Original Article

Cephalometric evaluation of the effects of the joint use of a mandibular protraction appliance (MPA) and a fixed orthodontic appliance on the skeletal structures of patients with Angle Class II, division 1 malocclusion

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Abstract

Objective: This study aimed to perform a cephalometric evaluation of the skeletal responses triggered by the joint use of a mandibular protraction appliance (MPA) and a fixed orthodontic appliance for correction of Class II, division 1 malocclusion in young Brazilian patients. **Methods:** The sample consisted of 56 lateral cephalograms of 28 patients (16 women and 12 men). The initial mean age was 13.06 years and mean duration of therapy with MPA was 14.43 months. The lateral radiographs were obtained before and after treatment and were compared by two calibrated examiners to identify the skeletal changes induced by the MPA using 16 linear and angular cephalometric measures. Some independent variables (patient age, sex, facial pattern, MPA model, total use time, archwire and technique used during therapy with MPA) were considered and related to those measures in order to demonstrate the influence of these variables on them. Responses to treatment were analyzed and compared by the Wilcoxon Signed Ranks test and Mann-Whitney test at a significance level of 5%. **Results:** The results showed restricted anterior displacement of the maxilla, increased mandibular protrusion, improved anteroposterior relationship of the basal bones and stability of the mandibular plane relative to the cranial base. The influence of variables age, facial pattern and MPA type was also noted. **Conclusions:** MPA proved an effective alternative in the treatment of Class II, division 1 malocclusion, inducing changes in the skeletal component with satisfactory clinical results.

Keywords: Cephalometry. Functional orthodontic appliances. Angle Class II malocclusion. Mandibular protraction appliance.

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INTRODUCTION AND LITERATURE REVIEW

Angle Class II, division 1 malocclusion is a frequent problem affecting about 55% of the Brazilian population.[2] It has a multifactorial etiology, and from a skeletal point of view, may be due to maxillary protrusion, mandibular retrusion or a combination of both.[16]

The literature is rich in treatment methods for this malocclusion, which traditionally rely on patient cooperation in wearing removable functional appliances (Activator, Balters' Bionator, Frankel appliance), using Class II elastics and/or extraoral traction appliances. Among the appliances used in Class II, division 1 cases are those which have as their key objective restricting the anterior displacement of the maxilla, those that push the mandible towards a more anterior position in order to redirect growth and lead to an appropriate morphological development, and those that induce changes in both arches.[12]

In recent decades, several authors began to develop fixed intraoral orthopedic appliances capable of correcting Class II molar relationship with mandibular retrognathism, since these appliances promote changes in mandibular posture, positioning it forward with the aim of stimulating its growth.[24,25] Since these appliances are fixed (Herbst,[25] Jasper Jumper,[17,18] Universal Bite Jumper,[4,28] Eureka Spring,[13] MARA,[1] Churro Jumper[5] and Superspring[19]) they are instrumental in decreasing the need for patient compliance during treatment.

However, the lack of specialized laboratories to fabricate these appliances, their high cost and scarcity of information about the installation of most of them led Coelho Filho[6] to design the Mandibular Protraction Appliance 1, also known as MPA 1, whose characteristics, at first quite simple, soon evolved into a more advanced version. In 1995, the inventor presented the clinical results achieved with his appliance as an alternative to Herbst,[6,20,21,22,23,26,27] reintroduced by Pancherz (1979), since the former uses the same mechanical design as the latter.

Some of the advantages of MPA over Herbst are that (a) it can be fabricated by professionals themselves, without the need for laboratory work, (b) it is affordable, (c) it is easy to insert, and (d) as it is less bulky, it provides greater patient comfort.[10,11,30]

MPA 1 was initially made with 0.032-in (0.9 mm) wire and consisted of a steel rod with a round loop at each end. In this first version, rectangular wires had to be in place and due to the conformation of the appliance only canine to canine brackets could be bonded. Moreover, the lower arch needed to have a strong torque in the anterior region to resist buccal displacement of lower incisors resulting from the protrusive forces generated by the appliance. Additionally, bends had to be applied on the distal side of lower molar tubes to enhance anchorage and prevent mesial drift of lower teeth.[6,8]

Although the clinical results achieved with MPA 1 were extremely positive, limitations in mouth opening caused frequent breakages.[7] Therefore, in 1997, the second MPA version was launched, featuring increased mouth opening, greater patient comfort and less frequent breakages. Besides all the installation details described for an MPA 1, the author emphasized insertion of anterosuperior buccal torque and two circular loops positioned mesial to the upper molars and distal to the lower canines to facilitate appliance installation. Also noteworthy was the fact that with this second version brackets could be bonded to premolars.

In contrast to these upsides, MPA 2 also showed some shortcomings. To address these issues the author created a fully modified third version termed MPA 3,[7,9,10] which had a completely different configuration from earlier versions, including telescopic stainless steel tubes through which ran 0.9 mm wire rods. The method of insertion in the lower arch was redesigned. All these improvements ensured greater appliance balance when patients opened and closed their mouth. The author also discussed the use of the appliance in cases of Class III malocclusion and anterior crossbite. To do so would require reversing the direction of the appliance.[7,9]

In 2001 and 2002, Coelho Filho introduced the latest version: MPA 4. The author reported that this new model seemed to surpass all previous models in terms of both shear strength and ease of installation. Furthermore, MPA 4 adaptation to the upper arch was modified to impart greater functional stability to the appliance.[11] The author also pointed out that MPA model did not determine differences in the outcome. All models feature the same mechanical principles. What makes each different is fabrication method, installation and patient comfort.[7]

Given their numerous advantages, as stated above, in addition to being versatile and featuring a wide range of applications, orthodontists were driven to study MPA treatment effects, prompting some to go as far as to propose other appliance models with similar mechanisms.[15,22] Thus, the purpose of this study was to analyze and determine skeletal changes in patients with Angle Class II, division 1 malocclusion resulting from treatment with MPA during the phase of active growth.

METHODS

This study can be defined as an uncontrolled, nonrandomized clinical trial. To conduct it, a sample was selected comprising 56 lateral cephalograms of 28 Brazilian youths of both sexes — 16 women and 12 men — according to the following criteria: Angle Class II, division 1 malocclusion with mandibular retrognathism, as assessed by study models, photographs and radiographs with a clear visualization of the structures of interest. Exclusion criteria were as follows: Agenesis, extraction or loss of permanent teeth; patients undergoing orthodontic treatment prior to MPA installation, since prior therapy would alter the Class II, division 1 malocclusion; and significant overjet.

Clinical records included the following clinical variables: Patient age, sex, facial pattern (dolichofacial, mesofacial and brachyfacial, but the latter was excluded during sample selection as only one case had this facial type, which might yield statistical results with a higher margin of error), MPA model (types 1, 2, 3 and 4; type 1 was associated with type 2, and type 3 with type 4, since only one patient was treated with MPA 1, and only 5 cases with MPA 3), total time of appliance use, archwires used during treatment with MPA (0.019x0.025-in, 0.021x0.025-in and 0.018x0.025-in stainless steel wires, with the latter two grouped together, totaling 12 cases, compared to 16 patients with 0.019x0.025-in stainless steel wire) and orthodontic technique (Standard Edgewise and Straight Wire).

The cephalograms used in this study were selected from the archives of Professor Carlos Martins Coelho Filho's private clinic (in the city of São Luís, Maranhão state, Brazil), and obtained with Funk Orbital X15 X-ray device, with a magnification factor of 9%, and operated by one and the same examiner.

Two lateral cephalograms of each of the 28 patients were used, referred to as T1 (initial) and T2 (final). The cephalograms were traced manually on a light box by two calibrated examiners in a darkened room at Professor Carlos Martins' private clinic in São Luís, Maranhão state.

Examiner calibration was performed approximately three months earlier, when 30 randomly selected cephalograms were retraced until minimum error was attained.

To obtain the cephalograms the authors used transparent Ultraphan acetate paper (Cephalometric Tracing Paper, GAC), Pentel pencil holder with a 0.3 mm tip, tape, soft rubber, template (Tracing Template, Unitek Corp.), and a light box. When double images of the anatomical design of bony structures were visualized both images were traced and a mean value was found between cephalometric points.

In the next step the images were imported via a scanner into a microcomputer containing the Radiocef Studio Cephalometry program (No. 020576, version 4.0, release 3 - Belo Horizonte/MG, Brazil), where values were obtained for T1 and T2 and their respective repetitions.

From then on, the following landmarks were identified to obtain angular and linear measurements: S (sella turcica), N (nasion), A (subspinale), B (supramentale), Pog (pogonion), Me (menton), Go (gonion), Gn (gnathion), Ar (articulare), ANS (anterior nasal spine) and PNS (posterior nasal spine) (Fig 1).

The reference planes used in this study were, as shown in Figure 2: a modified Frankfort Horizontal Plane (FHP)[29] (1), composed of a line that forms with the SN line a 7° angle down through point S; Mandibular planes Go-Me (2) and Go-Gn (3); Palatal Plane (PP) (4), formed by points ANS and PNS; lines SN (5), NA (6), NB (7), APog (8) and S-HFp (9).

Angular variables included, as shown in Figure 3: SN.PP (10), SN.GoGn (11), SN.GoMe (12), SNA (13), SNB (14), ANB (15) and NAPog (16); and the linear variables were, as shown in Figure 4: Go-Gn (17), ANS-FHP (18), Pog-FHP (19), A-FHP (20), B-FHP (21), ASFH (22), PFH (23), LPFH (24) and LAFH (25).

RESULTS

This study used a sample of 56 lateral cephalograms of 28 young Brazilian of both sexes comprising 16 women (57.1%) and 12 men (42.9%) (Table 1).

Mean age was 13.06 years, with a standard deviation of 1.3 years, with a minimum of 10.33 years and a maximum of 16.58 years, respectively.

As regards facial pattern, 39.3% (11 patients) were dolichofacial while 60.7% (17 patients)

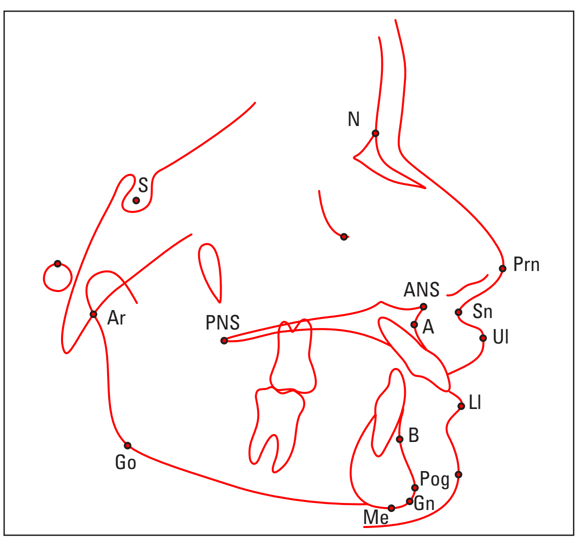

FIGURE 1 - Cephalometric points (landmarks).

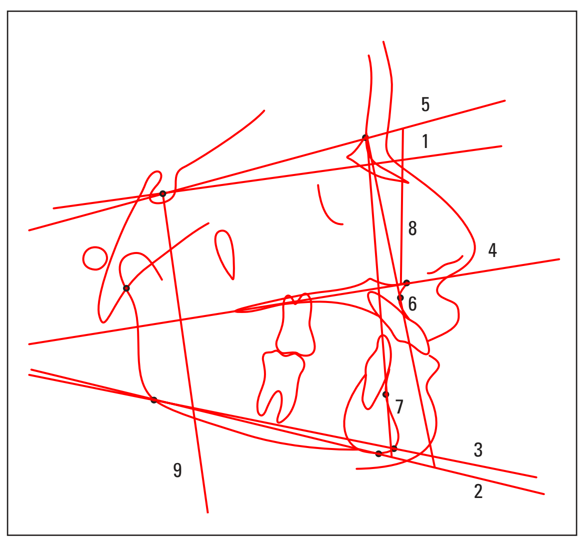

FIGURE 2 - Reference planes and lines.

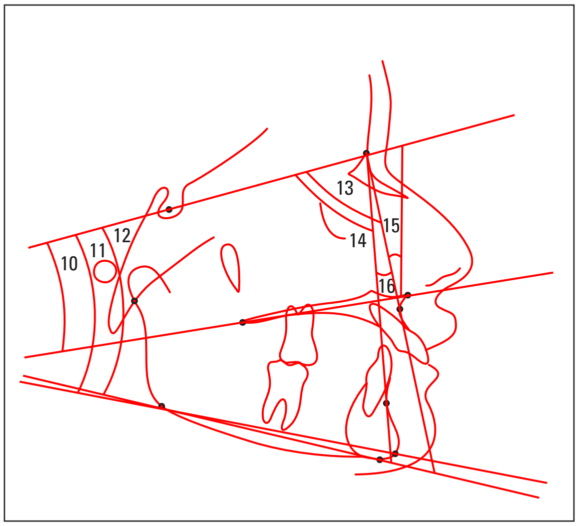

FIGURE 3 - Skeletal angular variables.

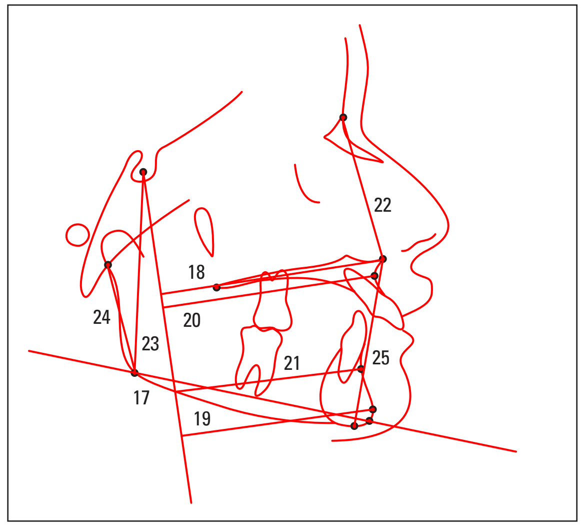

FIGURE 4 - Skeletal linear variables.

were mesofacial. As explained before, during sample selection the brachyfacial pattern was excluded as only one case had this facial type, which might yield unreliable statistical results.

Similarly, under variable MPA model, MPA type 1 was associated with MPA type 2, and type 3 with type 4, since only one patient (3.6%) had been treated with MPA 1 and 5 cases (17.9%) with MPA 3. The remaining percentages corresponded to 35.7% (10 cases) and 42.9% (12 cases) of MPAs 2 and 4, respectively.

For the variable archwire, the following types were noted: 0.019x0.025-in stainless steel (57.1% or 16 patients), 0.021x0.025-in stainless steel (10.7% or 3 patients) and 0.018x0.025-in stainless steel (32.1% or 9 patients). The latter two archwires were also grouped into a total of 12 cases.

The variable technique showed a frequency of 12 cases (42.9%) for the Straight Wire technique and a total of 16 cases (57.1%) for the Standard Edgewise technique.

The result achieved for the variable total MPA use time was 14.43 months, with a minimum of 3 months and maximum of 33 months, and a standard deviation of 9.33 months.

Table 2 shows the means for initial and final cephalometric measurements of patients of both sexes, their medians, quartiles 25 and 75, and statistical significance value (p), obtained with the Wilcoxon Signed Ranks Test. As can be observed, of all the skeletal cephalometric measures employed in this study, only SNA, SNB, ANB, NAPog, Go-Gn, Pog-FHP, FHP-B, ASFH, PFH, LPFH and LAFH were influenced by treatment with MPA, i.e., showed statistically significant values ($p<0.05$).

Among the seven independent variables, statistically significant results were found only for age, sex, facial pattern and MPA model. Tables 3 and 4 show differences between cephalometric measurements before and after treatment with MPA related to such variables, including their medians, quartiles 25 and 75,

Variables		Frequency n	Frequency %
Age	≤ 13.06 years ≥ 13.06 years	14 14	50 50
Sex	Female Male	16 12	57.1 42.9
Facial Pattern	Dolicho Meso	11 17	39.3 60.7
MPA Type	1+2 3+4	11 17	39.3 60.7
Archwire	0.019x0.025-in SS 0.021x0.025-in + 0.018x0.025-in SS	16 12	57.1 42.9
Technique	Straight Wire Standard Edgewise	12 16	42.9 57.1

TABLE 1 - Relationship between variables and sample distribution. Natal, Rio Grande do Norte State, Brazil, 2005.

and significance value (p) for each individual measure. For sex, only Go-Gn and LAFH showed a statistically significant results, and for age, only ANB. As for facial pattern, the only quantities that showed significant differences were PFH and LPFH. Regarding MPA type, statistical differences were found for Go-Gn, ANS-FHP, Pog-FHP, A-FHP, B-FHP, ASFH, PFH and LAFH.

Tables 5 and 6 show the variables associated with the skeletal cephalometric measures that exhibited changes after treatment. The variables were related to these measures prior to treatment. This revealed the influence that they exerted on these measures and whether differences existed in relation to these variables even before starting therapy with MPA. To obtain these results, the Mann-Whitney Test was employed.

As can be seen in Tables 5 and 6, only Go-Gn and LAFH showed statistical relevance even before starting treatment, when related to variable sex. All other measures, which were influenced by treatment with MPA, exhibited no statistically significant values in this pre-treatment phase.

TABLE 2 - Medians and 25/75 quartiles of initial and final skeletal cephalometric measurements and value of statistical significance. (Natal, Rio Grande do Norte state, Brazil, 2005).

Skeletal cephalometric measures	Median	$Q_{25} - Q_{75}$	P
Initial SN.PP Final SN.PP	6.67 6.77	4.58 - 9.00 4.88 - 9.03	0.608
Initial SN.GoGn Final SN.GoGn	29.47 29.69	27.74 - 34.35 26.30 - 32.63	0.374
Initial SN.GoMe Final SN.GoMe	31.19 30.99	29.53 - 36.16 28.03 - 34.10	0.219
Initial SNA Final SNA	89.86 81.95	80.07 - 86.03 79.26 - 84.24	**0.018***
Initial SNB Final SNB	77.25 78.07	75.74 - 78.91 76.36 - 80.03	**0.032***
Initial ANB Final ANB	5.88 3.92	3.59 - 7.49 1.91 - 5.54	**0.000***
Initial NAPog Final NAPog	11.00 7.17	3.95 - 14.15 3.03 - 9.63	**0.009***
Initial Go-Gn Final Go-Gn	70.44 76.35	39.23 - 79.62 45.30 - 84.19	**0.000***
Initial ANS-FHP Final ANS-FHP	75.49 77.67	43.15 - 84.63 44.79 - 86.14	0.187
Initial Pog-FHp Final Pog-FHp	64.78 65.75	37.66 - 72.68 38.80 - 77.38	**0.024***
Initial A-FHp Final A-FHp	71.45 71.97	40.86 - 81.40 41.70 - 82.30	0.255
Initial B-FHp Final B-FHp	63.84 63.84	35.61 - 71.44 36.75 - 72.95	**0.027***
Initial ASFH Final ASFH	51.48 53.48	29.93 - 55.90 30.79 - 57.68	**0.002***
Initial PFH Final PFH	71.24 76.23	40.79 - 83.02 43.15 - 83.91	**0.001***
Initial LPFH Final LPFH	42.26 45.16	22.79 - 49.42 24.94 - 51.85	**0.004***
Initial LAFH Final LAFH	59.85 62.72	35.43 - 72.56 36.25 - 71.05	**0.001***

*Significant difference ($p<0.05$) based on Wilcoxon test.

TABLE 3, 4 - Medians, 25/75 quartiles and significance of cephalometric measurements related to independent variables. (Natal, RN, Brazil, 2005).

Difference between T1 and T2 cephalometric measurements	ANB			Go-Gn			ANS-FHP			Pog-FHP			A-FHP		
	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p
Sex n															
Female (16)	2.24	1.12/2.96	0.246	-1.19	-3.76/-0.82	0.029	0.04	-1.76/1.27	0.194	-1.15	-6.13/1.67	0.194	-0.29	-1.02/1.19	0.114
Male (12)	1.18	0.04/3.00		-4.20	-11.44/-2.31		-1.11	-6.48/0.75		-6.13	-10.26/0.51		-1.48	-4.75/0.44	
Age (n)															
≤ 13.06 (14)	2.65	1.07/3.45	**0.035***	-3.72	-13.11/-1.14	0.183	-0.42	-2.64/0.38	0.748	-4.18	-9.66/1.65	0.383	-0.40	-2.37/1.67	1.000
>13.06 (14)	1.29	0.04/2.40		-1.66	-4.16/-0.80		-0.13	-4.89/1.02		0.79	-5.85/0.87		-0.34	-3.21/1.09	
Facial Pattern (n)															
Dolichofacial (11)	1.13	0.53/2.98	0.410	-2.83	-17.47/-1.23	0.312	-0.82	-4.66/0.78	0.335	-5.09	-9.35/1.84	0.621	-1.07	-3.58/1.24	0.556
Mesofacial (17)	2.37	0.78/3.03		-2.08	-6.31/0.83		0.06	-3.33/1.04		-1.20	-7.28/0.47		-0.37	-1.80/0.80	
MPA type (n)															
1 + 2 (11)	2.98	0.31/3.61	0.335	-4.83	-17.47/-3.65	**0.003***	-1.64	-5.02/-0.03	**0.018***	-7.19	-10.58/-1.95	**0.001***	-1.26	-3.74/-0.43	**0.006***
3 + 4 (17)	1.74	0.75/2.44		-1.23	-3.13/-0.61		0.67	-1.89/1.21		0.39	-3.25/3.30		0.56	-1.27/2.15	

*Significant difference (p<0.05).

Difference between T1 and T2 cephalometric measurements	B-FHP			ASFH			PFH			LPFH			LAFH		
	Mediana	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p
Sex (n)															
Female (16)	-0.84	-5.49/1.14	0.265	-0.89	-1.66/-0.14	0.057	-2.33	-5.50/-0.24	0.210	-2.27	-4.49/-0.27	0.430	-1.44	-2.98/-0.52	**0.010***
Male (12)	-5.44	-10.39/0.81		-2.38	-5.75/-0.53		-4.95	-7.65/-1.37		-4.39	-5.90/0.80		-5.13	-8.56/-3.11	
Age (n)															
≤ 13.06 (14)	-3.74	-7.91/1.14	0.312	-1.30	-3.74/0.76	0.963	-5.53	-8.64/-1.30	0.081	-4.43	-6.60/-0.68	0.154	-2.83	-5.85/-1.07	0.566
>13.06 (14)	-0.43	-5.15/1.01		-1.32	-2.50/-0.23		-2.33	-4.74/-0.01		-1.29	-4.35/-0.56		-2.57	-5.33/-0.47	
Facial Pattern (n)															
Dolichofacial (11)	-4.59	-6.93/1.29	0.724	-1.65	-4.84/-0.24	0.384	-5.54	-11.09/-2.99	**0.041***	-4.34	-8.00/-0.99	**0.046***	-3.41	-5.71/-0.93	0.371
Mesofacial (17)	-0.96	-6.37/0.70		-1.10	-2.38/0.16		-2.31	-5.38/0.28		-2.04	-4.53/-1.97		-2.62	-5.03/-0.58	
APM type (n)															
1 + 2 (11)	-6.29	-10.85/-1.74	**0.002***	-2.32	-6.09/-0.94	**0.048***	-5.67	-11.09/-3.37	**0.015***	-4.52	-8.00/-1.60	0.063	-5.21	-7.57/-2.00	**0.041***
3 + 4 (17)	0.49	-3.06/2.70		-0.85	-1.91/0.16		-2.31	-4.59/0.03		-0.99	-3.79/0.82		-1.12	-4.69/-0.47	

*Significant difference (p<0,05).

TABLE 5, 6 - Values of cephalometric measurements that showed statistically significant changes after treatment - related to independent variables - before starting treatment with MPA. (Natal, RN, Brazil, 2005).

	ANB			Go-Gn			ANS-FHP			Pog-FHP			A-FHP		
	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p
Sex (n)															
Female (16)				44.14	27.51/66.57	**0.003***									
Male (12)				75.39	71.04/91.29										
Age (n)															
≤ 13.06 (14)	5.57	3.26/7.23	0.730												
>13.06 (14)	6.04	3.95/7.84													
Facial Pattern (n)															
Dolichofacial (11)															
Mesofacial (17)															
MPA type (n)															
1 + 2 (11)				70.44	28.51/94.09	1.000	78.39	28.55/102.20	0.410	68.84	22.79/78.16	0.655	74.68	27.14/97.74	0.359
3 + 4 (17)				70.44	44.14/75.43		72.95	43.47/80.19		62.48	37.72/70.58		69.37	41.17/77.70	

*Significant difference (p<0.05).

	B-FHP			ASFH			PFH			LPFH			LAFH		
	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p	Median	Q_{25}/Q_{75}	p
Sex (n)															
Female (16)													36.38	26.94/58.82	**0.001***
Male (12)													69.29	62.43/79.77	
Age (n)															
≤ 13.06 (14)															
>13.06 (14)															
Facial Pattern (n)															
Dolichofacial (11)							78.12	39.86/89.06	0.525	45.62	23.68/55.61	0.269			
Mesofacial (17)							70.66	40.83/80.62		40.50	22.42/47.09				
MPA type (n)															
1 + 2 (11)	66.90	23.38/76.33	0.466	52.58	21.36/63.91	0.438	77.53	27.53/89.06	0.466				63.16	26.87/81.10	0.384
3 + 4 (17)	61.15	35.53/68.08		44.20	30.02/55.04		69.16	40.83/82.33					53.83	35.54/6929	

*Significant difference (p<0.05).

DISCUSSION

Angle Class II, division 1 malocclusion is a frequent problem since for its interception and/or correction a wide range of appliances have been proposed. Moreover, the literature is still scarce in studies that pinpoint which changes result from MPA use, be they skeletal, dental or cutaneous changes. Thus, this study sought to evaluate the skeletal changes triggered by the use of mandibular protraction appliances in patients with Class II, division 1 malocclusion associated with a corrective orthodontic appliance.

As for the sagittal maxillomandibular relationship, only measures ANB and NAPog were verified. The following measures were used to observe vertical changes: SN.PP, SN.GoGn, SN.GoMe, ASFH, PFH, LPFH and LAFH.

According to the results shown in Table 2, only SNA showed statistical significance for the maxillary component, suggesting that MPA acted by hindering anterior maxillary displacement, causing a reduction of 1.91°. It is known that during growth the maxilla moves forward and downward. In patients with Class II growth pattern it is common for point A to be positioned more anteriorly. Thus, when associated with the growth tendency observed in the maxilla of untreated patients, SNA often experiences an increase.[14] In this study, reduction in this skeletal cephalometric measurement can therefore be attributed to the use of the appliance favored by the growth factor, since the treated group had a mean age of 13.06 years.

Concerning mandibular changes, all measures showed significant differences and increased protrusion when MPA was used, but this fact does not warrant one to assert that protrusion was solely due to the MPA as this age group shows a predominance of mandibular growth. Cephalometric measurements correspond to SNB, Go-Gn, B-FHp and Pog-FHp (Table 2).

The measures used to verify the sagittal maxillomandibular relationship yielded statistically significant results. After using the appliance, an improved relationship was noted between the maxilla and mandible in the anteroposterior direction, with a more posterior positioning of the maxilla and more anterior positioning of the mandible. There was a decrease in maxillomandibular relationship values (ANB, NAPog) which resulted in the correction of the skeletal Class II (Table 2).

In observing the vertical changes resulting from therapy with MPA, it was found that the angular measures SN.PP, SN.GoGn and SN.GoMe showed no statistically significant differences after MPA use. The former two measures remained fairly constant and the latter experienced a slight downturn. Linear measures ASFH, PFH, LPFH and LAFH showed significant increases (Table 2). Once again the results reinforce Coelho Filho's finding that despite increases in anteroinferior and posterior facial height, the mandibular plane angle is not negatively affected when treatment induces the mandible to move to a more anterior position.

Tables 3 and 4 show the difference ratio between cephalometric initial and final measures, and independent variables. Only variables sex, age, facial pattern and MPA model influenced the final cephalometric measures. The other variables used in this research — total use time, archwire and technique used during treatment — showed no statistically significant results and do not seem to exert any influence on the skeletal cephalometric measures targeted in this study.

Regarding sex, there was a significant difference for Go-Gn and LAFH, and in both there was a larger increase for males and smaller increase for females since males exhibit greater growth potential (Tables 3 and 4). These measurements, however, were already different in relation to sex before treatment, suggesting that sex did not directly interfere with the outcome of therapy using MPA (Tables 5 and 6).

As regards age, the only measurement that showed significant alteration was ANB, and the difference between T1 and T2 was higher in the group aged ≤13.06 years and lower in the group aged >13.06 years, whose values correspond to 2.65 and 1.29, in the order given, due to greater growth potential with more significant skeletal changes at younger ages (Tables 3 and 4). However, this measure was not initially altered, suggesting that age influenced the treatment (Tables 5 and 6).

According to Enlow,[14] during puberty the growth velocity curve rises to a peak and then begins to fall rapidly. Peak velocity is called maximum height growth speed. Pubertal growth spurt occurs on average two years earlier in girls than in boys. Spurt initiation, i.e., the age at which the curve shows a steady increase, represents an age of 10.04±1,26 years for girls and 12.08±1.20 years for boys. As for spurt duration there seems to be no significant difference between the sexes (4.73 and 4.91 years for girls and boys, respectively). In this study, the group that exhibited the most significant changes had a mean age ≤13.06 years, with a decrease in ANB, as can be seen in Table 4. This can be explained both by the growth factor, since the group in question was experiencing maximum spurt, but also by the mechanics produced by the MPA, confirming once again studies by Coelho Filho which show satisfactory results from the use MPAs for facial convexity reduction and correction of the maxillomandibular relationship.

In analyzing facial pattern, only PFH and LPFH showed enhanced values, with dolichofacial patients showing slightly more changes than mesofacial patients (Tables 3 and 4). However, these measures showed no significant changes before starting therapy with the MPA, which may lead one to reason that facial pattern exerted some influence on the treatment (Tables 5 and 6).

Facial growth plays a significant role in the prognosis of patients treated orthodontically. A major goal in treating young patients during the active growth phase is to control facial growth direction. According to Björk,[3] Frankel and Frankel[15] and Vasconcelos[30] increases in the vertical facial factor are deleterious for patients with skeletal Class II malocclusion as the mandible rotates posteriorly, further worsening the sagittal malocclusion. In dolichofacial types, treatment of Class II should check anteroinferior facial height growth and posterior facial height growth. In this study, measures PFH and LPFH — after treatment with MPA — showed increases that were higher for the dolichofacial than for the mesofacial group. The other measures were correlated with the facial pattern and displayed no statistically significant results. This finding has major clinical bearing as it shows an improved profile, control over vertical facial increase and mandibular plane angle, or the latter's anterior rotation, improving the sagittal maxillomandibular relationship.

Regarding MPA type, in all that experienced changes (Go-Gn, ANS-FHP, Pog-FHP, A-FHP, B-FHP, ASFH, PFH, and LAFH) greater changes in measurements were observed in the group using MPA type 1 and 2 than in the second group using MPAs 3 and 4 (Tables 3 and 4). But this difference was not present prior to treatment (Tables 5 and 6). Such changes may be associated with the fact that MPAs type 1 and 2 showed more limited mouth opening, greater rigidity, longer-acting time and therefore greater effectiveness.

However, these findings cannot be considered fully conclusive due to some limitations in this study, among which are a small sample size, absence of a control group and the fact that patients were not randomly assigned. Thus, further studies need to be conducted, including assessment of variables that could influence the results.

CONCLUSIONS

Given the methods employed and the results obtained in this study, it can be concluded that treatment with MPA:

1. Worked by restricting anterior maxillary displacement, with decreased SNA.

2. Influenced the anterior-most mandibular position (SNB, Go-Gn, B-FHp and Pog-FHp).

3. Was effective in reducing facial convexity and correcting the maxillomandibular relationship.

4. Did not influence mandibular vertical growth since the angular variables showed no significant posttreatment behavior (SN.PP, SN.GoGn, SN.GoMe). However, anterior and posterior facial heights increased significantly, despite the fact that the mandibular plane angle remained stable. The following influences were noteworthy: (a) variable age (the sample was experiencing pubertal growth spurt), (b) variable facial pattern (dolichofacial patients benefited most), and (c) variable MPA type (probably due to the greater stiffness of types 1 and 2).

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