AJDS LAZHAR Al-Azhar Journal of Dental Science
Vol. 25- No. 2- 223:231- April 2022
Print ISSN 1110-6751 | online ISSN 2682 - 3314
https://ajdsm.journals.ekb.eg
Orthodontic & Pediatric Dentistry Issue *(Orthodontics and Pediatric Dentistry)*

THREE-DIMENSIONAL EVALUATION OF THE EFFICACY OF POWERSCOPE APPLIANCE IN TREATMENT OF SKELETAL CLASS II MALOCCLUSION: A PROSPECTIVE CLINICAL STUDY

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ABSTRACT

Objectives: This study was conducted to evaluate the efficacy of Powerscope appliance in the treatment of skeletal Class II patients by three-dimensional image. **Subjects and methods:** This study was conducted on 14 orthodontic patients with a mean age of 15.39 ± 1.25 years old. The study included post-pubertal female patients with skeletal Class 2 of ANB angle greater than 4° due to the retruded mandible. Cone-beam computed tomography was made before (T1) and after (T2) installation of the Powerscope appliance. The images were imported into Invivo dental software version 5.2 for the measurements. The collected data were tabulated and statically analyzed using Statistical Package for the Social Sciences (SPSS) version 23. Paired t-test was used to study the changes after treatment. The significance level was set at ≤ 0.05. **Results**: Results showed statistically significant changes regarding skeletal and dental parameters. **Conclusions:** (1) Powerscope appliance provides an effective tool for the treatment of skeletal Class II adolescent patients. (2) Effects of Powerscope appliance were mainly dental with lesser skeletal effects. (3) The skeletal changes were seen in the mandibular base with minimal maxillary skeletal effects.

KEY WORDS: Powerscope appliance, Skeletal Class 2, Fixed functional appliance, Cone Beam Computed Tomography

INTRODUCTION

Skeletal Class 2 discrepancy had been one of the most encountered problems in the orthodontic practice. It affects about 20% of Egyptian patients seeking orthodontic treatment [(1)]. Skeletal Class 2 could be due to maxillary excess, mandibular deficiency, or a combination of both. The mandibular skeletal deficiency was found to be the main feature or factor that attributed to the development of more than half of the Class II patients [(2)].

Over the years, different protocols have been advocated for the treatment of skeletal Class 2, including a variety of fixed appliances, extraction procedures, maxillary molar distalization, extraoral traction, surgical orthodontic procedures, and functional orthopedic devices. Treatment choice depends upon the characteristics associated with the deformity, such as the amount of anteroposterior discrepancy, age, patient compliance, psychological implications, financial conditions, and treatment timing [(3)].

The treatment of skeletal Class II mandibular deficiency patients aims for forward positioning of the mandible or changing its growth to a more

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DOI: *10.21608/ajdsm.2022.94736.1287*

favorable direction. Various appliances had been used, either removable or fixed functional appliances, to bring these changes [4].

There is always controversy regarding the effectiveness of fixed functional appliances (FFAs) in stimulating mandibular growth; many studies have demonstrated the successful correction of skeletal Class 2 in adolescent patients through the use of FFAs. In addition, FFAs don't rely on patient compliance and shorten the treatment time as there is no need for two-phase treatment [5].

Powerscope (American orthodontics corporation, Sheboygan, Wisconsin, USA) is one of the recently introduced hybrid fixed functional appliances. It has one size that fits all patients with right and left different assemblies. There is no need for any special laboratory work or special clinical steps as the appliance allows an intermaxillary wire to wire installation using a nut with a hexagonal screw. The ball and socket joint maximize the lateral movements provided by the appliance and improve patient comfort [6-8].

The evaluation of the treatment effects using Powerscope appliance had been conducted in several previous studies using lateral cephalometric radiography which is a two-dimensional evaluation tool that is subjected to distortion, superimposing, and magnification [9]. This study evaluated the effects of Powerscope appliance using CBCT, which presents high accuracy and precision [10].

MATERIALS AND METHODS

Study design: A prospective clinical study.

Study setting and population:

The current study was conducted on fourteen female orthodontic patients. All patients received treatment at the outpatient clinic at Orthodontic Department, Faculty of Dental Medicine (Boys - Cairo), Al-Azhar University, Egypt.

Sample size calculation:

To determine the effective sample size, a statistical power analysis was conducted according to a previous study [11] depending on an acceptable level of significance (alpha = 0.05) and power of the statistical test of 0.90 with an estimated effect size of 1.2137477, resulting in a sample size of 10 patients and for the dropouts, fourteen patients were enrolled in the study.

Ethical considerations:

Ethical approval of the study was obtained from the Ethical Committee of the Faculty of Dentistry, Al-Azhar University, (Cairo, Boys) with reference number [99/110/03-19]. The patients and/or the guardians were informed about the nature and benefits of their participation in the study, and they signed informed consent before any further procedures.

Inclusion criteria:

(1) Healthy post-pubertal female patients with cervical vertebrae maturational stages 4, 5, and 6 according to Baccetti et al. [12]. (2) Skeletal Class II patients of ANB angle greater than 4° due to deficient mandible with/without maxillary protrusion. (3) Angle Class II division 1 malocclusion with at least an end-on Class II molar relationship. (4) Presence of all permanent dentition excluding third molars. (5) Good oral hygiene.

Participants:

This study involved a single group of patients treated using fixed orthodontic appliances and Powerscope as a fixed functional appliance. Due to the age difference of pubertal growth spurt peak and the amount of overall growth between males and females and to avoid any sexual dimorphism, only female patients were involved in the study to eliminate any gender-based difference that could affect the results. The patients were selected according to their skeletal maturation stages based on the modified cervical vertebrae maturation stages

by Baccetti et al [12]. Fourteen post-pubertal female patients with cervical stages 4, 5, and 6 (CS4, CS5, and CS6) were enrolled in the study.

Patient records: For each patient, the following diagnostic records were taken before the orthodontic treatment: extraoral and intraoral photographs, orthodontic study model, digital panoramic radiograph, and digital lateral cephalometric radiograph. CBCT images were taken before and after the treatment using the Powerscope appliance.

Operative procedures:

Fixed orthodontic appliances: Transpalatal arch (TPA) was fabricated and cemented on the first maxillary molar, and that was to counteract the buccal forces exerted by the fixed functional appliance; TPA should be spaced from the palatal mucosa by 1 to 2 mm to avoid ulceration or impingement into the soft tissue as a result of the intrusive forces of the fixed functional appliance. Pre-adjusted Roth appliance (Dentaurum Discovery Smart Metal Brackets Kit, Dentaurum GmbH & Co, 75228 Ispringen, Germany) was bonded (Grengloo for metal brackets, Ormco Co 1717 West Collins Avenue, USA) on the upper and lower arches with a 0.022" x 0.028" slot. The buccal tube (M-Series mini buccal tubes, Dentaurum GmbH & Co, 75228 Ispringen, Germany) was bonded to the second permanent molar to ensure its stability with the arch form and prevent it from any rotation or deviation. Leveling and alignment phase took place until reaching 0.019" x 0.025" stainless steel archwire (Dentaurum remanium ideal arches, Dentaurum GmbH & Co, 75228 Ispringen, Germany). Its duration was 7.5±1.5 months.

Appliance activation:

After Powerscope installation, initial activation of the appliance was done (Figure 1). The inner middle shaft of the telescopic system at the canine end has three activation lines spaced 2 mm apart, which reference the activation level of the NiTi spring, ranging from no activation to partial activation to full activation. After the appliance installation, the activation lines were observed. If there were no or partial activation, crimpable shims would be added until full activation. The appliance should be checked at each appointment (every month), removed, and cleaned. The molar relation was observed, and then the appliance was reinstalled. Stepwise mandibular advancement activation is done by adding 2 mm Crimpable shims every two months, according to Aras et al. [13], until reaching an edge-to-edge bite with an unstrained Angle Class I molar relationship. Hence, no further activation of the appliance was done.

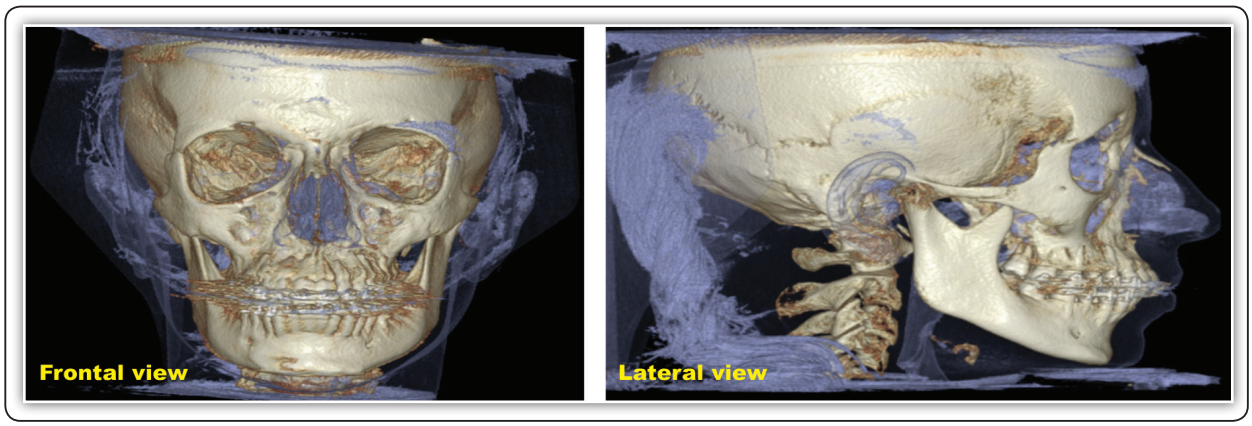
Appliance removal:

After six months of the treatment using Powerscope, the appliance was removed. Extraoral and intraoral photographs were taken as post appliance treatment records, and then the patient was sent to perform a cone-beam computed tomography. Finally, intermaxillary elastics (Wildlife Serie Elastomerics, American Orthodontics corporation, Sheboygan, Wisconsin, USA) were used to adjust the final occlusion.

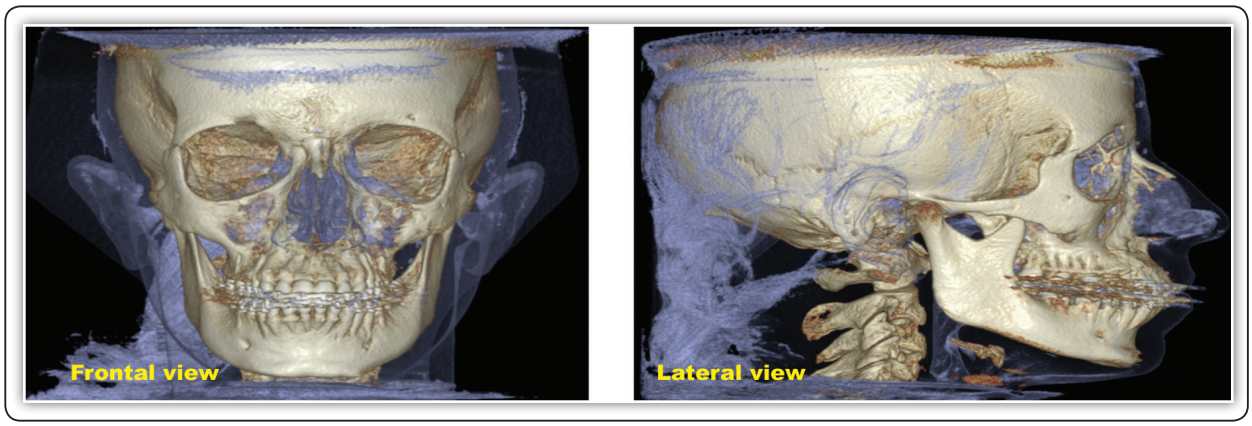
Cone Beam Computed Tomography (CBCT) images were taken before (T_1) and after (T_2) treatment using the Powerscope appliance. It was done using an I-Cat scanner (Imaging Sciences International, Hatfield, Pennsylvania, USA) under fixed parameters (120 KVP and 37 mA in 26.9 seconds) with an amorphous silicon flat-panel detector. Field of View (FOV) was 17x23 cm with voxel size 0.3 mm. The patients' heads were oriented with the Frankfurt Horizontal plane parallel to the floor and the mid-sagittal plane perpendicular to the floor. Instructions were given to the patients to maintain an upright standing posture and a natural head position with maximum intercuspation. The CBCT scans (Figure 1) were acquired in a Digital Imaging and Communications in Medicine (DICOM) format. The images were imported into Invivo (Anatomage Inc., San Jose, CA, USA) dental software version 5.2 for the measurements Table (1).

TABLE (1): Measurements used in this study.

Measurement	Definition
Skeletal Angular Measurements (degrees)	
SNA	The angle between 3-point landmarks Sella, Nasion, and A point, determines the anteroposterior position of the maxilla relative to the cranial base.
SNB	The angle between 3 point landmarks Sella, Nasion, and B point, determining the anteroposterior position of the mandible relative to the cranial base
ANB	The angle between 3 point landmarks, A point, Nasion, and B point, determining the anteroposterior relation between maxilla and the mandible relative to the cranium
Facial angle (FH-NPog)	The inferior inside angle in which intersection of the facial line (N-Pog) with Frankfort horizontal plane.
Skeletal Linear Measurements (mm)	
Lower anterior facial height (LAFH)	It is the vertical linear measurement from the ANS point to the Menton point.
Dental Angular measurements (degrees)	
U1-SN	The angle formed between the long axis of the upper central incisor (U1) and SN plane.
IMPA (L1-MP)	The angle formed between the long axis of the lower central incisor (L1) and the mandibular plane (MP).



(A) Before treatment with Powerscope appliance.



(B) After treatment with Powerscope appliance.

FIG (1): CBCT images. (A) Before treatment with Powerscope appliance. (B) After treatment with Powerscope appliance.

RESULTS

Dropouts: One patient was excluded from the study as she kept missing the appointments, didn't attain the oral hygiene measures, and repeatedly broke the fixed appliances. Therefore, the statistical analyses were performed on thirteen patients. The cervical vertebrae skeletal stages for the remaining thirteen patients were distributed as follows: 4 patients in cervical stage 4, 5 patients in cervical stage 5, and 4 patients in cervical stage 6.

Reliability and error analysis: Kolmogorov-Smirnov and Shapiro-Wilk tests were used to verify the normality of data distribution which showed normal distribution of all data. Parametric tests were used for statistical evaluation. Paired t-test was used for the normally distributed quantitative variables to compare the two periods (T_1 and T_2). Quantitative data were presented as mean and standard deviation with estimated upper and lower limits of the confidence intervals (CI) at a 95% confidence level. The significance of the obtained results was judged at the 5% level (P-value was considered significant at $P \leq 0.05$). The reliability of the analyzed data was verified using the method of intra-observer error assessment. A paired t-test was used to compare the first and second readings of 5 randomly selected patients with pre-and post-treatment CBCT images measured by the same investigator after three weeks interval.

Statistical and descriptive analysis: Table (2) shows descriptive statistics and comparison of skeletal and dental measurements before (T_1) and after (T_2) the treatment using Powerscope appliance.

Changes in the skeletal measurements:

There were statistically˚ significant ($P \leq 0.05$) decrease in SNA and ANB angle by -0.72˚ ± 0.4˚ and -2.58˚±0.58˚ respectively, while there were statistically significant ($P \leq 0.05$) increase in SNB and Facial angle by 1.87˚±0.59˚ and 1.52˚±0.89˚ respectively. The lower anterior facial height showed a statistically significant ($P \leq 0.05$) increase by 1.16 ± 1.42 mm.

Changes in the dental measurements:

There was a statistically significant ($P \leq 0.05$) decrease in the U1-SN angle by -6.49˚ ±4.19˚ and a statistically significant ($P \leq 0.05$) increase of the IMPA angle by 8.65˚ ±5.38˚.

TABLE (2): Descriptive statistics and comparison of skeletal and dental measurements before (T1) and after treatment (T2) using Powerscope appliance.

Parameters	T_1		T_2		$T_2 - T_1$				T value	p. value	Sig.
	Mean	SD	Mean	SD	Mean	SD	95% CI				
							LL	UL			
Skeletal Angular Measurements (degrees)											
SNA	81.63	1.63	80.91	1.59	-0.72	0.40	-0.96	-0.48	6.458*	<0.001*	S
SNB	74.47	1.50	76.34	1.63	1.87	0.59	1.51	2.22	11.486*	<0.001*	S
ANB	7.16	1.58	4.57	1.51	-2.58	0.58	-2.93	-2.23	16.092*	<0.001*	S
Facial angle	86.56	3.28	88.08	2.75	1.52	0.89	0.98	2.06	6.140*	<0.001*	S
Skeletal Linear Measurements (mm)											
LAFH	62.29	2.94	63.45	3.23	1.16	1.42	0.30	2.01	2.944*	0.012*	S
Dental Angular measurements (degrees)											
U1- SN	107.2	6.06	100.7	5.55	-6.49	4.19	-9.03	-3.96	5.583*	<0.001*	S
IMPA	103.9	4.94	112.5	6.82	8.65	5.38	5.40	11.90	5.800*	<0.001*	S

T1: Pre-treatment using Powerscope appliance, T2: Post-treatment using Powerscope appliance, SD: Standard deviation, C.I: Confidence interval, LL: Lower limit, UL: Upper Limit, S (*): Statistically significant at p ≤ 0.05.

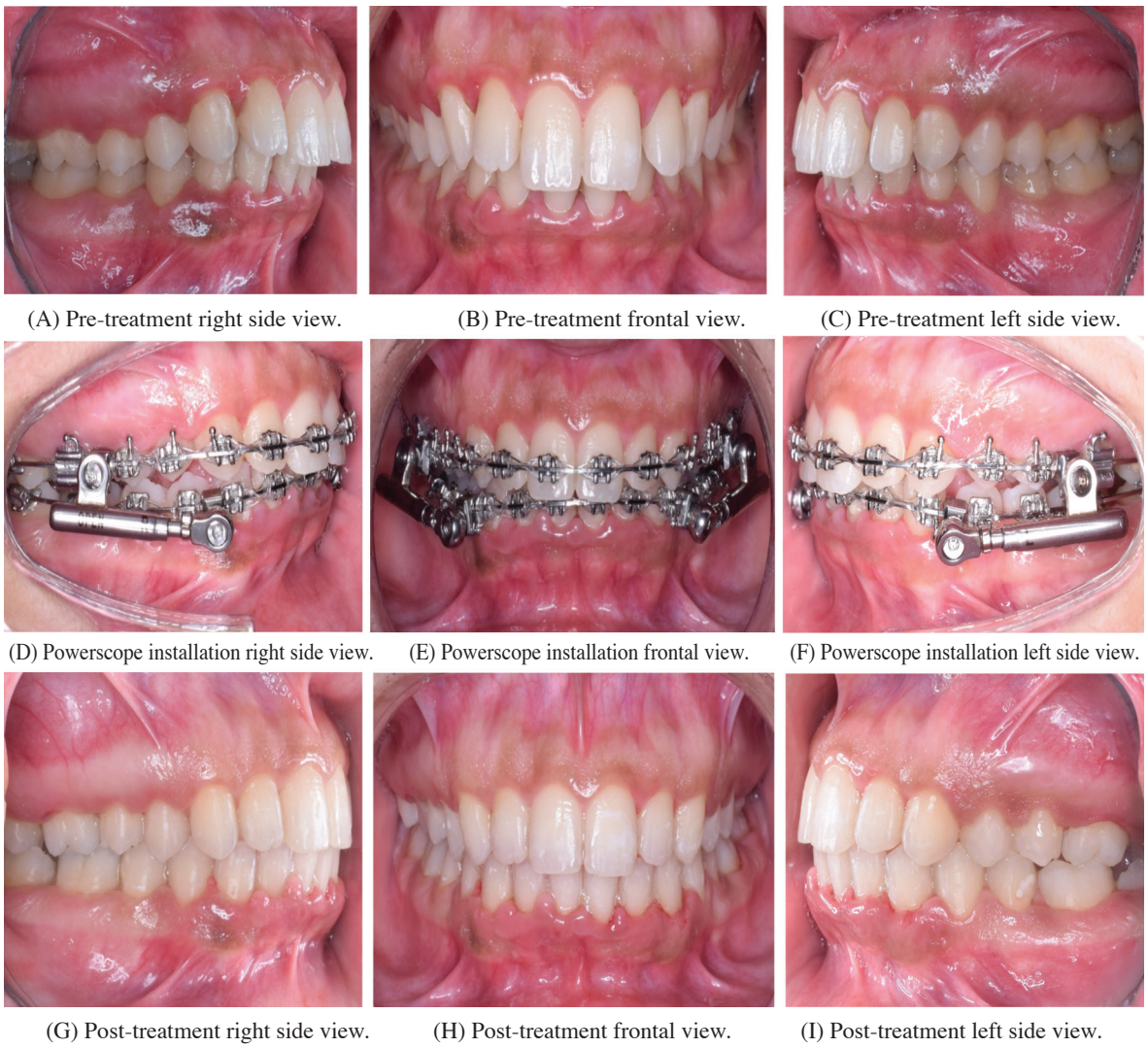


FIG (2): **(A,B,C)** Pre-treatment intraoral photographs, **(D,E,F)** Powerscope installation photographs, **(G,H,I)** Post-treatment intraoral photographs.

DISCUSSION

The present study included 14 orthodontic female patients, but unfortunately, one patient was dropped out, therefore the statistical analyses were performed on 13 patients. The mean age was 15.39 ± 1.25 years old. Only female patients were involved in the study to eliminate any sexual dimorphism that could affect the results of the study.

The duration of treatment using Powerscope appliance in this study was 6 months, similar duration was reported by previous studies [13-17] using Powerscope appliance. Other studies [18,19,23,24,28] reported a varied duration of Powerscope treatment ranging from 5 to 9 months until reaching a Class I molar relationship. In this study, a specific duration was used for fixation of the treatment time and precise evaluation of the appliance. Figure (2) shows pre-treatment, Powerscope appliance installation, and post-treatment intraoral photographs.

Changes in the skeletal measurements:

There was a statistically significant ($P \leq 0.05$) decrease in SNA angle which indicated the effect of Powerscope appliance on the restriction of the maxillary base that was agreed with the results reported by other Powerscope studies [23,24,16] in addition to studies [25,26,27] using Churro Jumper, Forsus Nitinol Flat Spring (FNFS), Jasper Jumper (JJ) and Sabbagh Universal Spring 2 (SUS 2) appliances. On the contrary, studies [11,14,18,19,17] using Powerscope appliance and other studies [20,21,22] using Mandibular Anterior Repositioning Appliance (MARA), Forsus Fatigue Resistant Device (FFRD) and Twin Force Bite Corrector (TFBC) appliances showed no statistically significant changes happened to SNA angle and consequently to the maxilla.

There was a statistically significant ($P \leq 0.05$) increase in SNB angle. This change was a result of the forward position of the mandibular base using the Powerscope appliance that brought the position of point B forward. That was in agreement with the results of Powerscope studies [(23,14,19,28,16,17)] in addition to the following studies [20,25,26,27] using MARA, Churro Jumper, FNFS, JJ, and SUS 2 appliances. On the contrary, studies [11,24] used the Powerscope appliance, and also studies [21,22] using FFRD and TFBC showed no significant change happened in the anteroposterior position of the mandible.

Regarding the maxillomandibular relationship, there was a statistically significant ($P \leq 0.05$) decrease of ANB angle that accounted for the minimal improvement of the sagittal intermaxillary jaw relationship. This was agreed with the results of studies[11,14,16,17,19,23,24,28] using PowerScope appliance and studies [20,21,22] using MARA, FFRD, and TFBC appliances. While a study [29] using Eureka Spring found no statistically significant change in the ANB angle.

The forward positioning of the chin takes place as a result of the action of the Powerscope appliance, which is explained by a statistically significant ($P \leq 0.05$) increase in the Facial angle. This was also found in Powerscope appliance studies [18,19,23] and a Churro Jumper study [25] which showed a statistically significant anterior or forward position of Pog point indicating forward positioning of the mandible.

There was a statistically significant ($P \leq 0.05$) increase in the lower anterior facial height (LAFH) which could be due to the distal movement of maxillary molars as a result of the distal force produced by the Powerscope appliance causing a wedging effect, this was agreed with the findings of studies [20,21] using MARA and FFRD. Other studies [17-19] showed no significant changes happened to the anterior facial height using the Powerscope appliance.

Changes in the dental measurements:

There was a statistically significant ($P \leq 0.05$) retroclination of the upper incisor with the decrease in U1- SN, which agreed with the results of Powerscope studies [14,23,24,28] in addition to studies [25,26,21] using Churro Jumper, FNFS, JJ, and FFRD appliances. On the contrary, studies [11,19,16,17] using Powerscope° appliance and a study [22] using TFBC showed no change in the upper incisor inclination.

There was proclination of the lower incisor with a statistically significant increase of IMPA by 8.65° ±5.38°, this agreed with the results of studies [11,23,14,16,17] using Powerscope appliance in addition to studies [20,25,29,21,27,22] using MARA, Churro Jumper, Eureka Spring, FFRD, SUS 2 and TFBC appliances. The findings were against the results of studies [28,24] using the Powerscope appliance, which showed no change in the lower incisor inclination.

CONCLUSIONS

The following conclusions could be drawn: (1) Powerscope appliance provides an effective tool for the treatment of skeletal Class II adolescent patients. (2) Effects of Powerscope appliance were mainly dental with lesser skeletal effects. (3) The skeletal changes were seen in the mandibular base with minimal maxillary skeletal effects.

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