Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/odw

Original article

Treatment effects of mandibular anterior position training versus a fixed Class II corrector in growing patients with skeletal Class II malocclusion

Khitparat Kamoltham, Chairat Charoemratrote *

Department of Preventive Dentistry, Faculty of Dentistry, Prince of Songkla University, Songkhla, Thailand

ARTICLE INFO

Article history:
Received 22 May 2018
Received in revised form
9 July 2018
Accepted 20 July 2018
Available online 1 September 2018

Keywords:
Orthodontic appliances
Functional
Orthopedics
Retrognathia
Mandible

ABSTRACT

Purpose: To compare treatment effects of Class II elastics and anterior mandibular position training against fixed Class II corrector (PowerScope™) during the correction of skeletal Class II malocclusion with fixed appliance in growing patients.
Materials and methods: Thirty-six growing patients with skeletal Class II malocclusion with a retruded pogonion position were randomly allocated to the Class II elastics or PowerScope™ groups. Preadjusted edgewise fixed appliances were used in both treatment groups. Skeletal, dental and profile changes were compared using lateral cephalograms taken before (T_0), after initial alignment (T_1) and after Class I obtained (T_2) for 16/18 patients in the Class II elastics group and 15/18 patients in the PowerScope™ group.
Results: The duration of treatment was significantly longer for the Class II elastics group than PowerScope™ group. In terms of skeletal changes, Class II elastics increased mandibular length, midfacial length and mandibular plane angle significantly more than the PowerScope™. In terms of dental changes, Class II elastics increased dental height significantly more than the PowerScope™.
Conclusions: Both treatment modalities reduced severity of Class II malocclusion and decreased profile convexity. Class II elastics with anterior mandibular position training increased mandibular length more but required longer treatment duration. The PowerScope™ had a greater effect on maxillary dento-alveolar restriction. (ClinicalTrials.in.th: TCTR 20180220003).

1. Introduction

Mandibular retrognathism is one of common characteristics in children with Class II division 1 malocclusion [1]. Young adults with Class II malocclusion who do not receive treatment exhibit significant mandibular retrusion due to growth deficiency during adolescence [2,3]. Skeletal and dental Class II disharmony cannot self-correct [3,4]; various treatment approaches have been applied during the pubertal growth spurt [4]. Headgear, functional appliances and fixed orthodontic appliances reduce the severity of Class II relationships

* *Corresponding author at*: Department of Preventive Dentistry, Faculty of Dentistry, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand.
E-mail address: metalbracket@hotmail.com (C. Charoemratrote).
https://doi.org/10.1016/j.odw.2018.07.003
1344-0241/

[5,6], with the Herbst and Twin-block appliances providing greatest mandibular growth stimulation [5]. The skeletal changes that lead to normalization of Class II malocclusion include maxillary growth restriction and mandibular growth stimulation, along with dento-alveolar correction [6].

The main objective of treating Class II malocclusion is to promote skeletal growth; however, dental compensation usually limits mandibular growth. The forces produced by functional appliances can induce unwanted dental changes, including lower molar extrusion [7] and lower incisor proclination [8]. Patients who utilize their own musculature to posture their mandible forward are less likely to display compensatory dental movement than those who receive external pressure from appliance. The more dental moves, the less skeletal correction occurs [9]. Therefore, the role of muscles may also affect the success of treatment. Retracting muscles that refuse to stay forward during mandibular advancement induced by an orthopedic appliance will cause dental compensation. Thus, in this study patients are trained to place their mandible in a forward position with the guidance of Class II elastics. Self-mandibular advancement attempts to decrease muscle pull, to prevent dental movement compensating for the pull.

The purpose of this study was to compare the skeletal, dental and profile changes in growing patients with skeletal Class II malocclusion during treatment with a fixed orthodontic appliance. We compared the effect of two mandibular advancement techniques: (i) self-training to maintain an anterior mandibular position under the guidance of light force Class II elastics with a modified point of force application and (ii) a fixed PowerScope^{TM} Class II corrector, a commercial derivative of the Herbst appliance.

2. Materials and methods

2.1. Patients

Under institutional ethics committee approval, we prospectively recruited patients with: (1) skeletal Class II malocclusion and a retrognathic mandible (retruded pogonion vs. nasion perpendicular line, ≤4 mm); (2) growth stage 4–5 (acceleration/peak growth) on hand and wrist radiographs according Björk [10] and Grave and Brown [11]; (3) and no underlying disease. Patients were excluded from analysis if: (1) they did not comply to training or wearing Class II elastics; (2) the PowerScope^{TM} broke repeatedly, or (3) class II relationship did not improve after 12 months of wearing fixed appliance. All excluded patients were treated using other methods until malocclusion resolved.

Sample size was calculated using PS: Power and Sample Size Calculation software, version 3.0.43 (Vanderbilt University, Nashville, TN, USA) based on an expected 1.8 mm difference in Pg-Nprep$_{mm}$ (standard deviation, 1.6; from Lai and McNamara [12]) between groups, level of significance and power of 95% ($\alpha = 0.05$) and 80% ($\beta = 0.2$). A minimum of 13 patients were required per group; 36 patients provided written informed consent and were randomly allocated to Class II elastics group or PowerScope^{TM} group.

2.2. Treatment protocol

Preadjusted edgewise fixed appliances including 0.018-in. slot brackets on incisors and 0.022-in. slots on remaining teeth (Roth^{TM} system; Ormco, City, CA, USA) were placed on all patients. Initial alignment was achieved using NiTi archwires and stainless steel until 0.016 × 0.022-in. stainless steel wires were placed.

2.2.1. Class II elastics group

Stainless steel wire (0.016″ × 0.022″) was retained on upper and lower arches. Kobayashi hooks were attached to mesial upper lateral incisors and distal lower second premolars. Light force Class II elastics (1/4″ 2 oz) were placed between upper lateral incisors and lower second premolars (Fig. 1). Patients were instructed to use Class II elastics continually, except when eating and brushing teeth.

Patients received mandibular position training and were instructed to hold their mandible forward at all times when awake, and chew/bite and perform intra-oral function using

Fig. 1 – Class II elastics applied between upper lateral incisors and lower second premolars as a training device for (A) centric and (B) protruded malocclusion.

the protruded position and bite in Class I position. Patients were reminded at each appointment and their awareness of protruding the mandible increased with practice.

2.2.2. *PowerScope™ group*

Rigid 0.018″ × 0.025″ stainless steel archwires were inserted on upper and lower arches. Colligation was performed using a 0.010″ stainless steel ligature wire from right first molar to left first molar on both arches to recruit all teeth as one unit.

PowerScope™ Class II Corrector (American Orthodontics, Sheboygan, WI, USA) was inserted (Figs. 2 and 3). Maxillary attachment screws were engaged and placed mesially to first molar on maxillary arch wire. Mandibular attachment screws were placed distally to canine on mandibular arch wire. Maximum jumping was employed to obtain a Class I canine and molar relationship with normal overjet. PowerScope™ is a one-size-fits-all appliance pre-assembled with attachment nuts; crimpable shims were added to provide adequate advancement at initial installation. Steel ligatures were used instead of elastic ligatures on lower canines, lower first premolars and upper second premolars to prevent elastic tearing and tooth rotation.

Screws were checked at each appointment for loosening; if necessary, the internal NiTi spring was further activated by adding crimpable shims to ensure symmetrical maximum jumping of the mandibular arch.

2.3. *Data collection and analysis*

Lateral cehalograms were taken by one radiographer (Gendex GXDP-700™ series; Gendex Dental System, Hatfield, PA, USA) before treatment (T_0), after initial alignment (T_1) and after Class I occlusion was obtained (T_2). For the verification that Class I occlusion at T_2 was taken in the centric occlusion, patients were asked to move their jaw backward to the most posterior position. Also, mandible was guided manually by primary examiner to move the mandible backward. Until the visit that mandible can no longer move back at existing Class I position, the cephalogram was taken at this position.

Distances and angles were measured using Dolphin® Imaging 11.7 software (Dolphin Imaging, Chatsworth, CA, USA) by one clinician blinded to treatment group/time-point. The description of cephalometric measurements was provided on Table 1.

Method errors in locating radiographic landmarks and measurements were assessed using Dahlberg's formula [13]; 15 randomly selected radiographs were remeasured by the same clinician after 2 months. Linear and angular measurements did not exceed 0.5 units for any variable.

2.4. *Statistical analyses*

Statistical analysis was carried out using SPSS 17.0 for Windows (SPSS, Chicago, IL, USA); significance was defined as $P < 0.05$ for all tests. Initial cephalometric values and treatment changes were reported as means and standard deviations. Normality was tested using the Shapiro–Wilk test. Independent *t*-tests (or Mann–Whitney *U*-test for non-normally distributed data) were used to compare initial values and treatment changes between groups.

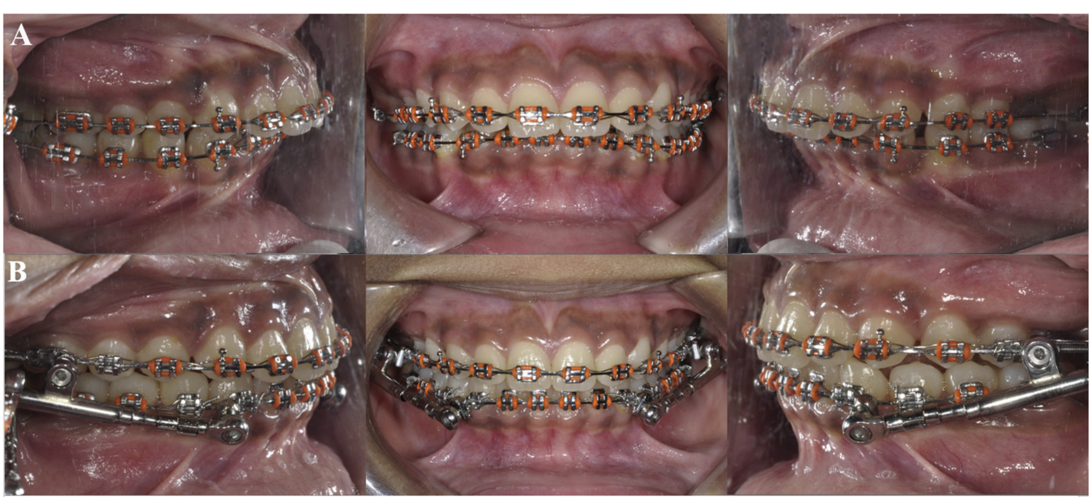

Fig. 2 – (A) Occlusion in centric position (B) PowerScope™ maintains a protruded position.

Fig. 3 – Full mouth opening when wearing a PowerScope™ extended at maximum length.

Table 1 – Cephalometric distances and angles used for the analysis.

	Definition
Sagittal skeletal measurements	
SNA°	Angle between sella-nasion-point A
SNB°	Angle between sella-nasion-point B
ANB°	Angle between point A-nasion-point B
Co-A_{mm} (McNamara analysis)	Midfacial length (distance from condylion to point A)
Co-Gn_{mm} (McNamara analysis)	Mandibular length (distance from condylion to gnathion)
A-$Nperp_{mm}$ (McNamara analysis)	Distance from point A to N-perpendicular
Pg-$Nperp_{mm}$ (McNamara analysis)	Distance from pogonion to N-perpendicular
Vertical skeletal measurements	
SN-MP° (Steiner analysis)	Angle between sella-nasion plane and mandibular plane (plane tangent to gonial angle and gnathion)
FH-MP° (Downs analysis)	Angle between Frankfort horizontal plane and mandibular plane (plane tangent to lower border of mandible and the lowest point at symphysis)
NS-Gn°	Angle between sella-nasion plane and the Y-axis (the line connecting sella to gnathion)
Occlusal plane angles	
SN-OP° (Steiner analysis)	Angle between sella-nasion plane and occlusal plane (line connecting the region of the overlapping cusps of first premolars and first molars)
FH-OP° (Downs analysis)	Angle between Frankfort horizontal plane and occlusal plane (line bisecting the overlapping cusps of the fist molars and the incisal overbite)
Dental measurements	
U1-NA°	Angle between axial inclination of maxillary incisors and the line from nasion to point A
U1-NA_{mm}	Distance between incisal tip of maxillary incisors and the line from nasion to point A
L1-NB°	Angle between axial inclination of mandibular incisors and the line from nasion to point B
L1-NB_{mm}	Distance between incisal tip of mandibular incisors and the line from nasion to point B
U1-L1°	Interincisal angle (angle between axial inclination of maxillary and mandibular incisors)
U1-PP°	Angle between axial inclination of maxillary incisor and the palatal plane (line connecting anterior and posterior nasal spine)
L1- MP°	Angle between axial inclination of mandibular incisor and the mandibular plane (plane tangent to gonial angle and the lowest point at symphysis)
ADH_{mm}	The perpendicular distance from upper incisal edge projected at a right angle to the palatal plane
PDH_{mm}	The perpendicular distance from mesio-buccal cusp tip of first molar with the functional occlusal plane to inferior border of palate
$Overjet_{mm}$	Horizontal overlapping distance from incisal edge of maxillary incisors to labial surface of mandibular incisors
$Overbite_{mm}$	Vertical overlapping distance of maxillary and mandibular incisal edges
Nasolabial angle	
NLA°	Angle between the line tangents to the base of the nose and upper lip
Profile convexity	
FCA°	Angle form by intersection of grabella-subnasale line and subnasale-soft tissue pogonion line

3. Results

Sixteen patients in the Class II elastics group (9 females, 7 males; 2/18 excluded for non-compliance) and 15 patients in the PowerScope™ group (9 females, 6 males; 3/18 excluded due to appliance breakage) were analyzed. Age was comparable between groups; duration of treatment was 12 months longer for Class II elastics than PowerScope™ (P=0.001; Table 2). Initial cephalometric values were not significantly different between groups (Table 3). Different changes between cephalometric values at T_0, T_1 and T_2 were shown in Table 4. The change from initial alignment (T_0 and T_1) did not show statistical significance between two groups. Representative photos and cephalometric superimposition of changes between T_0 and T_2 from each group are provided in Fig. 4.

Table 2 – Demographic data for the Class II elastics and PowerScope™ groups.

Group	Age at T_0 (years)	P-value	T_0–T_2 interval (months)	P-value
Class II elastics (n = 16; 9 females, 7 males)	11.41 ± 0.90	0.422	34.33 ± 3.80	0.001
PowerScope™ (n = 15; 9 females, 6 males)	11.72 ± 1.09		22.33 ± 7.83	

Values are mean ± SD; shaded areas indicate significant differences between groups ($P < 0.05$), Mann–Whitney U-test.

Table 3 – Initial configuration of patients in the Class II elastics and PowerScope™ groups.

Measurement	Group	Initial configuration (T_0) Mean	Standard deviation	P-value
SNA°	Class II elastics	84.48	3.29	0.710
	PowerScope™	83.91	3.63	
SNB°	Class II elastics	78.29	3.44	0.737
	PowerScope™	77.62	5.53	
ANB°	Class II elastics	6.20	2.36	0.940
	PowerScope™	6.28	2.28	
$AO\text{-}BO_{mm}$	Class II elastics	0.38	3.53	0.339
	PowerScope™	2.06	4.33	
$Co\text{-}A_{mm}$	Class II elastics	86.27	4.44	0.599
	PowerScope™	87.50	6.16	
$Co\text{-}Gn_{mm}$	Class II elastics	110.70	6.84	0.702
	PowerScope™	109.64	5.06	
$A\text{-}Nperp_{mm}$	Class II elastics	1.71	3.24	0.716
	PowerScope™	1.28	1.46	
$Pg\text{-}Nperp_{mm}$	Class II elastics	-8.04	5.19	0.672
	PowerScope™	-9.07	5.69	
Sn-GoMe°	Class II elastics	35.29	4.57	0.711
	PowerScope™	36.41	8.90	
FH-MP°	Class II elastics	28.08	4.90	0.732
	PowerScope™	28.96	6.74	
SN-OP°[a]	Class II elastics	19.93	6.29	0.651
	PowerScope™	19.39	5.39	
NS-Gn°	Class II elastics	68.58	3.50	0.921
	PowerScope™	68.81	6.75	
FH-OP°	Class II elastics	12.68	3.88	0.663
	PowerScope™	11.93	3.69	
U1-NA°	Class II elastics	29.97	8.37	0.942

(continued on next page)

Table 3 (continued)

Measurement	Group	Initial configuration (T_0)		P-value
		Mean	Standard deviation	
	PowerScope™	29.67	10.28	
U1-NA$_{mm}$	Class II elastics	8.18	2.97	0.561
	PowerScope™	7.29	3.91	
L1-NB°	Class II elastics	32.34	4.81	0.612
	PowerScope™	31.02	6.94	
L1-NB$_{mm}$ [a]	Class II elastics	8.76	2.45	0.219
	PowerScope™	7.58	2.45	
U1-L1°	Class II elastics	111.47	8.80	0.725
	PowerScope™	113.07	11.82	
U1-PP°	Class II elastics	121.66	8.36	0.935
	PowerScope™	121.34	8.97	
L1- MP°	Class II elastics	98.78	6.01	0.559
	PowerScope™	96.98	7.88	
ADH$_{mm}$	Class II elastics	29.51	2.17	0.390
	PowerScope™	28.46	3.32	
PDH$_{mm}$	Class II elastics	16.80	1.97	0.231
	PowerScope™	18.12	2.94	
Overbite$_{mm}$	Class II elastics	3.51	1.86	0.672
	PowerScope™	3.94	2.79	
Overjet$_{mm}$	Class II elastics	8.53	2.08	0.708
	PowerScope™	8.94	2.90	
NLA°	Class II elastics	96.76	11.13	0.898
	PowerScope™	96.12	11.06	
FCA°	Class II elastics	21.06	5.40	0.335
	PowerScope™	18.50	6.44	

P-values for normally distributed data were calculated using the independent *t*-test.
[a] The Mann–Whitney *U*-test was used to compare non-normally distributed data.

3.1. *Differences in skeletal changes between groups*

First, we assessed sagittal skeletal changes between T_0 and T_2; midfacial length (Co-A$_{mm}$) and mandibular length (Co-Gn$_{mm}$) were significantly different between groups. Despite requiring a longer treatment time, Class II elastics increased midfacial length by 1.32 mm more/year (P=0.001; Table 4). Mandibular length increased significantly more in the Class II elastics than PowerScope™ group (1 mm more/year; P=0.003). Compared to Class II elastics, the distance to point A from SNA° and A-Nperp$_{mm}$ decreased more (by 0.7° and 0.3 mm/year, respectively), the pogonion position from Pg-Nperp$_{mm}$ was slightly more forward (by 1 mm/year) and the annual decrease in the severity of Class II relationship from ANB° was 0.7° greater in the PowerScope™ group, though these differences were not significant.

In terms of vertical skeletal changes between T_0 and T_2, mandibular plane angle increased significantly more in the Class II elastics group (P=0.007). Sn-GoMe° increased by 0.6° per year in the Class II elastics group and decreased by 0.3° per year in the PowerScope™ group. Additionally, FH-MP° increased by 0.4° per year in the Class II elastics group and decreased by 0.9° per year in the PowerScope™ group.

3.2. *Differences in dental changes between groups*

Treatment-induced sagittal dental changes were not significantly different between groups. The upper incisors were retroclined and retruded in both groups (slightly more in Class II elastics group) and the lower incisors were proclined and protruded in both groups (slightly more in PowerScope™ group). Interincisal angles were more obtuse for Class II elastics (by 1.7°) and overjet reduction was greater in the PowerScope™ group (by 1.13 mm), though these changes were not significant.

In terms of vertical dental changes, the increase in posterior dental height from PDH$_{mm}$ was significantly different between groups (P=0.003). Class II elastics led to an annual increase of

Table 4 – Differences in the changes in cephalometric values from T_0 to T_2 between groups.

	Group	T1–T0			T2–T1			T2-T0			Average annualized change
		Mean difference	Standard deviation	P-value	Mean difference	Standard deviation	P-value	Mean difference	Standard deviation	P-value	
SNA°	Class II elastics	−1.13	1.37	0.550	0.27	2.53	0.085	−0.86	2.22	0.279	−0.3
	PowerScope™	−0.77	1.29		−1.61	2.28		−1.91	2.03		−1.03
SNB°	Class II elastics	−0.04	1.18	0.472	0.48	1.64	0.446	0.44	1.87	0.822	0.15
	PowerScope™	0.42	1.72		0.01	1.10		0.27	1.53		0.15
ANB°++	Class II elastics	−1.09	1.30	0.860	−0.21	1.62	0.148	−1.3	1.29	0.345	−0.45
	PowerScope™	−1.19	1.14		−1.64	2.79		−2.21	2.28		−1.19
AO-BO$_{mm}$	Class II elastics	1.24	2.89	0.995	−3.20	3.11	0.758	−1.96	3.89	0.86	−0.68
	PowerScope™	1.23	3.24		−3.68	4.09		−2.28	4.24		−1.23
Co-A$_{mm}$	Class II elastics	1.28	0.39	0.993	5.43	3.79	0.009**	6.71	3.86	0.011*	2.35
	PowerScope™	1.24	0.49		1.01	3.63		1.92	3.79		1.03
Co-Gn$_{mm}$++	Class II elastics	4.75	0.52	0.097	8.54	4.06	0.001***	12.04	4.91	0.003**	4.21
	PowerScope™	3.92	1.54		2.37	2.97		5.91	3.47		3.18
A-Nperp$_{mm}$	Class II elastics	−0.54	2.12	0.302	0.35	1.37	0.018*	−0.2	2.52	0.673	−0.07
	PowerScope™	0.48	2.26		−1.53	2.04		−0.68	2.65		−0.37
Pg-Nperp$_{mm}$	Class II elastics	1.39	3.28	0.357	0.58	2.96	0.749	1.98	4.24	0.533	0.69
	PowerScope™	3.24	5.68		0.22	2.12		3.22	4.73		1.73
Sn-GoMe°++	Class II elastics	−0.12	0.53	0.681	1.85	2.41	0.013*	1.73	2.23	0.007**	0.6
	PowerScope™	−0.32	1.60		−0.42	1.11		−0.56	1.37		−0.3
FH-MP°	Class II elastics	−0.13	0.66	0.060	1.27	2.03	0.031*	1.14	2.17	0.007**	0.4
	PowerScope™	−1.47	2.22		−0.50	1.42		−1.73	2.15		−0.93
SN-OP°	Class II elastics	−3.88	3.72	0.384	3.94	5.91	0.925	0.06	6.51	0.874	0.02
	PowerScope™	−5.49	4.55		4.22	7.85		−0.44	7.81		−0.24
NS-Gn°++	Class II elastics	0.67	1.30	0.547	0.22	1.56	0.853	0.88	2.19	0.56	0.77
	PowerScope™	0.27	1.69		0.11	0.97		0.41	1.06		0.22
FH-OP°	Class II elastics	−4.42	2.77	0.465	3.96	6.19	0.767	−0.46	6.57	0.704	−0.16

(continued on next page)

Table 4 (continued)

	Group	T1–T0			T2–T1			T2-T0			Average annualized change
		Mean difference	Standard deviation	*P*-value	Mean difference	Standard deviation	*P*-value	Mean difference	Standard deviation	*P*-value	
	PowerScope™	−5.52	4.04		3.19	5.69		−1.59	6.77		−0.85
U1-NA°	Class II elastics	−1.58	2.38	0.858	−7.81	10.86	0.168	−9.39	12.05	0.301	−3.28
	PowerScope™	−1.08	9.34		−2.63	3.82		−4.12	9.99		−2.22
$U1\text{-}NA_{mm}$	Class II elastics	−2.45	2.38	0.076	−0.93	2.45	0.652	−3.38	3.81	0.207	−1.18
	PowerScope™	−0.10	3.38		−0.35	3.43		−1.07	4.24		−0.58
L1-NB°	Class II elastics	1.36	2.19	0.592	3.11	5.06	0.946	4.47	5.91	0.787	1.56
	PowerScope™	2.71	8.28		2.97	4.15		5.30	8.06		2.85
$L1\text{-}NB_{mm}$	Class II elastics	−1.13	2.86	0.186	2.00	1.92	0.182	0.87	2.51	0.471	0.3
	PowerScope™	0.46	2.27		1.05	1.11		1.68	2.49		0.9
U1-L1°	Class II elastics	9.16	9.51	0.072	−2.93	8.89	0.223	6.23	11.78	0.365	2.18
	PowerScope™	−0.51	13.84		1.32	6.43		0.99	14.1		0.53
U1-PP°	Class II elastics	−9.11	9.35	0.066	−0.83	7.43	0.276	−9.94	11.31	0.278	−3.48
	PowerScope™	−1.30	8.70		−3.68	3.29		−4.76	9.33		−2.56
L1-MP°	Class II elastics	−0.49	3.87	0.272	2.78	4.55	0.761	2.28	5.28	0.283	0.8
	PowerScope™	2.64	8.56		3.37	4.45		5.60	8.47		3.01
ADH_{mm}	Class II elastics	1.02	1.41	0.501	1.57	2.14	0.449	2.58	2.51	0.218	0.9
	PowerScope™	0.63	1.04		0.94	1.54		1.33	1.77		0.72
PDH_{mm}	Class II elastics	1.88	1.33	0.140	0.78	1.15	0.010**	2.65	1.88	0.003**	0.93
	PowerScope™	0.80	1.87		−0.62	1.14		0.07	1.47		0.04
$Overbite_{mm}$	Class II elastics	−1.63	1.85	0.884	−1.09	1.93	0.631	−2.73	2.02	0.761	−0.95
	PowerScope™	−1.50	2.30		−1.45	1.41		−3.01	2.21		−1.62
$Overjet_{mm}$	Class II elastics	−2.65	1.76	0.589	−2.80	2.10	0.355	−5.45	2.92	0.881	−1.91
	PowerScope™	−2.13	2.56		−3.55	1.49		−5.66	3.25		−3.04
NLA°++	Class II elastics	0.22	11.33	0.979	0.27	11.96	0.163	0.48	11.01	0.204	0.17
	PowerScope™	0.33	7.31		7.71	12.08		7.01	11.6		3.77
FCA°	Class II elastics	−3.33	3.36	0.226	−1.61	2.79	0.182	−4.94	4.31	0.103	−1.73
	PowerScope™	−1.76	1.96		0.00	2.62		−1.8	3.95		−0.97

P-values for normally distributed data were calculated using the independent t-test; ++ Mann-Whitney U-test was used to compare non-normally distributed data; The asterisks indicated significant changes between groups: * P=.05; ** P=.01; *** P=.001; ****P=.0001.

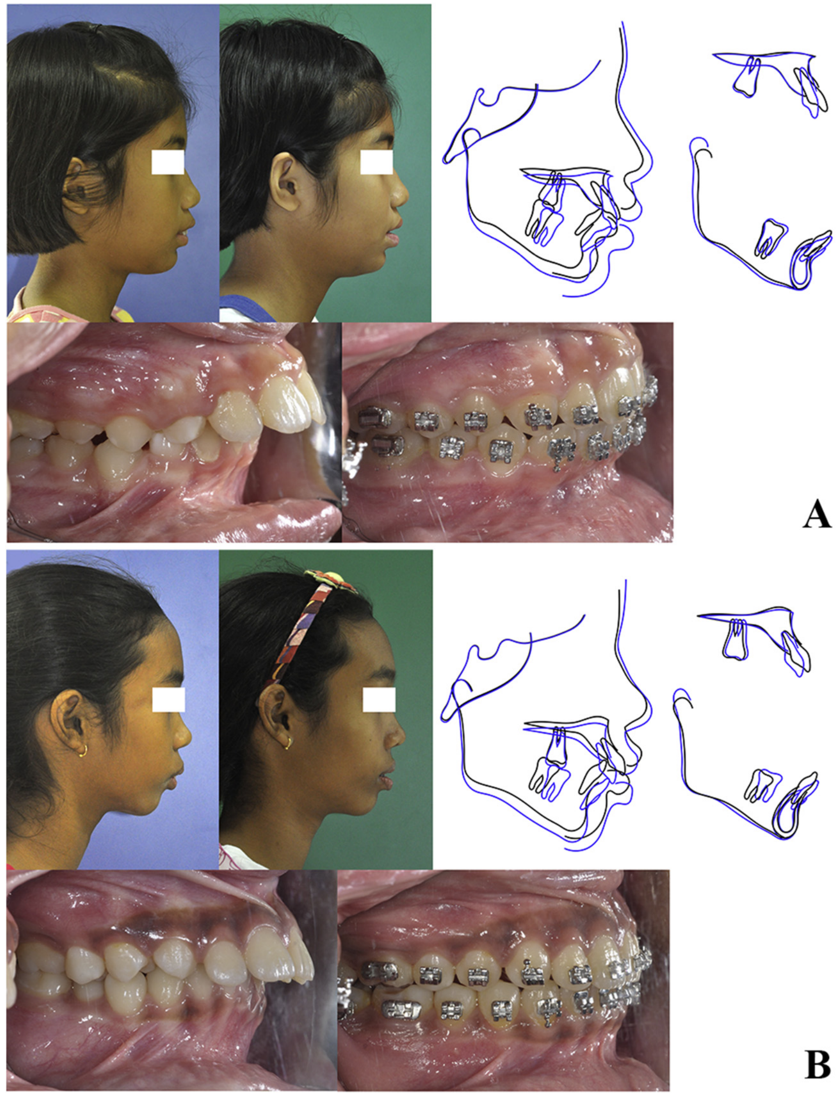

Fig. 4 – Cephalometric superimposition showing changes between T_0 to T_2 for (A) Class II elastics group and (B) PowerScope™ group.

almost 1 mm, while PDH_{mm} remained the same in the PowerScope™ group. Anterior dental height increased by nearly 1 mm in both groups. Overbite reduction was 0.7 mm more in the PowerScope™ group, but the difference was not significant.

3.3. *Differences in profile changes between groups*

Changes in nasolabial angle (NLA°) and facial convexity (FCA°) were not significantly different between groups. Nasolabial angle did not change in the Class II elastics group but became more obtuse (by nearly 4°/year) in the PowerScope™ group. Both treatments decreased profile convexity by 1–2°.

4. Discussion

4.1. *The PowerScope™ appliance*

Telescopic systems, popular derivatives of the Herbst appliance, do not require patient compliance. Various fixed function systems exist, such as the AdvanSync appliance [14], Forsus Resistant Device [15], Jasper jumper [16] and Twin Force Bite Corrector [17,18]; the PowerScope™ is one of the newest of these systems [19]. Fixed functional appliances induce skeletal and dental changes to correct Class II malocclusion [15,17]. Force is exerted posteriorly towards upper posterior teeth and anteriorly towards lower anterior teeth; the maxillary posterior teeth move distally and mandibular incisors move mesially [12]. Fixed functional appliances induce this "headgear effect"; the distal force exerted on the maxilla and maxillary teeth helps to correct a Class II relationship [17,20]. We found the PowerScope™ restrained the anterior maxilla at point A slightly more (though not significantly) than Class II elastics. The PowerScope™ also induced greater proclination of the lower incisors, as previously reported in fixed functional appliance [8,21]. A systematic review found functional appliances increased mandibular growth by more than 2 mm (vs. untreated patients) [5]. Of fixed appliances, the Herbst appliance was reported to stimulate the greatest extent of mandibular growth (0.28 mm/month [5];

3.36 mm/year). Similarly, we found the PowerScope^{TM} increased mandibular growth by 3.18 mm/year. However, appliance damage occurred in some patients, as previously reported [22,23].

4.2. *Class II elastics*

Class II elastics are widely accepted to effectively correct Class II malocclusion [24]; however, most studies focused on dentoalveolar changes [24]. Class II elastics lead to lingual tipping, upper incisor retrusion and extrusion, together with labial tipping and intrusion of mandibular incisors and mesialization and extrusion of mandibular molars [25,26]. We explored whether mandibular anterior position training could reduce the side-effects of Class II elastics and increase skeletal effects in growing patients. However, position training, even using light force elastics with a modified point of application, did not prevent unwanted dento-alveolar effects. It is possible that young patients did not practice adequate compliance or light force Class II elastics created forward movement of the mandibular teeth, as previously reported in treatment involving Class II elastics application [26]. The treatment effect in this study therefore appear as the result of both mandibular anterior position training and Class II elastics. Moreover, there might be a possibility that patients could bite in anterior position while taking cephalograms at T2 stage. So they were confirmed clinically as mentioned in data collection procedure. The cephalometric analysis in this study confirmed that the mandibular length increased. The superimposition of cephalometric radiograph also justified the constant Co position.

4.3. *Treatment comparison*

Treatment effects of fixed functional appliances and Class II elastics have previously been compared. An assessment of fatigue-resistant devices found no differences in the treatment effects of a fixed functional appliance and Class II elastics, though the fixed functional appliance was recommended for noncompliant patients [15]. The AdvanSync produced similar effects to Class II elastics, though elastics led to less maxillary growth restriction, but increased maxillary incisor retrusion and retroclination [14]. In this study, posterior dental height significantly increased and bite opening occurred as the mandibular plane angles enlarged in the Class II elastics group. In contrast, the headgear effect induced by the PowerScope^{TM} appliance prevented extrusion of the posterior teeth and limited backward mandibular rotation. Therefore, the greater mandibular growth observed in the Class II elastics group was not associated with a more forward pogonion position or greater reduction in profile convexity. Reduction of profile convexity is one of the most desirable objectives when treating Class II malocclusion. However, less convex [27], more convex, and insignificant [28] treatment-induced profile changes have been reported in Class II growing patients. Both treatment modalities in this study reduced the facial contour angle by around 1–2°, which could be advantageous when treating a Class II relationship. However, the treatment time employed both modalities were significant different. Class II elastics group required longer treatment duration to correct the occlusion from Class II to Class I. The post-treatment cephalometric data may be difficult to compare directly, so annualized changes were also shown in the result table (Table 4). Moreover, the difference in wire size between the 2 groups could influence the labiolingual inclination of anterior teeth. Even statistical significance was not found, the larger archwire in in fixed Class II corrector group should contributed to more upright incisal inclination. However, the result in Table 4 found more upright upper incisors from Class II elastics group in which side effect of Class II elastics might overcome the size of wire.

4.4. *Limitations and suggestions for future work*

We did not recruit an untreated control group due to the ethical problem of not treating patients at the optimal age of initiating treatment. Compliance was essential for anterior position training in the Class II elastics group, but was difficult to assess. Patients treated using the PowerScope^{TM} may require frequent visits for some of complications e.g. breakage and soft tissue irritation. Furthermore, we only explored the treatment effects of two appliances, and long-term treatment changes should be evaluated. The treatment effect of mandibular anterior position training and Class II elastics were inseparable in this study, therefore the result presented was the combination of both light elastics force and jaw training.

5. Conclusions

Both Class II elastics with anterior mandibular position training and the PowerScope^{TM} reduced the severity of Class II malocclusion and decreased profile convexity. However, Class II elastics with anterior mandibular position training required a longer duration of treatment. Moreover, Class II elastics mainly increased mandibular length and mandibular plane angles, with the undesirable effect of backward rotation, whereas the PowerScope^{TM} mainly restricted growth of maxillary dento-alveolar development.

Ethics approval and consent to participate

This study was approved by the ethics committee on human research at the Faculty of Dentistry, Prince of Songkla University (EC5803-05-P-HR) and registered in the Thai Clinical Trial Registry (ClinicalTrials.in.th: TCTR 20180220003). Informed consent was obtained from the subjects' parents before inclusion in the study.

Conflict of interest

The authors have declared no conflicts of interest.

Funding

Grant support from the Graduate School and Faculty of Dentistry of Prince of Songkla University.

Acknowledgments

We thank the Graduate School and Faculty of Dentistry, Prince of Songkla University for grant support and Dental-Siam company and American Orthodontics (AO) for providing the PowerScopeTM appliances.

REFERENCES

[1] Lux CJ, Raeth O, Burden D, Conradt C, Komposch G. Sagittal and vertical growth of the jaws in class II, division 1 and class II, division 2 malocclusions during prepubertal and pubertal development. J Orofac Orthop 2004;65(4):290–311.
[2] Baccetti T, Stahl F, McNamara Jr. JA. Dentofacial growth changes in subjects with untreated Class II malocclusion from late puberty through young adulthood. Am J Orthod Dentofacial Orthop 2009;135(2):148–54.
[3] Bishara SE. Mandibular changes in persons with untreated and treated Class II division 1 malocclusion. Am J Orthod Dentofacial Orthop 1998;113(6):661–73.
[4] Stahl F, Baccetti T, Franchi L, McNamara Jr. JA. Longitudinal growth changes in untreated subjects with Class II Division 1 malocclusion. Am J Orthod Dentofacial Orthop 2008;134 (1):125–37.
[5] Cozza P, Baccetti T, Franchi L, De Toffol L, McNamara Jr. JA. Mandibular changes produced by functional appliances in Class II malocclusion: a systematic review. Am J Orthod Dentofacial Orthop 2006129(5) 599.e1-12; discussion e1-6.
[6] Baccetti T, Franchi L, Kim LH. Effect of timing on the outcomes of 1-phase nonextraction therapy of Class II malocclusion. Am J Orthod Dentofacial Orthop 2009;136(4):501–9.
[7] Janson GR, Toruño JLA, Martins DR, Henriques JFC, De Freitas MR. Class II treatment effects of the Fränkel appliance. Eur J Orthod 2003;25(3):301–9.
[8] Flores-Mir C, Ayeh A, Goswani A, Charkhandeh S. Skeletal and dental changes in Class II division 1 malocclusions treated with splint-type Herbst appliances: a systematic review. Angle Orthod 2007;77(2):376–81.
[9] Proffit WR, Fields HW, Sarver DM. Treatment of skeletal problems in children and preadolescents. In: Proffit WR, Fields HW, Sarver DM, editors. Contemporary orthodontics. 5th ed. St. Louis: Mosby; 2013. p. 498–9.
[10] Björk A. Timing of interceptive orthodontic measures based on stages of maturation. Trans Eur J Orthod 1972;61–74.
[11] Grave K, Brown T. Skeletal ossification and the adolescent growth spurt. Am J Orthod 1976;69(6):611–9.
[12] Lai M, McNamara Jr. JA. An evaluation of two-phase treatment with the Herbst appliance and preadjusted edgewise therapy. Semin Orthod 1998;4(1):46–58.
[13] Dahlberg G. Statistical methods for medical and biological students. Br Med J 1940;2(4158):358–9.
[14] Jayachandran S, Wiltshire WA, Hayasaki SM, Pinheiro FH. Comparison of AdvanSync and intermaxillary elastics in the correction of Class II malocclusions: a retrospective clinical study. Am J Orthod Dentofacial Orthop 2016;150(6):979–88.
[15] Jones G, Buschang PH, Kim KB, Oliver DR. Class II non-extraction patients treated with the Forsus Fatigue Resistant Device versus intermaxillary elastics. Angle Orthod 2008;78 (2):332–8.
[16] Lima KJ, Henriques JF, Janson G, Pereira SC, Neves LS, Cançado RH. Dentoskeletal changes induced by the Jasper jumper and the activator-headgear combination appliances followed by fixed orthodontic treatment. Am J Orthod Dentofacial Orthop 2013;143(5):684–94.
[17] Chhibber A, Upadhyay M, Uribe F, Nanda R. Mechanism of Class II correction in prepubertal and postpubertal patients with Twin Force Bite Corrector. Angle Orthod 2013;83(4):718–27.
[18] Guimaraes Jr. CH, Henriques JF, Janson G, de Almeida MR, Araki J, Cançado RH, et al. Prospective study of dentoskeletal changes in Class II division malocclusion treatment with twin force bite corrector. Angle Orthod 2013;83(2):319–26.
[19] Paulose J, Antony PJ, Sureshkumar B, George SM, Mathew MM, Sebastian J. PowerScope a Class II corrector — a case report. Contemp Clin Dent 2016;7(2):221–5.
[20] Al-Jewair TS, Preston CB, Moll E-M, Dischinger T. A comparison of the MARA and the AdvanSync functional appliances in the treatment of Class II malocclusion. Angle Orthod 2012;82 (5):907–14.
[21] von Bremen J, Pancherz H, Ruf S. Reduced mandibular cast splints an alternative in Herbst therapy? A prospective multicentre study. Eur J Orthod 2007;29(6):609–13.
[22] Moro A, Janson G, Moresca R, de Freitas MR, Henriques JFC. Comparative study of complications during Herbst treatment with Cantilever Bite Jumper and removable mandibular acrylic splint. Dent Press J Orthod 2011;16:e1–e10.
[23] Silva JFE, Gerszewski C, Moresca RC, Correr GM, Flores-Mir C, Moro A. Retrospective study of clinical complications during orthodontic treatment with either a removable mandibular acrylic splint Herbst or with a cantilever Herbst. Angle Orthod 2014;85(1):64–71.
[24] Janson G, Sathler R, Fernandes TM, Branco NC, Freitas MR. Correction of Class II malocclusion with Class II elastics: a systematic review. Am J Orthod Dentofacial Orthop 2013;143 (3):383–92.
[25] Reddy P, Kharbanda OP, Duggal R, Parkash H. Skeletal and dental changes with nonextraction Begg mechanotherapy in patients with Class II Division 1 malocclusion. Am J Orthod Dentofacial Orthop 2000;118(6):641–8.
[26] Jones G, Buschang PH, Kim KB, Oliver DR, Class II. Non-extraction patients treated with the Forsus Fatigue Resistant Device Versus intermaxillary elastics. Angle Orthod 2008;78 (2):332–8.
[27] Baysal A, Uysal T. Soft tissue effects of Twin Block and Herbst appliances in patients with Class II division 1 mandibular retrognathy. Eur J Orthod 2013;35(1):71–81.
[28] Hourfar J, Lisson JA, Gross U, Frye L, Kinzinger GSM. Soft tissue profile changes after Functional Mandibular Advancer or Herbst appliance treatment in class II patients. Clin Oral Investig 2018;22(2):971–80.