Cephalometric evaluation of the effects of a mandibular protraction appliance (MPA) combined with fixed orthodontic appliance on dentoalveolar and soft tissue structures of Class II, division 1 patients

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Abstract

Objective: To perform a cephalometric evaluation of dentoalveolar and soft tissue changes in Brazilian youths with Class II, division 1 malocclusion, treated with a mandibular protraction appliance (MPA) combined with fixed corrective orthodontics. **Methods:** The sample consisted of 28 patients (16 females and 12 males) with a mean age of 13.06 years, treated for a mean period of 14.43 months. The changes were measured on 56 specific cephalometric analysis obtained from lateral cephalograms taken before and after treatment by two calibrated examiners in order to identify soft tissue and dentoalveolar changes using linear and angular cephalometric measures. The independent variables sex, age, facial pattern, MPA model, archwire, technique and treatment time were registered and analyzed using linear and angular cephalometric measures. Treatment responses were analyzed and compared by the Wilcoxon Signed Ranks and Mann-Whitney tests at a significance level of 5%. **Results:** The results showed dentoalveolar changes of great magnitude, which caused positive changes in soft tissue. It was also noted that the variables age, MPA model and technique influenced the treatment. **Conclusions:** MPA proved to be an effective alternative in the treatment of Class II, division 1 malocclusion, inducing dentoalveolar and soft tissue changes with satisfactory clinical results.

Keywords: Cephalometry. Mandibular protraction appliance. Class II, Division 1 malocclusion. Dento-alveolar and soft tissue changes.

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INTRODUCTION

Angle Class II, Division 1 malocclusion is highly prevalent among Brazilian children, affecting 55% of patients with malocclusion.[1] It is characterized by lack of sagittal harmony between the basal bones due to maxillary prognathism and mandibular retrognathia, either in isolation or in combination, being the mandibular retrognathism one of the major causes of this malocclusion.[23,26]

In recent decades, many researchers began to develop fixed intraoral orthopedic appliances to correct Class II malocclusion caused by mandibular retrognathism. These devices promote changes in mandibular posture by positioning it forward and generating forces that are delivered to the teeth and basal bone, thereby correcting the problem. One such example is the Herbst appliance.[15-21]

Due to difficulties on importing, a lack of specialized laboratories, high costs and challenging installation procedure regarding most of these appliances, Coelho Filho[3,4] was driven to devise the Mandibular Protraction Appliance 1(MPA 1) as an alternative to the Herbst appliance.[18,19] In his articles on this subject,[3,4] the author mentions as advantages of the MPA over the Herbst appliance its easy confection and installation, as well as its low cost and less bulky design, ensuring greater patient comfort.

MPA 1 was made with 0.032-in (0.9 mm) wire, which received two small loops between the headgear tube and the distal bend of the mandibular canine.

Although effective, it did not allow brackets to be bonded to premolars, mouth opening was limited and it broke frequently, leading the author to develop a second version.[3,4,9] This new version consisted of two 0.032-in archwire segments with loops in the ends and an open coil intending to maintain a proper relationship between the archwire segments, allowing greater mouth opening range and the bonding of brackets to premolars.

Coelho Filho[3] described 4 clinical cases of Class II patients with mandibular retrognathism treated during the growth period with fixed appliance and MPA. Noteworthy among the changes were those of a dentoalveolar nature, such as lingual inclination of maxillary incisors. However, some skeletal changes were also observed such as increases in the length of the mandible and its ascending ramus, resulting in reduced facial convexity, improved soft tissue profile and decreased overjet.

The author went on to develop the MPA 3,[5,6] with quite different characteristics, with the purpose of overcoming some limitations of previous versions.

MPA 3 used 0.9 mm wire rods that ran through telescopic stainless steel tubes. This imparted greater stability to the appliance during mouth opening and closing and was easier to install. However, it required a more careful fabrication procedure and, thereby, more complex.

Between the years 2001 and 2002, Coelho Filho[9,10,11,13] made changes on MPA 3 with a new design for the upper arch intermaxillary telescopic tube fitting, enhancing stability during mouth opening and closing. This new version, named MPA 4,[9,10,11,13] surpassed all previous appliances in terms of breaking strength, ease of installation and fabrication. The author[11,13] pointed out that the current version has shown clinical efficacy and final results similar to those of previous models since the mechanical principles are the same.

Therefore, this study analyzes and determines dentoalveolar and soft tissue changes — using lateral cephalograms of Class II, division 1 patients treated with MPA combined with fixed orthodontic appliance during active growth period — also relating them to the independent variables sex, age, facial pattern, MPA model, archwire, technique and MPA usage time.

METHODS

This is an uncontrolled, non-randomized clinical trial conducted on a sample comprising 56 lateral cephalograms (28 initial and 28 final cephalograms) of 28 Brazilian patients with Angle Class II, Division 1 malocclusion, 12 males and 16 females, mean age of 13.06 years at the beginning of treatment, who were treated for a mean period of 14.43 months with mandibular protraction appliances (MPA) associated with fixed orthodontic appliance. All patients were treated at the private practice of Professor Carlos Martins Coelho Filho in São Luís, Maranhão State, Brazil. The following inclusion criteria were adopted: Angle Class II, Division 1 malocclusion with mandibular retrognathism, as assessed by photographs, study models, in addition to cephalograms that allowed clear visualization of the structures of interest. Sample exclusion criteria were: Patients who had agenesis, extraction or missing permanent teeth, cases of Angle Class II, Division 1 treated only with MPA, patients with pronounced overjet.

A clinical form was used for data collection including seven variables: Patient age, sex, facial pattern (dolichofacial, mesofacial and brachyfacial, although the latter was excluded during sample selection as only one case displayed this facial type, which might lead to statistical results with a higher margin of error), MPA model (types 1, 2, 3 and 4), total time of appliance usage, archwires used during treatment with MPA (0.019 x 0.025-in, 0.021 x 0.025-in and 0.018 x 0.025-in stainless steel wires) as well as the orthodontic technique (standard Edgewise and Straight-Wire).

Research instruments consisted of 56 lateral cephalometric radiographs obtained at two stages: before (T1) and after treatment (T2). All radiographs used in this study were obtained with a Funk Orbital X15 X-ray device, with a magnification factor of 9%, by the same operator.

A sheet of acetate paper was fixed over each radiograph with adhesive tape and the anatomical structures of interest for the construction of the cephalometric analysis were traced. This tracing was performed in a darkened room by two previously calibrated examiners on a viewbox to facilitate the visualization of structures.

Examiners calibration lasted approximately three months, during which 30 randomly selected radiographs were traced and compared until minimum error was attained.

The materials used by examiners to build the cephalometric tracing consisted of a viewbox, sheet of transparent acetate paper (Cephalometric Tracing Paper® - GAC), 0.07 mm thick, size 17.5 x 17.5 cm, Pentel mechanical pencil with 0.3 mm fine point, template (Tracing Template®, Unitek Corp.), millimeter ruler, adhesive tape, soft eraser and black cardboard mask. When double images of the anatomical bony structures were visualized both images were traced and a mean position between them was found for determining the cephalometric points.

In a following stage, 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, Brazil), which was used to obtain the values for T1 and T2 as well as their respective repetitions. The results were stored and subsequently subjected to statistical analysis.

Changes in the dental and soft tissue structures were measured by means of the following angular and linear cephalometric measures. Angular: 1.NA (1), 1.NB (2), IMPA (3), ANL (4); Linear: 1-NB (5), 1-FHp (6), 1a-FHp (7), 1-MP (8), 6-MP (9), 6-FHp (10), 6a-FHp (11), LL-Pog'Sn (12), LL-FHp (13), 1-NA (14), 1-FHp (15), 1a-FHp (16), 1-PP (17), 6-PP (18), 6-FHp (19), 6a-FHp (20), UL-Pog'Sn (21), UL-FHp (22).

The measures used to evaluate the dentoalveolar component were: 1.NA (1), 1-NA (14), 1-PP (17), 1-FHp (15), 1a-FHp (16), 6-PP (18), 6-FHp (19), 6a-FHp (20), IMPA (3), 1.NB (2), 1-NB (5), 1-PM (8), 1-FHp (6), 1a-FHp (7),

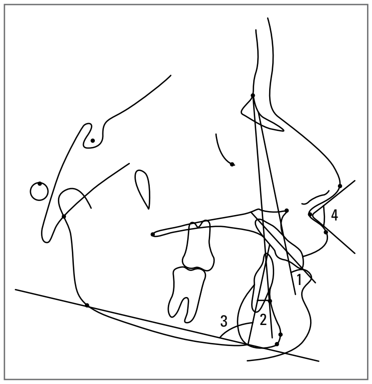

FIGURE 1 - Angular cephalometric measurements.

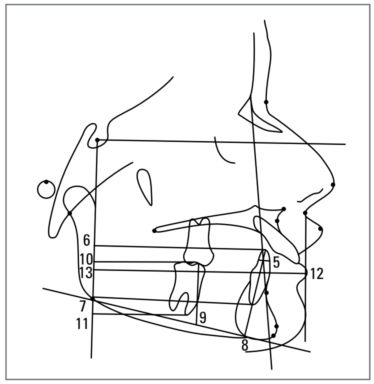

FIGURE 2 - Linear cephalometric measurements. Lower dentoalveolar and soft tissue components.

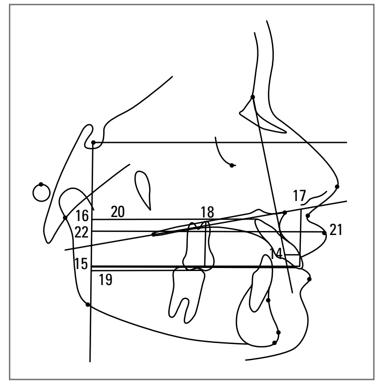

FIGURE 3 - Linear cephalometric measurements. Upper dentoalveolar and soft tissue components.

6-PM (9), 6-FHp (10) and 6a-FHp (11). For the soft tissue profile: ANL (4), UL-Pog'Sn (21), LL-Pog'Sn (12), UL-FHp (22) and LL-FHp (13).

RESULTS

The dentoalveolar and soft tissue changes induced by the combined use of MPA and a fixed orthodontic appliance were evaluated in 28 patients with Class II, Division 1 malocclusion with mean age of 13.06 years, treated for a mean period of 14.43 months (53.6%). These changes were measured in 56 lateral radiographs in two stages: Before (T1) and after treatment (T2).

Regarding the MPA model, the sample initially consisted of four groups of patients that corresponded to the four types of MPA. However, the frequency of the group that used MPA models 1 and 3 was low and statistically discrepant in relation to models 2 and 4. Therefore, the four were gathered into two groups — labeled 0 and 1 respectively — the first resulting from the sum of the number of patients with MPA 1 and 2 (46.4%) and the second, the sum of those using MPA models 3 and 4 (53.6%).

For the variable archwire, the following types were noted: 0.019 x 0.025-in stainless steel (57.1% or 16 patients), 0.021 x 0.025-in stainless steel (10.7% or 3 patients) and 0.018 x 0.025-in stainless steel (32.1% or 9 patients). The two latter were also grouped into a total of 12 cases.

The sample consisted of 57.1% (16 patients) of female subjects and 42.9% (12 patients) male. Only two of the three facial patterns (mesofacial and dolichofacial) were analyzed. The first type accounted for 64.3% (18 patients) of patients and the second, 35.7% (10 patients).

The Straight-Wire technique was used in 42.9% (12 patients) of individuals and standard Edgewise in 57.1% (16 patients). Measures 1-NB, ILi-FHp and 6-PP showed statistically significant differences compared to the group using the Edgewise technique.

Tables 1 and 2 show the initial (T1) and final (T2) dentoalveolar and soft tissue cephalometric measurements of patients of both sexes, their medians, 1st and 3rd quartiles, and statistical significance (p-value), obtained with the Wilcoxon Signed Ranks Test. Results were con-

TABLE 1 - Median, 1st and 3rd quartiles for differences between initial and final dentoalveolar cephalometric measurements and significance value.

Dentoalveolar cephalometric measurements	Median	1st quart.	3rd quart.	p
1.NA initial	29.785	24.615	35.455	0.001*
1.NA final	23.160	12.575	27.275	
1.NB initial	26.895	20.557	31.768	0.024*
1.NB final	29.515	25.102	32.865	
IMPA initial	97.420	91.420	104.312	0.179
IMPA final	99.620	95.095	103.182	
1-NA initial	4.395	3.180	7.695	0.002*
1-NA final	2.880	1.752	5.570	
1-NB initial	3.970	2.685	6.867	0.011*
1-NB final	4.855	3.235	7.545	
1-PP initial	24.290	13.977	30.535	0.007*
1-PP final	26.685	15.052	29.610	
1-PM initial	38.455	22.147	44.777	0.891
1-PM final	36.465	21.502	44.788	
6-PP initial	19.485	11.190	23.192	0.000*
6-PP final	21.065	11.940	24.258	
6-PM initial	26.075	15.780	33.470	0.000*
6-PM final	29.620	17.533	35.330	
IUi-FHp initial	77.060	43.365	86.707	0.151
IUi-FHp final	74.945	41.405	83.895	
ILi-FHp initial	69.510	39.750	78.497	0.017*
ILi-FHp final	72.475	39.877	79.782	
AUi-FHp initial	64.295	37.120	74.945	0.349
AUi-FHp final	65.750	38.297	75.852	
ALi-FHp initial	56.295	32.205	64.512	0.032*
ALi-FHp final	57.925	33.135	66.145	
CMS-FHp initial	39.560	23.907	49.892	0.092
CMS-FHp final	40.520	24.452	48.807	
CMI-FHp initial	38.745	24.167	49.672	0.001*
CMI-FHp final	43.155	26.035	51.212	
AMS-FHp initial	41.190	25.377	52.690	0.509
AMS-FHp final	41.920	26.372	50.265	
AMI-FHp initial	31.560	21.602	41.027	0.000*
AMI-FHp final	37.985	22.485	46.590	

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

TABLE 2 - Median, 1st and 3rd quartiles for differences between initial and final soft tissue cephalometric measurements and significance value.

Soft tissue cephalometric measurements	Median	1st quart.	3rd quart.	p
ANL initial	111.170	103.657	116.367	0.145
ANL final	112.790	106.480	118.387	
UL-Pog'Sn initial	5.030	2.815	7.295	0.001*
UL-Pog'Sn final	3.195	1.945	6.265	
LL-Pog'Sn initial	2.155	1.037	3.445	0.838
LL-Pog'Sn final	1.795	1.032	3.435	
Pog'-FHp initial	76.170	44.387	87.030	0.010*
Pog'-FHp final	79.970	45.685	89.912	
UL-FHp initial	88.905	50.940	101.325	0.48
UL-FHp final	91.690	50.435	101.605	
LL-FHp initial	69.510	39.750	78.490	0.016*
LL-FHp final	87.190	48.200	95.390	

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

sidered significant at 5% significance ($p<0.05$), indicating at least 95% confidence in the conclusions. In Tables 1 and 2 are shown the following statistically significant dentoalveolar and soft tissue cephalometric measures: 1.NA, 1.NB, 1-NA, 1-NB, 1-PP, 6-PP, 6-PM, ILi-FHp, ALi-FHp, CMI-FHp, AMI-FHp (Table 1), UL-Pog´Sn, Pog´-FHp and LL-FHp (Table 2).

Table 3 shows that sex was the only variable with a statistically significant influence on cephalometric measures 6-PM and AMI-FHp before treatment.

Tables 4 and 5 depict the values of significant difference between the cephalometric measurements at T1 and T2. These results show statistically significant labial inclination of lower incisors related to the independent variable age. The independent variable MPA model showed a statistically significant relationship with a

TABLE 3 - Median, 1st and 3rd quartiles and p-value for cephalometric measurements related to the independent variable sex at T1.

Independent variable		Initial 6-PM				Initial AMI-FHp			
Sex	n	median	1st quart.	3rd quart.	p	median	1st quart.	3rd quart.	p
Female	16	16.325	11.252	30.937	0.016*	22.295	12.995	38.367	0.014*
Male	12	29.760	26.590	34.347		38.230	32.315	44.500	

*Significant difference (p<0.05) based on the Mann-Whitney test.

TABLE 4 - Median, 1st and 3rd quartiles and p-value for cephalometric measurements related to the independent variables.

Difference between the cephalometric measurements (T1 - T2)		1-NB dif.				1.NB dif.				1-PP dif.				6-PP dif.			
		M	1st q.	3rd q.	p	M	1st q.	3rd q.	p	M	1st q.	3rd q.	p	M	1st q.	3rd q.	p
Sex	**n**																
Female	16	-4.355	-7.910	2.722	0.227	-0.365	-0.710	0.202	0.889	-0.910	-1.507	-0.295	0.676	-1.025	-1.680	-0.327	0.164
Male	12	-3.265	-8.837	1.442		-1.065	-1.812	0.272		-0.740	-2.290	1.045		-2.240	-3.882	-0.490	
Age	**n**																
≤13.06 years	13	-6.310	-11.03	-1.515	0.205	-0.620	-1.340	-0105	0.032*	-1.010	-2.895	-0.250	0.300	-1.010	-2.895	-0.250	0.205
>13.06 years	15	-1.360	-5.110	3.200		-0.350	-1.030	0.360		-0.650	-1.530	-0.100		-0.650	-1.530	-0.100	
Facial pattern	**n**																
Dolichofacial	10	-2.915	-8.412	-0.982	0.270	-0.810	-1.742	0.020	1.000	-1.080	-3.057	-0.292	0.195	-1.530	-3.992	-0.722	0.375
Mesofacial	18	-4.470	-8.095	2.360		-0.435	-1.137	0.372		-0.665	-1.542	0.195		-1.140	-2.420	-0.125	
MPA model	**n**																
1+2	13	-4.450	-8.755	1.260	0.147	-0.740	-1.305	0.125	0.596	-1.290	-3.330	-0.510	0.025*	-1.880	-4.100	-1.105	0.020*
3+4	15	-3.210	-7.670	3.200		-0.350	-1.250	0.360		-0.610	-0.970	0.940		-0.860	-2.600	-0.200	
Archwire	**n**																
0.019 x 0.025-in	16	-4.780	-7.910	1.442	0.642	-0.540	-1.232	-0.027	0.516	-0.630	-3.277	-0.680	0.353	-0.945	-4.040	-0.055	0.577
0.018 x 0.025-in + 0.021 x 0.025-in	12	-2.340	-8.310	2.722		-0.305	-1.330	0.387		-1.090	-1.587	-0.380		-1.090	-1.587	-0.380	
Technique	**n**																
Straight-Wire	12	-1.490	-6.320	6.075	0.013*	0.300	-0.680	0.730	0.137	-0.465	-1.020	0.160	0.137	-0.860	-1.782	0.027	0.047*
Edgewise	16	-4.565	-9.560	1.487		-0.830	-1557	-0.192		-1.090	-1.950	-0.292		-1.765	-4.075	-0.860	
Usage time	**n**																
≤ mean 14.43 (months)	13	-2.510	-6.990	5.495	0.222	-0.380	-1.065	0.300	0.222	-0.850	-4.070	0.420	0.872	-1.180	-3.285	-0.045	0.908
> mean 14.43 (months)	15	-4.680	-9.520	1.290		-4.680	-9.520	1.290		-0.870	-1.290	-0.340		-1.190	-3.710	-0.380	

*Significant difference (p<0.05).

TABLE 5 - Median, 1st and 3rd quartiles and p-value for cephalometric measurements related to the independent variables.

Difference between the cephalometric measurements (T1 - T2)		6-PM dif.				AMI-FHp dif.				ILi-FHp dif.			
		M	1st q.	3rd q.	p	M	1st q.	3rd q.	p	M	1st q.	3rd q.	p
Sex	**n**												
Female	16	-1.320	-2.307	-0.465	0.016*	-2.345	-4.067	0.737	0.009*	-0.785	-3.475	1.067	0.095
Male	12	-2.895	-3.640	-1.672		-8.080	-11.150	-4.467		-6.970	-8.237	0.792	
Age	**n**												
≤13.06 years	13	-1.430	-2.450	-0.685	0.222	-3.490	-8.080	-1.180	0.836	-3.220	-8.125	-0.235	0.322
>13.06 years	15	-2.590	-3.490	-1.050		-4.420	-9.660	0.400		-0.880	-6.530	1.350	
Facial pattern	**n**												
Dolichofacial	10	-2.710	-3.540	-1.410	0.080	-4.640	-10.075	-1.902	0.231	-4.730	-7.697	-0.797	0.150
Mesofacial	18	-1.515	-2.537	-0.515		-3.110	-7.357	1.117		-0.570	-6.750	1.390	
MPA model	**n**												
1+2	13	-1.440	-2.880	-0.685	0.645	-4.260	-10.490	-1.515	0.322	-3.560	-7.690	-0.715	0.093
3+4	15	-2.430	-3.230	-1.050		-2.730	-6.890	0.400		0.170	-6.530	1.450	
Archwire	**n**												
0.019 x 0.025-in	16	-2.450	-3.137	-0.457	0.501	-3.935	-8.420	0.087	0.853	-2.820	-7.777	1.142	0.577
0.018 x 0.025-in + 0.021 x 0.025-in	12	-1.435	-2.682	-0.885		-3.875	-8.397	-1.760		-1.090	-1.587	-0.380	
Technique	**n**												
Straight-Wire	12	-2.185	-3.345	-0.625	0.848	-3.000	-4.890	1.152	0.213	0.345	-2.190	1.750	0.013*
Edgewise	16	-1.610	-2.877	-0.922		-4.435	-10.075	-1.345		-4.470	-8.012	-0.797	
Usage time	**n**												
≤ mean 14.43 (months)	13	-2.590	-3.460	-0.725	0.240	-4.610	-9.700	-0.335	0.596	-1.560	-6.705	2.050	0.504
> mean 14.43 (months)	15	-1.430	-2.470	-0.830		-2.730	-7.400	-0.850		-1.220	-7.480	0.170	

*Significant difference (p<0.05).

greater extrusion of incisors and molars found in the group using the MPA 1+2. The group using the Edgewise technique showed statistically significant measurements in relation to the labial inclination of lower incisors and increased extrusion of maxillary molars.

DISCUSSION

The use of MPA in Angle Class II treatment is aimed at correcting the sagittal relationship between the maxilla and the mandible, mainly through dentoalveolar changes.[3-13] In order to evaluate the influence of the independent variables sex, age, facial pattern, MPA model, archwire, technique and MPA treatment time in the sample described before, the means of cephalometric differences between T1 and T2 were compared and yielded statistically significant results.

The results displayed in these tables show that, for the variable sex, measures 6-PM and AMI-FHp were significant, and higher for females than males. Based on the results of the significance test (p-value), that show which independent variables affected treatment (Table 5), cephalometric measures 6-PM and AMI-FHp were statistically significant at the beginning of treatment, with measurements equal to the medians, which shows that the variable sex did not influence treatment outcome, since measurements were already significant prior to treatment.

The only measure that showed a statistically significant median value with respect to the variable age was 1.NB. The mean found for patients aged below 13.06 years was associated with greater mandibular incisor inclination. This result is probably related to a failure in banding the lower second molars, which reduced anchorage. Moreover, another factor that probably contributed to a smaller inclination of the lower incisors in the group older than 13.06 years was that in this group there was a more pronounced mandibular growth component, thereby moving point B to a more anterior position by correcting the skeletal discrepancy and consequently causing less dental compensation (mandibular incisor inclination).

Regarding variable MPA model, Group 1 (MPA 3+4) showed statistically significant means between T1 and T2 for measures 1-PP and 6-PP. These results were probably due to the aligning and leveling extrusive mechanics applied prior to MPA use and growth. Group 1 (MPA 3+4) showed lower extrusion of incisors and molars relative to the palatal plane, probably due to increased uprighting of the incisors and limited extrusion of upper molars related to a lower breakage rate in this group.

Measures 1-NB, ILi-FHp and 6-PP showed statistically significant differences in relation to Group 1 (Edgewise technique) for the independent variable technique. This result probably occurred because the group did not use pre-adjusted brackets, resulting in greater inclination of mandibular incisors and consequent lower lip protrusion. In Group 2 (Straight-Wire technique), there was significantly less extrusion of upper molars, probably due to palatal torque of molar crowns, which positioned the roots of these teeth on the buccal cortex, thereby strengthening anchorage.[22,25] The other independent variables (facial pattern, archwire and MPA use time) showed no statistically significant differences.

In order to facilitate the interpretation of results a separate discussion was conducted on the changes that took place in the maxillary dentoalveolar component, mandibular dentoalveolar component and soft tissue component.

Maxillary dentoalveolar component

The MPA forces used in this investigation were delivered by means of dental structures and, thus, significant dentoalveolar effects were expected. The maxillary alveolar component (Table 1) was assessed by means of measures 1.NA, 1-NA, IUi-FHp, AUi-FHp, 6-PP, CMS-FHp, 1-PP, AMS-FHp. Assessment of the position and inclination of upper incisors (1.NA, 1-NA, IUi-FHp) showed a marked lingual inclination that was statistically significant for measures 1.NA and 1-NA, and with no statistical significance for measures IUi-FHp and AUi-FHp, corroborating Coelho Filho,[3-13] Siqueira[24] and White.[27] The results showed a slight distal movement of upper molars, demonstrated by measures CMS-FHp and AMS-FHp, although not statistically significant. Assessment of measures 6-PP and 1-PP denoted statistically significant extrusion of the upper molars and incisors.

These results were probably due to alveolar bone growth[2,14] and the extrusive aligning and leveling mechanics utilized prior to MPA use. MPA use is probably not related to the extrusion of molars and incisors, since according to Coelho Filho,[13] MPA generates intrusive and distal forces and is therefore indicated for use in Class II patients with a high mandibular plane angle.

Mandibular dentoalveolar component

It was assessed trough measures 1.NB, 1-NB, IMPA, ILi-FHp, 1-PM, ALi-FHp, 6-PM, CMI-FHp and AMI-FHp (Table 1). However, most measures that evaluated lower incisor position (1.NB, 1-NB, ILi-FHp, ALi-FHp) demonstrated significant proclination and protrusion of these teeth, with the exception of IMPA which, although increased, was not statistically significant. This result was probably due to the occurrence of bone apposition in the mandibular plane during treatment.[2,14] The measures related to the assessment of lower molar positioning (CMI-FHp, AMI-FHp, 6-PM) exhibited significant mesial movement and extrusion of these teeth. In agreement with these results, Siqueira[24] hinted that these effects probably occur due to the direction of forces delivered by the device owing to a limited vertical development of upper molars. It is also believed that the mechanical alignment and leveling occurring prior to MPA use contributes to the extrusion of lower molars. Assessment of the degree of lower incisor intrusion, as revealed by measure 1-PM, showed little intrusion of these teeth, although not statistically significant. This decreased value may be due to lower incisor protrusion, which reduces the distance from their incisal edge to the mandibular plane.

Soft tissue component

This component was analyzed by means of cephalometric measures ANL, UL-Pog´Sn, LL-Pog´Sn, Pog´-FHp, UL-FHp, LL-FHp (Table 2). In assessing the upper lip, however, two measures (UL-Pog´Sn and UL-FHp) disclosed that the upper lip was retracted, following the retrusion and lingual inclination of the upper incisors, while only UL-Pog'Sn exhibited a statistically significant difference. This fact is probably related to bone apposition in the pogonion[2,14] and the more anterior position of the mandible at the end of treatment. According to Coelho Filho[3-13] and White[27], the dentoskeletal changes induced by MPA use caused favorable changes in soft tissue, such as upper lip retraction, which improves the soft tissue profile. The lower lip was examined by cephalometric measures LL-Pog´Sn, LL-FHp and Pog´-FHp by comparing T1 with T2. Measures LL-Pog´Sn and LL-FHp showed protrusion of the lower lip due to a marked proclination and protrusion of the mandibular incisors at the end of orthodontic treatment, although only measures LL-FHp and Pog'-FHp were statistically significant. It is worth noting that measure Pog'-FHP is related to bone apposition of the pogonion[2,14] and a more anterior position of the mandible at the end of treatment.

These findings, however, 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 with larger samples are warranted in order to assess the influence of independent variables and compare results with the control group.

CONCLUSIONS

Based on the methods employed and results achieved in this study, the authors concluded that treatment with MPA combined with a fixed orthodontic appliance for correction of Class II, Division 1 malocclusion produces considerable dentoalveolar changes, which can be summarized as follows:

1. Maxillary dentoalveolar component: There was retrusion and substantial lingual inclination of the upper incisors.

2. Mandibular dentoalveolar component: There was protrusion and proclination of the lower incisors, in addition to mesial drift and extrusion of the lower molars.
3. Soft tissue component: The dentoalveolar changes exerted a positive, significant influence on the soft tissue profile of the patients.
4. Age: A greater lower incisor inclination was noted in the group of patients younger than 13.06 years.
5. MPA model: Less extrusion was observed in the upper incisors and molars in the group that used MPA 3 and 4 due to the greater effectiveness of these appliances.
6. Technique: A higher labial inclination of lower incisors and greater extrusion of upper molars were noted in the group using standard Edgewise brackets.

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