc	Mean	120.29	123.24	**	0.48	0.40
	s.d.	6.28	6.70			
N-Goc	Mean	102.21	105.18	**	043	0.85
	s.d.	8.18	8.09			
Co-A	Mean	79.68	80.85	**	0.53	0.75
	s.d.	5.92	5.83			
Co-Gn	Mean	105.68	107.97	**	0.67	0.70
	s.d.	7.18	7.47			
ANS-Me	Mean	61.74	64.15	**	0.38	0.70
	s.d.	3.07	3.31			

Table 2 - Mean and standard deviation (SD) of angular cephalometric measurements (in degrees) and random error at T_1 and T_2.

		T_1	T_2	Significance (p)	Random error T_1	Random error T_2
Â.Sella	Mean	119.26	119.53	0.484	0.89	0.53
	s.d.	5.76	5.85			
Â. Articulare	Mean	147.62	149.09	0.076	1.14	1.04
	s.d.	6.27	6.55			
Â. Gonial	Mean	127.27	127.09	0.608	0.47	0.81
	s.d.	5.27	5.38			
Â Sup.Gon.	Mean	52.06	51.12	0.033*	0.60	0.70
	s.d.	3.09	3.02			
Â. Inf.Gon.	Mean	75.21	75.97	0.043*	0.45	0.60
	s.d.	3.95	4.14			
SNA	Mean	82.82	83.62	0.002*	0.18	0.87
	s.d.	4.58	4.79			
SNB	Mean	81.35	80.74	0.108	0.35	0.50
	s.d.	4.63	4.91			
ANB	Mean	1.47	2.88	**	0.25	0.79
	s.d.	2.27	2.10			
1.PP	Mean	111.18	111.62	0.554	0.98	1.40
	s.d.	6.25	7.17			
IMPA	Mean	85.79	84.79	0.039*	0.59	0.74
	s.d.	7.08	7.38			
SN.PP	Mean	4.65	4.94	0.478	1.03	1.24
	s.d.	3.94	3.50			

Class III due to maxillary deficiency, mandibular excess or a combination of both factors. The magnitude of skeletal discrepancy was not taken into account as it can be seen in the wide variability exhibited by the ANB angle at T_1 (mean 1.470 ± 2.270).

The present study combined prior expansion with maxillary traction based on the fact that protraction in combination with an initial period of expansion may yield more significant skeletal results[7,13,18,27] even though expansion produces undesirable dentoalveolar side effects, such as mandibular rotation.[16] On the other hand, studies showed that RME does not influence the correction of Class III with a face mask.[7,20]

A meta-analysis[13] of clinical studies that used face masks was undertaken to determine the most convenient time to employ this treatment method. The authors found major orthopedic alterations in younger patients. In summary, maxillary protraction may be effective during the period in which the maxillary sutures are still open. Major orthopedic changes can be achieved and retained in permanent dentition as long as the face mask treatment happens in the deciduous or early mixed dentition.[30] In this study the average chronological age of patients was 8 years and 7 months (ranging from 6 years and 1 month to 11 years old at T_1).

Although the treatment goal when using a face mask is to displace the maxilla forward by applying force to the circum-maxillary sutures, there are skeletal and dental changes with forward displacement of the maxilla (1-3 mm),[2,19] maxillary incisors flaring, downward and backward mandibular rotation and, finally, lingual inclination of mandibular incisors.[2,5,9,19,29] The orthopedic alterations are responsible for 75% of the correction (25% dental) with maxillary advancement representing 75% of the skeletal correction (25% due to downward and backward mandibular rotation).[27] In comparison with the average, the results of this research are in agreement with other findings in the literature. There was an anterior displacement of the maxilla and the mean value of the SNB angle decreased, although this reduction was not statistically significant, suggesting that the downward and backward mandibular rotation increased the ANB angle. Interestingly, although the gonial angle did not change, the upper and lower gonial angles changed significantly. This is due to the tendency of the mandible to rotate clockwise.

The patients in this study did not show any maxillary rotation. The direction of the force produced by the mask was more horizontal and parallel to the occlusal plane.[11,27] The literature shows a high incidence of anterior movement without rotation.[3] The earlier the therapy is started the greater is the anterior displacement due to the release of the pterygomaxillary fissure.[2]

The anterior and posterior vertical dimensions of the face increased significantly between T_1 and T_2. When patients were evaluated separately, they showed no facial patterns changes between T_1 and T_2 in 12 cases (70.5%). The changes followed a more vertical pattern In four out of five cases (29.4%) whose facial patterns experienced modifications. In only one case there was a more horizontal pattern. Increases were found in all linear values, although they were not significant at the level of the ramus. Angular measurements tended to worsen in the vertical direction. Overall, the changes may be considered minimal in the vertical plane, with stability occurring in the facial growth pattern[25] in 70.5% of the cases.

It is noteworthy that at T_1, 9 cases showed hypodivergent patterns (52.94%), 5 cases neutral patterns (29.41%) and 3 cases hyperdivergent patterns (17.64%). Thus, regarding the absence of the palatal plane rotation, it can be speculated that most patients exhibited horizontal growth patterns, which helped to preserve the facial pattern.

Dentoalveolar compensation had a bearing on the process of malocclusion correction, although only the lower incisors changed significantly between T_1 and T_2. A non-significant change was found in upper incisor inclination, which may have been due to expansion in all cases, with a consequent compensation caused by the uprighting of these teeth. A marked variability was observed in treatment time (6 to 18 months) with this type of protocol, which can be ascribed to the severity of the malocclusion at T_1 and patient cooperation in wearing the face mask.

Regarding to the anterior cranial base (S-N) and the length of the mandibular body (Goc-Me), the ratio is 1:1 at age 11 years, according to Jarabak.[26] The mean value of the anterior cranial base

(S-N) is 71 ± 3 mm. The patients in this study had an average chronological age of 8 years and 7 months with an average size of the anterior cranial base of 65.12 mm at T_1. These results were in agreement with the findings of Jarabak, who noted a decreased anterior cranial base in subjects with skeletal Class III malocclusion. According to Jarabak[26] the length of the mandibular body at that same age (11 years) is 71 ± 5 mm. A difference between 0 and 5 mm in favor of the anterior cranial base is usually found in prepubertal ages. The mandibular body, therefore, is 5 mm shorter than the anterior cranial base in 8-year-old children. In this study, the subjects displayed a mean value of 65.03 mm of mandibular length at T_1, therefore nearly the same size as the anterior cranial base, which characterized a Class III malocclusion. At T_2, the average size of the anterior cranial base was 65.97 mm, showing an increase of 0.85 mm compared to T_1 and growing less than 1 mm, what is considered the average standard for a 1-year assessment.[26] In patients with a ratio of 1:1 (Goc-Me and S-N) at age 11 years the annual increment in mandibular growth is 1.5 mm per year, reaching 2 mm in Class III malocclusions. In this study, a mean increase of 1.8 mm was noted in the mandibular length between T_1 and T_2, showing increased mandibular growth.

According to Björk,[26] the sella angle (Ar.S.N.) displays a mean value of 123 ± 6°. The present study found a mean value of 119.26° at T_1 and 119.53° at T_2, whereas no significant change was noticed during treatment. A smaller angle lower than the norm, or a closed angle, indicates a more vertical position of the posterior cranial base (S-Ar). With growth, this situation tends to favor the anterior projection of the mandible, usually found in Class III malocclusions and skeletal deep bite.

The clinical outcomes showed that malocclusions were overcorrected in compliant patients, achieving in some cases a Class II of 3 to 4 mm. A longitudinal follow-up of the treated cases is warranted before stability of the results can be ascertained. The long-term treatment prognosis of Angle's Class III malocclusions tends to be better if the malocclusion is caused by maxillary deficiency rather than by mandibular prognathism.[28] New treatment protocols are emerging for maxillary traction and research should be conducted alternating rapid expansion and constriction of the maxilla, where previous studies[14,15] reported an average protraction of 5.8 mm at point A. It was conducted a study[24] using anchorage implants in the search for a device capable of providing an extremely stable and secure anchorage in maxillary orthopedic treatments. A discrete anterior displacement of the jaw has also emerged as an alternative treatment. Osseointegrated mini-implants have emerged which can also be used as anchorage for maxillary protraction.[20] Thus, in a short term, alternative evidence-based treatment protocols will afford more efficient orthopedic corrections that minimizes undesirable side effects.

CONCLUSIONS

After a short-term assessment, it was concluded that treatment with RME combined with a face mask was effective in the correction of Class III malocclusion, leading to changes in the facial growth pattern in a few cases.

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