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EFFICACY OF MANDIBULAR PROTRACTION APPLIANCE IV VERSUS POWERSCOPE IN TREATMENT OF CLASS II MALOCCLUSION; A COMPARATIVE, RANDOMIZED CLINICAL TRIAL

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ABSTRACT

Objective: To evaluate and compare the efficacy of Mandibular protraction appliance IV (MPA-IV) and PowerScope (PS) in the treatment of skeletal Class II malocclusion patients. **Subjects and methods**: A total of 16 circumpubertal class II patients (ANB°>4°) with mandibular deficiency were randomly divided equally into two groups; group 1: treated by MPA-IV, their mean age was 14.98 ± 1.33 years, group 2: treated by PS appliance (American Orthodontics, Sheboygan, Wis), their mean age was 14.67 ± 1.37 years. In both groups, fixed functional appliances were installed for six months. Treatment outcomes were assessed by cephalograms taken immediately pre- and post-functional appliances therapy. **Results**: Intergroup comparisons of the mean treatment changes revealed significant improvements (P ≤ .05) in SNB°, SN-Pog°, Ar-Go-Me°, Co-Gn mm, B-Sv mm, Pog-Sv mm, S-Go mm, and lower lip advancement (Li-Sv mm and Pog'-Sv mm) in MPA-IV group. While in the PS group, there were significant greater decrease of SNA° and upper incisors retraction (P ≤ .05). **Conclusion:** Both appliances could be used efficiently in the treatment of class II malocclusion. MPA-IV produces superior mandibular advancement and lower lip projection, while the effects of PS are mainly dentoalveolar changes.

KEYWORDS: Mandibular protraction appliance, PowerScope, fixed functional appliance, class II malocclusion, growth modification.

INTRODUCTION

Class II malocclusion is among the most prevalent forms in orthodontics. It may have skeletal or dental backgrounds, or a combination of both, with a higher prevalence of mandibular retrusion[1–5].

Growing individuals with skeletal class II malocclusion due to mandibular retrognathism are best treated with functional appliances for growth modification. The treatment should be started during the active growth stage to produce more significant skeletal effects [6,7].

Functional appliances are accompanied by various dentoalveolar changes due to many factors, including the patient's age, skeletal pattern, and the type of appliance used [2,3,8,9].

Fixed functional appliances (FFAs) were designed to exclude patients' compliance and to be worn 24 hours/day to maximize the remaining growth capacity of the patients in a favorable direction. Different fixed functional appliances were introduced; they may be rigid, hybrid, or flexible. The skeletal, dental, and soft tissue treatment outcomes of each type varied in the literature [10–12].

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Rigid FFAs permanently protrude the condyles away from the glenoid fossa, producing a maintained tissue strain. In contrast, the hybrid FFAs make intermittent condylar jumping because the patient can retrude the condyles back by the action of masticatory muscles [12].

The Mandibular Protraction Appliance (MPA-I) is a rigid FFAs, developed by Coelho Filho in 1995[13,14]. It's an in-office made, low-cost, and efficient in class II malocclusion treatment. MPA-IV was developed in 2001[15] to be easier in construction and installation, to provide greater stability and jaw movements, and to be more comfortable for the patient. It is composed of a telescopic mechanism in which a 0.9 mm St.St. wire acts as a mandibular piston rod that slides inside a telescopic St.St. maxillary tube of approximately 1 mm in diameter. It is fitted between the headgear tube of the maxillary first molars and a coil bent in the mandibular arch wire distal to the canines. MPA-V was the last version that was developed in 2015 [16]. It was simpler in placement and adjustment.

The PowerScope was among the latest versions of hybrid FFAs. It was developed by Andrew Hayes in 2014 [17]. It's composed of a single unit telescopic mechanism, incorporating an internal nickel titanium spring giving 260 gm when activated. It's a single size appliance fits all patient's mouths, since shims of different sizes are supplied for quick adjustment [18,19].

This study aimed to compare two different forms of FFAs; the first one was the Mandibular protraction appliance–IV (MPA-IV), a rigid FFA. The second appliance was the PowerScope (PS), a hybrid FFA.

SUBJECTS AND METHODS

The present study was approved by the ethical committee of the Faculty of Dental Medicine, Al-Azhar University (Cairo, Boys), with a reference number (346/1137/16/10/19).

The inclusion criteria were skeletal (ANB° > 4°) and dental class II malocclusion with mandibular retrognathia, overjet ≥ 5 mm, patients in Cervical Vertebral Maturation Index (CVMI) 3-4 according to Baccetti et al[20], positive pretreatment visual treatment objective (VTO), no or minimum crowding in dental arches requiring no extraction of any permanent teeth (excluding third molars), good oral hygiene and general health, and no previous orthodontic treatment or jaw's surgery.

Calculation of sample size was based on the mean difference derived from a study of Arora et al[6] Using G power statistical power analysis program (version 3.1.9.4) for sample size determination[21]. A total of twenty patients (10 in each group) were found to be sufficient to detect a large effect size (d)= 1.56, with an actual power (1-β error) of 0.9 (90%) and a significance level (α error) 0.05 (5%) for two-sided hypothesis test.

The patients were collected from the outpatient clinic at the Orthodontic Department, Faculty of Dental Medicine, Al-Azhar University (Cairo, Boys). Four patients dropped out of the study for different reasons; therefore, the statistical analyses were performed on only 16 patients. They were randomly divided into two groups; group 1: comprised 8 patients (5 males, 3 females) with a mean age of 14.98±1.33 years treated by MPA-IV. Group 2: comprised 8 patients (5 males, 3 females) with a mean age of 14.67±1.37 years, treated by PowerScope appliance (American Orthodontics, Sheboygan, Wis).

Intervention

All patients in both groups were treated by a single investigator. Roth's prescription preadjusted edgewise 0.022" x 0.028" slot-sized brackets (Ormco, Glendora, CA, USA) were bonded to all teeth anterior to the first molars in both arches. In addition, maxillary first molars were banded with bands having an auxiliary headgear tube (Ormco, Glendora, CA, USA), while mandibular first molars were either banded or bonded.

In both groups, levelling and alignment were done sequentially until reaching 0.019 x 0.025" stainless steel archwire, upon which both appliances were installed. A transpalatal arch of 0.1mm St.St. wire was used in the upper arch to prevent buccal flaring of posterior maxillary teeth during fixed functional appliance therapy. It was made after completion of the levelling and alignment phase to allow archwire expansion.

Both mandibular and maxillary archwires were cinched back distally. A continuous elastic power chain was stretched between all incorporated mandibular and maxillary teeth. Ten degrees of labial root torque were bent on the mandibular 0.019 x 0.025" stainless steel mandibular archwire to minimize lower anterior flaring [6,22–24].

In group 1, MPA-IV was used. It was a laboratory-made appliance constructed according to Coelho [15]. The mandible was jumped into edge-to-edge incisal bite during the installation visit and maintained during the functional appliance treatment duration. (Figure 1).

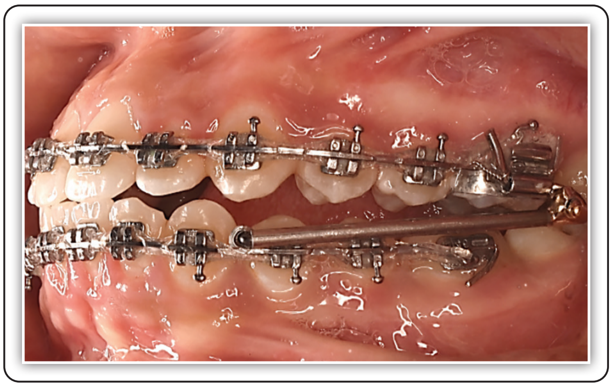

FIG (1) Intraoral photograph showing MPA-IV installed in edge-to-edge bite.

In group 2, the PowerScope appliance (American Orthodontics, Sheboygan, WI, USA) was installed. (Figure 2). During the installation visit, full activation of the internal spring of the appliance was done, which was evident by hiding the three activation marks of the appliance. Additional three millimeters activation shim was crimped to the appliance for further initial mandibular advancement. After one month, 2mm activation shim were added to maintain the internal spring compressed and also to increase the bite jumping. Then the internal spring was maintained fully compressed during the follow-up visits.

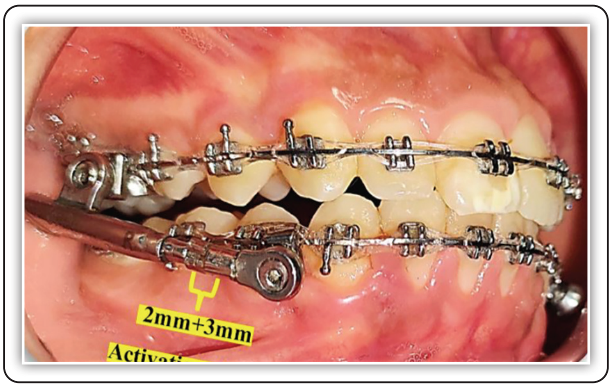

FIG (2) Intraoral photograph showing PowerScope appliance with 3mm activation shim beyond the regular activation which achieved in this case by 2mm activation shim.

The patients were evaluated regularly every four weeks. During each follow-up visit, the continuous elastic power chains in both arches were changed, and any adjustment to the appliance was made.

The FFA therapy in both groups was discontinued in both groups after a fixed duration of six months, since the average mandibular advancement duration was 5-7 months[8,25] and also to decrease the confounding factors in the outcomes.

Cephalometric analysis.

Tracing and measurements of the immediately pre- and post-fixed functional appliance (T1 and T2) cephalometric radiographs were done at the same time to decrease the frame of errors in determining the anatomical structures.[26] When double images of the anatomical bony structures were visualized, both structures were traced, and a mean position between them was determined [22].

Reliability check

It was done by retracing the T1, and T2 cephalograms of five randomly selected cases (about 30% of the total sample) at 4-week intervals by the same investigator. The mean differences between the first and second measurements were tested using paired t-test to determine the intra-examiner error.

Statistical Analysis

All statistical analyses were performed using IBM SPSS (SPSS Inc, Chicago, Ill) Version 25 for Windows. The Shapiro-Wilk test showed that the data were normally distributed (P > .05). Thus, parametric tests were used. Independent sample t-tests were performed to detect changes among the two investigated groups.

RESULTS

The reliability check revealed non-statistically significant differences (p>.05) between all measurements in both groups. Intergroup comparisons of pretreatment age and gender distribution (Table 1) showed nonsignificant differences (p > .05) that ensure the homogeneity of the two groups. Baseline cephalometric parameters of the two groups (Table 2) also revealed no significant differences between all variables (p>.05).

Intergroup comparisons of the mean treatment changes (Table 3) were as follows:

The MPA-IV group showed significant improvements (P≤0.05) in SNB°, SN-Pog°, Gonial angle, Co-Gn mm, B-Sv mm, Pog-Sv mm, and S-Go mm. On the contrary, there was a significant decrease in SNA° (P≤0.05) in favor of the PS group. No statistically significant differences (P≤0.05) between the two groups for all other skeletal measurements.

A significantly more (P≤0.05) lower incisors protrusion (LI-Sv mm) was found in the MPA-IV group, while the PS group showed a significantly more (P≤0.05) upper incisors retraction (UI-Sv mm). No statistically significant differences (P≤0.05) between the two groups for all other dental measurements.

TABLE (1) Descriptive statistics of patients' genders and ages (chronological and skeletal) in the two investigated groups using the Chi-square test and independent t-test.

Variables	MPA (n = 8)	PS (n = 8)	Test of Sig.	p	Sig
Gender					
Male	5	5	χ^2= 0.0	^{FE}p=1.000	NS
Female	3	3			
Chronological age	14.98 ± 1.33 years	14.67 ± 1.37 years	t= 0.476	.805	NS
Skeletal age					
CVMI 3	2	3	t= 0.509	.334	NS
CVMI4	6	5			

χ2: Chi-square test, FE: Fisher Exact, t: Student t-test, p: p-value, NS: Nonsignificant, CVMI: cervical vertebral maturation index, MPA: Mandibular protraction appliance, PS: PowerScope.

TABLE (2) Comparison of before appliance/baseline (T1) cephalometric parameters among the two investigated groups using independent t-test.

	Variables	MPA (n = 8)		PS (n = 8)		Mean difference	SE	95% Confidence Interval		t-value	p	Sig
		Mean	SD.	Mean	SD.			Lower	Upper			
Skeletal	SNA°	78.88	2.70	78.36	3.67	0.51	1.61	-2.94	3.97	.318	.755	NS
	SNB°	73.03	3.39	71.49	3.44	1.54	1.71	-2.12	5.20	.901	.383	NS
	ANB°	5.78	1.39	6.88	1.21	-1.10	0.65	-2.50	0.30	-1.688	.114	NS
	SN-Pog°	74.01	3.95	71.66	3.75	2.35	1.92	-1.78	6.48	1.221	.242	NS
	Angle of conv.	9.78	4.34	13.05	3.53	-3.28	1.98	-7.52	0.97	-1.655	.120	NS
	Sn-Mp°	39.85	7.17	44.51	7.78	-4.66	3.74	-12.68	3.36	-1.247	.233	NS
	Gonial angle	126.41	5.73	128.21	5.05	-1.80	2.70	-7.59	3.99	-.666	.516	NS
	Co-Sv mm	16.30	2.84	16.60	3.12	-0.30	1.49	-3.50	2.90	-.201	.844	NS
	Co-Gn mm	104.10	8.88	105.71	6.63	-1.61	3.92	-10.01	6.80	-.410	.688	NS
	Co-A mm	82.89	3.97	83.62	3.66	-0.73	1.91	-4.82	3.37	-.380	.710	NS
	ANS-Sv mm	70.08	5.34	67.31	4.52	2.76	2.47	-2.54	8.07	1.117	.283	NS
	A-Sv mm	63.98	5.67	61.43	4.21	2.56	2.50	-2.80	7.91	1.024	.323	NS
	B-Sv mm	50.92	5.35	46.32	7.52	4.60	3.26	-2.40	11.60	1.409	.181	NS
	Pog-Sv mm	50.34	7.80	43.92	9.36	6.42	4.31	-2.82	15.66	1.490	.158	NS
	N-Me mm	109.38	8.71	115.06	5.65	-5.68	3.67	-13.55	2.19	-1.548	.144	NS
	N-ANS mm	48.50	3.97	51.48	2.45	-2.98	1.65	-6.52	0.55	-1.811	.092	NS
	ANS-Me mm	60.88	6.62	63.57	3.63	-2.70	2.67	-8.42	3.03	-1.010	.329	NS
	S-Go mm	66.11	7.23	67.23	5.64	-1.12	3.24	-8.08	5.84	-.345	.735	NS
Dental	UI-SN°	105.55	8.22	102.03	8.17	3.52	4.10	-5.27	12.32	.860	.404	NS
	LI-Mp°	99.73	5.39	96.44	5.79	3.29	2.80	-2.71	9.29	1.176	.259	NS
	MxOP°	18.81	5.10	23.01	2.86	-4.20	2.07	-8.63	0.23	-2.031	.062	NS
	UI-Sv mm	68.59	3.41	66.42	6.37	2.17	2.55	-3.31	7.65	.850	.410	NS
	LI-Sv mm	61.13	3.06	58.76	5.55	2.37	2.24	-2.43	7.18	1.059	.308	NS
	U6-Sv mm	37.51	3.65	35.01	5.55	2.50	2.35	-2.53	7.54	1.066	.304	NS
	U6-cFH mm	61.42	5.06	65.73	3.73	-4.31	2.22	-9.08	0.45	-1.940	.073	NS
	L6-Sv mm	35.01	4.64	32.13	5.18	2.88	2.46	-2.39	8.15	1.171	.261	NS
	L6-cFH mm	61.64	4.64	65.84	3.66	-4.20	2.09	-8.68	0.28	-2.012	.064	NS
Soft tissue	NLA°	97.19	11.05	98.89	16.47	-1.70	7.01	-16.74	13.34	-.242	.812	NS
	Ls-Sv mm	81.30	4.05	79.90	3.98	1.41	2.01	-2.90	5.71	.701	.495	NS
	Li-Sv mm	73.33	4.56	72.30	6.65	1.03	2.85	-5.09	7.14	.361	.723	NS
	Pog'-Sv mm	61.37	6.91	57.21	7.63	4.16	3.64	-3.64	11.97	1.144	.272	NS

SD: Standard deviation, SE: Slandered error, t: independent t-test, p: p-value for comparing the two studied groups, Sig: Statistically significant at p ≤ 0.05, NS: Statistically nonsignificant, MPA: Mandibular protraction appliance, PS: Power Scope.

A Significantly greater ($P \leq 0.05$) lower lip advancement (Li-Sv mm and Pog'-Sv mm) was achieved in the MPA-IV group. No statistically significant differences ($P \leq 0.05$) were found between the two groups for other soft tissue measurements.

TABLE (3) Descriptive statistics and test of significance (independent sample t-test) for the mean differences (T2-T1) of cephalometric variables between the two investigated groups.

	Variables	MPA (n = 8)		PS (n = 8)		Mean difference	SE	95% Confidence Interval		t-value	p	Sig
		Mean	SD.	Mean	SD.			Lower	Upper			
Skeletal	SNA°	0.54	1.10	-0.80	1.14	1.34	0.56	0.14	2.54	2.393	.031	Sig
	SNB°	1.64	0.70	0.05	1.02	1.59	0.44	0.65	2.52	3.642	.003	Sig
	ANB°	-1.03	1.26	-0.85	1.01	-0.18	0.57	-1.40	1.05	-.307	.764	NS
	SN-Pog°	1.71	0.68	0.21	0.98	1.50	0.42	0.59	2.41	3.550	.003	Sig
	Angle of conv.	-2.51	3.07	-0.78	1.49	-1.74	1.20	-4.32	0.85	-1.442	.171	NS
	Sn-Mp°	-0.65	1.10	-0.04	0.70	-0.61	0.46	-1.60	0.38	-1.325	.206	NS
	Gonial angle	1.51	1.47	-0.90	1.61	2.41	0.77	0.76	4.07	3.122	.007	Sig
	Co-Sv mm	-0.52	1.10	0.39	1.06	-0.91	0.54	-2.07	0.25	-1.681	.115	NS
	Co-Gn mm	3.21	1.66	1.14	1.60	2.08	0.82	0.32	3.83	2.543	.023	Sig
	Co-A mm	0.19	2.47	0.05	1.14	0.13	0.96	-1.93	2.19	.139	.892	NS
	ANS-Sv mm	1.05	1.45	0.08	0.59	0.98	0.56	-0.21	2.17	1.765	.099	NS
	A-Sv mm	-0.24	4.34	-0.22	1.01	-0.02	1.58	-3.40	3.36	-.014	.989	NS
	B-Sv mm	2.88	1.40	-0.20	1.87	3.08	0.82	1.31	4.85	3.740	.002	Sig
	Pog-Sv mm	3.57	1.37	0.66	1.56	2.91	0.73	1.34	4.48	3.967	.001	Sig
	N-Me mm	1.59	3.53	2.50	2.62	-0.91	1.56	-4.25	2.43	-.586	.567	NS
	N-ANS mm	0.50	0.77	1.33	1.06	-0.84	0.46	-1.83	0.16	-1.809	.092	NS
	ANS-Me mm	1.09	3.28	1.17	2.38	-0.07	1.43	-3.15	3.00	-.052	.959	NS
	S-Go mm	2.20	1.59	0.62	1.33	1.58	0.73	0.01	3.15	2.158	.049	Sig
Dental	UI-SN°	-8.55	5.55	-9.66	3.67	1.11	2.35	-3.94	6.16	.473	.644	NS
	LI-Mp°	5.18	5.49	4.86	4.60	0.31	2.53	-5.12	5.74	.123	.904	NS
	MxOP°	3.94	2.05	5.76	2.43	-1.83	1.12	-4.24	0.59	-1.623	.127	NS
	UI-Sv mm	-1.56	1.40	-4.26	0.99	2.70	0.61	1.40	4.00	4.451	.001	Sig
	LI-Sv mm	4.24	1.06	1.56	0.90	2.68	0.49	1.62	3.73	5.436	.000	Sig
	U6-Sv mm	-0.63	1.33	-1.39	0.89	0.76	0.56	-0.45	1.97	1.344	.200	NS
	U6-cFH mm	0.03	0.97	-0.11	1.30	0.14	0.57	-1.09	1.37	.246	.809	NS
	L6-Sv mm	4.50	1.48	3.54	1.11	0.96	0.65	-0.45	2.36	1.462	.166	NS
	L6-cFH mm	1.73	0.65	1.90	1.01	-0.17	0.42	-1.08	0.74	-.405	.692	NS
Soft tissue	NLA°	-0.09	4.95	2.90	8.45	-2.99	3.46	-10.41	4.44	-.863	.403	NS
	Ls-Sv mm	-0.11	1.49	-1.30	1.23	1.19	0.68	-0.28	2.65	1.732	.105	NS
	Li-Sv mm	4.86	2.59	0.67	1.77	4.19	1.11	1.81	6.56	3.779	.002	Sig
	Pog'-Sv mm	3.83	1.77	1.14	1.93	2.69	0.93	0.70	4.68	2.906	.012	Sig

SD: Standard deviation, SE: Slandered error, t: independent t-test, p: p-value for comparing the two studied groups, Sig: Statistically significant at $p \leq 0.05$, NS: Statistically nonsignificant, MPA: Mandibular protraction appliance, PS: Power Scope.

DISCUSSION

The purpose of this study was to compare the MPA-IV, a rigid FFA, with a PowerScope appliance, a hybrid FFA.

This study was conducted on 20 patients, divided equally into the two studied groups. The sample size calculation was based on a power test that utilized the mean treatment differences derived from a similar previous study [6].

Unfortunately, four patients (two from each group) dropped out of the study because lack of good cooperation to complete the study objectives. Therefore, the statistical analyses were performed on only 16 patients (eight patients in each group).

The age of the patients was determined by skeletal age (CVMI)[20] to accurately assess the growth stages and to overcome the gender variations [6,7]. There were no significant differences between the patients in the two studied groups regarding skeletal age, maturational level, and gender distribution.

MPA-IV was a rigid FFA that mimics the Herbest in its effects[27]. It's made in the laboratory at a low cost[15]. The mode of bite jumping in the MPA-IV group was done in a single step till the edge-to-edge incisor relationship according to the original activation protocols of both Herbest[28,29] and MPA[14,15] appliances. It was reported that the larger the condylar advancement, the more mechanical tissue strain and the more bone formation than the smaller advancement [30].

In group 2, the PS was activated by a regimen combining rigid and flexible modes of mandibular advancement. This was based on the following; 1) It was reported that when keeping the condyles out of the fossae for a long time, the newly formed bone will occur with a more stable type 1 collagen matrix. Also, normal levels of mandibular growth can be secured after the removal of the appliance [31]. 2) To mimic the stepwise mandibular advancement found in previous studies to have a more significant skeletal effect than single-step advancement [32,33].

The growth pattern of the patients in both groups was almost vertical. Since most class II patients seeking orthodontic treatment in the outpatient clinic at the Orthodontic Department, Faculty of Dental Medicine, Al-Azhar University (Cairo, Boys) were of high angle pattern in the period of patients' recruitment. A previous systematic review and meta-analysis by Ishaq et al. in 2016 [34] reported minimal effects of FFAs on the vertical parameters. Subsequently, they justified the use of FFAs in high-angle cases.

The treatment duration in this study was six months in both groups. It was reported that the average mandibular advancement duration was 5-7 months [8,25]. Standardized treatment duration was aimed to decrease the confounders in the treatment outcomes.

The significant decrease of SNA angle in the PS group (1.34 ±.56°, P=.031) than in MPA group may be due to the more significant retraction of upper incisors in PS (UI-Sv = -2.7±0.61 mm, P=.001) since point A was reported to be affected by the dentoalveolar movement of the upper incisors [23,35]. Greater restriction of maxillary growth also may have a role in this difference. This was in agreement with Henriques et al. in 2019[23]. They found a significant decrease of SNA° in Jasper jumper (JJ) (hybrid FFA) when compared with Herbest (rigid FFA). While another study[12] revealed a nonsignificant difference in the anteroposterior position of point A when comparing rigid (Herbest) and hybrid (Xbow) FFAs. This may be due to the differences in sample ages since their participants were younger than those in the present study, longer treatment duration (14 months), and type of appliances.

The significantly more mandibular prognathism in favor of the MPA-IV group (SNB°, SN-Pog°, Co-Gn (mm), B-Sv (mm) and Pog-Sv (mm) by 1.59±0.44°, 1.5±0.42°, 2.08±0.82mm, 3.08±0,82mm, 2.91±0.73 mm respectively) seemed to be attributed to a different mode of action of both appliances. The MPA-IV caused a rigid bite jumping of the mandible for a long time since the patients cannot return the mandible to the original retruded position. This was reported to enhance the mandibular growth and glenoid fossa remodeling than hybrid FFAs, where the patient can return the mandible into a retruded position upon muscle counteraction, so the condyles were intermittently advanced from the glenoid fossa [12,31].

Another factor that may shear in more significant mandibular advancement was the more horizontal and lesser vertical direction of force delivered by MPA-IV since the appliance attached distally to the molar tube in the upper arch, unlike the PS installed mesially.

Significant mandibular lengthening (Co-Gn mm) of rigid FFAs was reported in a previous study that compared rigid and hybrid FFAs (Herbest and JJ). At the same time, there were no significant differences between both categories of FFAs in SNB° and the anteroposterior position of the Pogonion point. These may be due to the difference in study type (retrospective), time of T2 assessment radiographs (after total treatment duration > 2.5 years), and different kinds of appliances used [23].

Insabra et al. in 2021 [12] also found a significant increase in mandibular length (Co-Gn mm) in Herbest (rigid FFA) group than in Xbow appliance (hybrid FFA) group, with no significant differences in the anteroposterior position of the chin (Pog-Sv mm). This disagreement with the present study may be due to the difference in the functional appliance treatment duration (14 months), study design (retrospective study), the initial form of the sample's malocclusion, and appliances used.

The maxillomandibular relationship in the form of ANB° was not significantly different between the two groups in this study. The significant increase in SNB° in the MPA-IV group was compensated by the significant decrease of SNA° of the PS group, so the mean change of ANB° between the two groups did not significantly differ.

The nonsignificant difference in ANB° between the two groups was in agreement with a study by Henriques et al. [23] who compared MPA (Rigid FFA) and JJ (hybrid FFA). Also nonsignificant difference in Wits appraisal was found between Herbest (Rigid FFA) and Xbow (hybrid) appliances [12]. On the contrary, there was a significantly greater reduction of ANB° with Monoblock (RFA) therapy when compared to Twin Force Bite Corrector (hybrid FFAs), which may be due to the difference in the type of functional appliances [36].

Vertically, there were no statistically significant differences in the above-mentioned vertical parameters except posterior facial height (S-Go mm) and gonial angle (Ar-Go-Me) in the MPA-IV group, which were significantly increased by 1.58 ± 0.73 mm and 2.41° ± 0.77° respectively. These seemed to result from significant additional mandibular lengthening and chin projection in this group. In addition, the condylar growth and glenoid fossa remodeling were reported to be in a downward and forward direction [37], which may cause greater posterior facial height in this group.

Greater mandibular advancement was reported to be accompanied by condylar growth and glenoid fossa remodeling [38–43]. These were found to alter the position of the articular point (Ar) posteriorly along the ramus and condyle outlines and subsequently affected the gonial angle to be increased [44]. Another explanation for a significant increase in gonial angle was remodeling at the gonial angle region due to altered muscle strain concomitant to rigid bite jumping [25,45].

Dentally, the significant more retraction of the upper incisors in favor of PS seemed to be related to the absence of significant mandibular advancement. So the force of the appliance was concentrated in the dentoalveolar structure. These also resulted in a significantly greater distalization of upper molars.

In the MPA-IV group, the greater skeletal mandibular advancement reduced the forces upon maxillary molars, so the amount of distalization in this group was not significant. In contrast, the significant protrusion of lower incisors (LI-Sv mm = 2.68 ± 0.49 mm p=.000) resulted from the accompanied anterior positioning of the whole mandible, in addition to the dentoalveolar movement. These also agreed with a previous study [23] compared MPA (rigid) with JJ (flexible) FFAs.

On the contrary, Insabra et al. in 2021[12] who compared Herbest (rigid) and Xbow (hybrid) FFAs, found a nonsignificant difference in the amount of distalization of maxillary molars between the two appliances. This disagreement may be due to the difference in sampling (82 patients), different study designs (retrospect study), longer treatment duration of FFAs (14 months), and different FFAs used.

The significantly greater advancement of the lower lip and soft tissue chin in the MPA-IV group (Li-Sv mm = 4.19 ± 1.11 mm, p= .002 - Pog'– Sv mm = 2.69 ± 0.93, p=.012) than in the PS group were seemed to be secondary to the greater mandibular skeletal effects of MPA-IV appliance. It resulted in more profile enhancement of class II malocclusion patients with the deficient mandible.

CONCLUSIONS

1. MPA-IV and PS are efficient in treating class II malocclusion-growing patients.
2. MPA-IV produces more mandibular skeletal effects.
3. Soft tissue enhancement is superior with MPA-IV therapy due to lower lip and chin advancement.

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