

Soft Tissue Evaluation of Mandibular Protraction Appliance IV and PowerScope in Treatment of Class II Malocclusion; A Comparative Randomized Clinical Trial

Abubakr Mohammed Fouad¹, Ramadan Youssef Abu-Shahba², Ezzat Barakat Abdel-Fattah³

¹ Assistant lecturer, Department of Orthodontics, Faculty of Dental Medicine (Boys), Al-Azhar University, Cairo, Egypt.

² Associate professor, Department of Orthodontics, Faculty of Dental Medicine (Boys), Al-Azhar University, Cairo, Egypt.

³ Professor, Department of Orthodontics, Faculty of Dental Medicine (Boys), Al-Azhar University, Cairo, Egypt.

Abstract

Objective: To evaluate and compare the soft tissue treatment outcomes of Mandibular protraction appliance IV (MPA-IV) and PowerScope (PS) in skeletal Class II malocclusion patients. **Materials and methods:** A total of 16 circumpubertal class II patients ($ANB^\circ > 4^\circ$) 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:** Significant lower lip and chin advancement were achieved in MPA-IV group (Li-Sv mm = 4.86 ± 2.59 mm, $p = 0.001$ - Li-E line mm = 1.05 ± 0.96 mm, $p = .017$ - Pog' - Sv mm = 3.83 ± 1.77 , $p = 0.000$). In the PS group, a significant upper lip retraction was revealed (Ls-Ss mm = -1.3 ± 1.23 mm, $p = .020$ - Ls - Eline mm = -1.25 ± 1.35 mm, $p = .035$). Intergroup comparison showed a significant lower lip and chin advancement (Li-Sv mm = 4.19 ± 1.11 mm, $p = 0.002$ - Pog' - Sv mm = 2.69 ± 0.93 , $p = 0.012$) in favor of MPA-IV group. **Conclusion:** Both Mandibular protraction appliance IV and PowerScope are useful for enhancing the soft tissue profile of class II malocclusion patients. This was attained by lower lip and chin advancement with MPA-IV and by upper lip retraction with PS.

Keywords: Mandibular protraction appliance, PowerScope, fixed functional appliance.

Date of Submission: 15-01-2023

Date of Acceptance: 31-01-2023

I. 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 retrusion¹⁻³.

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^{4,5}.

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^{2,6,7}.

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^{8,9}.

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 retrace the condyles back by the action of masticatory muscles⁹.

The Mandibular Protraction Appliance I (MPA-I) is a rigid FFAs, developed by Coelho Filho in 1995^{10,11}. It's an in-office made, low-cost, and efficient in class II malocclusion treatment. The MPA-IV was developed in 2001¹² 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 2015¹³. It was simpler in placement and adjustment.

The PowerScope (PS) was among the latest versions of hybrid FFAs. It was developed by Andrew Hayes in 2014¹⁴. 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 that fits all patient's mouths since shims of different sizes are supplied for quick adjustment^{15,16}.

This study aimed to compare two different forms of FFAs; the first one was the Mandibular protraction applianceIV, a rigid FFA. The second appliance was the PowerScope, a hybrid FFA.

II. Materials And Methods

The present study was approved by the ethical committee of the Faculty of Dental Medicine, Al-Azhar University (Cairo, Boys), with reference number (346/1137/16/10/19).The inclusion criteria were skeletal ($ANB^{\circ} > 4^{\circ}$) and dental class II malocclusion with mandibular retrognathia, overjet ≥ 5 mm, patients in Cervical Vertebral Maturation Index (CVMI) 3-4 according to Baccetti et al¹⁷, 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.

The calculation of sample size was based on the mean difference derived from a study of Arora et al⁴ Using G power statistical power analysis program (version 3.1.9.4) for sample size determination⁽¹⁸⁾. 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 ($1-\beta$ error) of 0.9 (90%) and a significance level (α error) 0.05 (5%) for the 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 Mandibular Protraction Appliance 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 the 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^{4,19-21}.

In group 1, MPA-IV was used. It was a laboratory-made appliance constructed according to Coelho¹². The mandible was jumped into edge-to-edge incisal bite during the installation visit and maintained during the functional appliance treatment duration. (Figure 1).

In group 2, PS 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. An additional three millimeters activation shim was crimped to the appliance for further initial mandibular advancement. After one month, a 2mm activation shim was added to maintain the internal spring compressed and also to increase the bite jumping. Then the internal spring was maintained fully compressed during



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

the follow-up visits.



Figure 1: Intraoral photograph showing Mandibular Protraction Appliance IV installed in edge-to-edge bite.

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^{6,22} 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 (Table 1) were done at the same time to decrease the frame of errors in determining the anatomical structures.²³ Sella-Nasion line was used to construct a horizontal reference line (constructed Frankfurt Horizontal plane (cFH)), by drawing a line 7° clock-wise from Sella-Nasion intersecting at Sella point. The vertical reference lines (Sella vertical (Sv)), was then constructed perpendicular to the horizontal reference (cFH) intersecting at S point²⁴. The linear variables measured from the vertical reference lines were made parallel to the horizontal plane. When double images of the anatomical bony structures were visualized, both structures were traced, and a mean position between them was determined¹⁹.

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.

Table (1): Angular and linear measurements used in this study.^{4,24,25}

	Measurement	Definitions
skeletal	SNA°	The angle formed between S, N and A points.
	SNB°	The angle formed between S, N, and B points.
	ANB°	The angle formed between A, N and B points.
	SN/MP°	The angle formed between SN plane and mandibular plane (MP)
Dental	UI-SN°	The angle formed between the long axis of upper incisors and SN plane.
	IMPA°	The angle formed between the long axis of lower incisors and MP.
Soft tissue	NLA	The angle formed between two lines passing through the lower edge of the nose (the columella) and the edge of the upper lip.
	Pg'-Sv	The perpendicular distance between Pg' and Sv.
	Ls-Sv	The perpendicular distance between Ls and Sv.
	Li-Sv	The perpendicular distance between Li and Sv
	UL/E-line (mm)	The perpendicular distance between Ls and E line.
	LL/E-line (mm)	The perpendicular distance between Li and E line.

III. 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 2) showed nonsignificant differences ($p > .05$) that ensure the homogeneity of the two groups. Baseline cephalometric parameters of the two groups (Table 3) also revealed no significant differences between all variables ($p > .05$).

Table (2): 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	$\chi^2=$	^{FE} p=	NS
Female	3	3	0.0	1.000	
Chronological age	14.98 ± 1.33 years	14.67 ± 1.37 years	t=	.805	NS
			0.476		
Skeletal age					
CVMI 3	2	3	t=	.334	NS
CVMI4	6	5	0.509		

χ^2 : 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.

Paired sample t test was performed between the pre and post appliance cephalometric soft tissue variables to determine the statistical significance of the treatment effects in each group separately. There were significant changes of upper lip and lower lip parameters in MPA-IV group [Ls-E line mm ($p=.002$) - Li-Sv mm ($p= 0.001$) - Li-E line ($p= .017$) - Pog' - Sv mm ($p=0.000$)], while the NLA° and Ls-Sv mm were non-significantly changed ($P > 0.05$) with treatment (Table 4).

A significant upper lip retraction (Ls-Sv mm and Ls-E line mm) were obtained in PS group ($P \leq 0.05$) while NLA° and lower lip parameters (Li-Sv mm and Li-E line mm) were non-significantly changed ($P > 0.05$) with treatment (Table 5).

Table (3): Comparison of the 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	
	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
	SNB°	73.03	3.39	71.49	3.44	1.54	1.71	-2.12	5.20	.901	.383
	ANB°	5.78	1.39	6.88	1.21	-1.10	0.65	-2.50	0.30	-1.688	.114
	Sn-Mp°	39.85	7.17	44.51	7.78	-4.66	3.74	-12.68	3.36	-1.247	.233
Dental	UI-SN°	105.55	8.22	102.03	8.17	3.52	4.10	-5.27	12.32	.860	.404
	LI-Mp°	99.73	5.39	96.44	5.79	3.29	2.80	-2.71	9.29	1.176	.259
Soft tissue	NLA°	97.19	11.05	98.89	16.47	-1.70	7.01	-16.74	13.34	-.242	.812
	Ls-Sv mm	81.30	4.05	79.90	3.98	1.41	2.01	-2.90	5.71	.701	.495
	Li-Sv mm	73.33	4.56	72.30	6.65	1.03	2.85	-5.09	7.14	.361	.723
	Ls-E line mm	1.96	2.98	2.76	2.76	-0.79	1.44	-3.87	2.28	-.553	.589
	Li- E line mm	3.19	3.61	4.81	3.00	-1.61	1.66	-5.17	1.95	-.972	.347
	Pog' -Sv mm	61.37	6.91	57.21	7.63	4.16	3.64	-3.64	11.97	1.144	.272

SD: Standard deviation, SE: Slanderred error, t: independent t-test, p: p-value for comparing the two studied groups, *: $p \leq 0.05$, **: $p \leq 0.01$, ***: $p \leq 0.001$, MPA: Mandibular protraction appliance, PS: PowerScope.

Independent sample t-test has been performed to compare the mean treatment changes of soft tissue cephalometric parameters between the two groups (Table 6). Significant lower lip and chin advancement [Li-Sv mm, $p= 0.002$ - Pog' - Sv mm ($p=0.012$)] were revealed in favor of MPA-IV patients. There were no-statistically significant differences ($P > 0.05$) among the two groups for the remaining soft tissue measurements.

Table (4): The soft tissue treatment effect within MPA-IV group using paired t-test.

Variable	Pre-MPA-IV		Post- MPA-IV		Paired difference				t-Value	P value
	Mean	SE	Mean	SD	Mean	SD	95% Confidence Interval of the Difference			
							Lower	Upper		
NLA°	97.19	3.91	97.10	11.47	-0.09	4.95	-4.22	4.05	-.050	.962
Ls-Sv mm	81.30	1.43	81.19	4.09	-0.11	1.49	-1.36	1.14	-.212	.838
Li-Sv mm	73.33	1.61	78.19	4.70	4.86	2.59	2.69	7.02	5.311	.001***
Ls-E line mm	1.96	1.05	-0.38	2.50	-2.34	1.32	-3.45	-1.23	-4.99	.002**
Li- E line mm	3.19	1.27	4.24	2.92	1.05	0.96	0.25	1.85	3.106	.017*
Pog'-Sv mm	61.37	2.44	65.20	7.05	3.83	1.77	2.36	5.31	6.128	.000***

SD: Standard deviation, SE: Slandered error, t: independent t-test, p: p-value for comparing the two studied groups, *: p ≤ 0.05, **: p ≤ 0.01, ***: p ≤ 0.001, MPA: Mandibular protraction appliance.

Table (5): The soft tissue treatment effect within PS group using paired t-test.

Variable	Pre-PS installation (n=8)		Post- PS installation (n=8)		Paired difference				t-Value	P value
	Mean	SD	Mean	SD	Mean	SD	95% Confidence Interval of the Difference			
							Lower	Upper		
NLA°	98.89	16.47	101.79	10.04	2.90	8.45	-4.16	9.96	.971	.364
Ls-Sv mm	79.90	3.98	78.60	4.07	-1.30	1.23	-2.33	-0.27	-2.983	.020*
Li-Sv mm	72.30	6.65	72.97	6.06	0.67	1.77	-0.81	2.15	1.070	.320
Ls-E line mm	2.76	2.76	1.51	1.97	-1.25	1.35	-2.38	-0.12	-2.613	.035*
Li- E line mm	4.81	3.00	5.10	2.35	0.30	1.94	-1.33	1.92	.430	.680
Pog'-Sv mm	57.21	7.63	58.35	7.97	1.14	1.93	-0.47	2.76	1.674	.138

SD: Standard deviation, SE: Slandered error, t: independent t-test, p: p-value for comparing the two studied groups, *: p ≤ 0.05, **: p ≤ 0.01, ***: p ≤ 0.001, PS: PowerScope.

Table (6): Descriptive statistics and test of significance (independent sample t-test) for the mean differences (T2-T1) of cephalometric variables between the two investigated groups.

	MPA (n = 8)		PS (n = 8)		Mean difference	SE	95% Confidence Interval		t-value	p
	Mean	SD.	Mean	SD.			Lower	Upper		
Ls-Sv mm	-0.11	1.49	-1.30	1.23	1.19	0.68	-0.28	2.65	1.732	.105
Li-Sv mm	4.86	2.59	0.67	1.77	4.19	1.11	1.81	6.56	3.779	.002**
Ls-E line mm	-2.34	1.32	-1.25	1.35	-1.09	0.67	-2.52	0.35	-1.623	.127
Li- E line mm	1.05	0.96	0.30	1.94	0.76	0.77	-0.89	2.40	.987	.340
Pog'-Sv mm	3.83	1.77	1.14	1.93	2.69	0.93	0.70	4.68	2.906	.012*

SD: Standard deviation, SE: Slandered error, t: independent t-test, p: p-value for comparing the two studied groups, *: p ≤ 0.05, **: p ≤ 0.01, ***: p ≤ 0.001, MPA: Mandibular protraction appliance, PS: PowerScope.

IV. Discussion

The purpose of this study was to compare the Mandibular Protraction Appliance 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⁽⁴⁾.

Unfortunately, four patients (two from each group) dropped out of the study because lack of good cooperation to complete objectives of the study. 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)¹⁷ to accurately assess the growth stages and to overcome the gender variations^{4,5}. 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 Herbst in its effects²⁶. It's made in the laboratory at a low cost¹². 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 Herbst^{27,28} and MPA^{11,12} appliances. It was

reported that the larger the condylar advancement, the more mechanical tissue strain and the more bone formation than the smaller advancement²⁹.

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 appliance³⁰. 2) To mimic the stepwise mandibular advancement found in previous studies to have a more significant skeletal effect than single-step advancement^{31,32}.

The growth pattern of the patients in both groups was almost vertical, Ishaq et al³³ in their systematic review and meta-analysis reported minimal effects of FFAs on the vertical parameters and subsequently 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^{6,22}. This standardized treatment duration was aimed to decrease the confounders in the treatment outcomes.

The profile was enhanced by lower lip protrusion and chin advancement (Li-Sv - Li-E line- Pog'- Sv) in the MPA-IV group which is valuable for a retrognathic profile of mandibular origin. However, the upper lip position was retracted in relation to the E line (Ls- E line) it was not significantly changed in relation to the stable cranial reference line (Sv), this contradiction may be related to the more anterior positioning of the E line due to greater advancement of the soft tissue chin (Pog').

Following the findings of this group, Alves et al²⁶ found significant lower lip advancement and upper lip retraction in relation to the S line when they used MPA. Interestingly, Baccetti et al³⁴ in their Herbst study reported significant lower lip and chin advancement and nonsignificant upper lip change since they assumed a more stable vertical reference in the measurement. On the other hand, Amuk et al³⁵ in another Herbst study revealed significant upper lip retraction and lower lip and chin advancement in relation to a true vertical line. This difference may be attributed to different baseline characteristics (normal to low angle cases (SN - GoGn ≤ 38o), mode of appliance activation and the functional treatment duration (9.5 ± 1.1 months).

In the PS group, there was a significant upper lip retrusion (Ls -Sv – Ls -E line) which aid in reducing the profile convexity of class II malocclusion patients while the lower lip and soft tissue chin (Pog') positions were not significantly changed. These may be a sign of limited mandibular advancement in this group. Similarly, Eissa et al²⁵ revealed a significant upper lip retraction and nonsignificant lower lip advancement when they evaluated Forsus Fatigue Resistant Device (FFRD) and miniscrew supported FFRD in class II malocclusion treatment. On the contrary, Karacay et al³⁶ and Aslan et al³⁷ found nonsignificant upper lip retraction and significant lower lip advancement after hybrid FFAs therapy. This difference may be due to differences in sampling, comparison to controls and different FFAs used.

Regarding intergroup comparison, significant advancements of the lower lip and soft tissue chin were found in the MPA-IV group than the PS group (Li-Sv mm - Pog' – Sv mm). These are supposed to be secondary to the further mandibular advancement of the MPA-IV than PS since superior mandibular prognathism was reported with rigid than with hybrid FFAs.⁹

V. Conclusion

Both Mandibular protraction appliance IV and PowerScope are useful for enhancing the soft tissue profile of class II malocclusion patients. This was attained by lower lip and chin advancement with MPA-IV and by upper lip retraction with PS.

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