ORIGINAL RESEARCH

Comparative Three Dimensional Evaluation of Dentoskeletal Parameters using AdvanSync & Herbst Appliance in Class II Malocclusion: "A Randomized Controlled Trial"

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Abstract

Aim: To evaluate and compare the dental and skeletal changes of AdvanSync and Herbst appliance using CBCT.

Materials and methods: A single blinded clinical trial was conducted with a total of 39 Class II division 1 patients during their skeletal growth spurt and were randomly divided into three groups; AdvanSync group (n = 13), Herbst group (n = 13), and fixed mechanotherapy group (n = 13) who matched for skeletal age, sex, and craniofacial morphology. CBCT was taken at Pretreatment (T1) stage and Post-treatment stage (T2) after 8 months of appliance placement. Treatment changes were evaluated between these two time points using dentoskeletal variables. Statistical comparisons were done using one-way ANOVA with post hoc Tukey's test.

Results: A significant mandibular growth increment with Herbst and significant headgear effect with AdvanSync appliance was observed as compared to fixed mechanotherapy group. Both appliances showed significant increase in total mandibular length, anterior, and posterior facial height.

Conclusion: The AdvanSync and Herbst appliance resulted in correction of the Class II malocclusion. The AdvanSync showed more dentoalveolar effects but less mandibular length increment when compared to Herbst.

Clinical significance: This study suggests that if the Class II malocclusion is due to retrognathic mandible mainly and the patient is in peak pubertal growth spurt, Herbst is the appliance of choice as this appliance supports more skeletal changes while in Class II malocclusion with a more dental and less skeletal contribution AdvanSync appliance works well. Also the age of the patient and compliance support the use of the AdvanSync appliance as for this appliance treatment duration is lesser and it is more patient friendly.

Keywords: AdvanSync, CBCT, Class II malocclusion, Fixed functional appliance, Herbst.

World Journal of Dentistry (2022): 10.5005/jp-journals-10015-2048

Introduction

Orthodontics is always aimed at the treatment of malaligned teeth and restoring a beautiful smile with enhancing the occlusion both functionally and esthetically. The imbalance in harmony of face and occlusion is reflected through soft tissue drape which follows skeletal and dental architecture. Among a number of dental and skeletal combinations which can create a class II malocclusion, the mandibular retrusion is the most common characteristics found in these patients. According to McNamara,[1] most of the skeletal class II patients have mandibular deficiency and he suggested growth modifying treatment modalities to treat the jaw at fault. Treatment ranges from dental compensation which includes camouflage with extractions to surgical procedures aiming at moving the jaw at fault. If growth is remaining, growth modification can be considered as an intermediate treatment option.

Skeletal class II correction by growth modification methods can be accomplished by either restriction of forward maxillary growth and promoting the forward mandibular growth leading to improvement in the anteroposterior jaw positioning. Pubertal growth spurt[2-5] (CS3–CS4[6]) is considered as the best time for orthopedic class II correction using growth modification procedures. Fixed functional appliances have proven to be efficient and compliant in correcting the sagittal malocclusion in a relatively shorter treatment duration. Herbst, an original bite jumping appliance was developed by Emil Herbst[7] and later revisited by Hans Pancherz[8] in 1979. Since then, a number of other fixed functional appliances have been reported in literature such as mandibular protraction appliance (MPA),[9] Jasper Jumper,[10] mandibular anterior repositioning appliance (MARA)[11] etc.

AdvanSync was developed by Terry Dischinger (2010) in conjunction with Ormco™ as a treatment option for skeletal class II malocclusion.[12] The appliance was designed to advance the mandible to class I occlusion within 6–9 months, while allowing for simultaneous use of fixed orthodontic appliances.

It has been shown that Cone-beam computed tomography (CBCT) is an accurate and reliable method as it has an inherent advantages of shorter radiation exposure and reduced image distortion due to patient movements and increased efficiency. Hence, this study was designed to evaluate and compare the

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How to cite this article: Kaushik K, Sidhu MS, Grover S, *et al.* Comparative Three Dimensional Evaluation of Dentoskeletal Parameters using AdvanSync & Herbst Appliance in Class II Malocclusion: "A Randomized Controlled Trial". World J Dent 2022;13(3):228–233.

Source of support: Nil

Conflict of interest: None

skeletal and dental changes produced by AdvanSync and Herbst appliance using CBCT (Planmeca, Helsinki, Finland).

Materials and Methods

This study got ethical approval on 23rd October 2018 and was registered in Clinical trial of India (CTRI/2020/09/ 027942) as well. The sample for the study consisted of 39 class II growing patients with age range of 12–14 years. Patients were screened from February 2019 to July 2019 for skeletal class II malocclusion with inclusion criteria:

- CVMI stages 2, 3, and 4
- Class II malocclusion with ANB >4°
- Retrognathic mandible
- Horizontal growth pattern
- Minimum crowding in dental arches
- Positive VTO.

The exclusion criteria were:

- Patients with Class II malocclusion with ANB <4°
- Vertical growth pattern
- Crowded dental arches.

Total 70 patients were selected form the outpatient department of SGT University, Gurugram. After initial screening 39 patients fulfilled the inclusion criteria and were included in the study. Sample size calculation was done by power analysis evaluation established by G*power, version 3.0.1 (Franz Faul Universität, Kiel, Germany). A sample size of 39 subjects would yield 80% power to detect significant differences, with effect size of 0.649* and significance level at 0.05. Selected sample was divided into three groups; group I ($n = 13$) treated with AdvanSync (Ormco, Glendora, CA, USA). Group II ($n = 13$) treated with Herbst appliance and group III ($n = 13$) treated by fixed mechanotherapy with class II elastics.

Randomization Method:

Randomization was conducted to computer generated allocation sequence of 1:1:1 to group I [treated with AdvanSync (Ormco, Glendora, CA, USA)], group II (treated with Herbst appliance), and group III (treated by fixed mechanotherapy). The researchers conducting the research were blind to the group allocation. After that each patient was then assigned to the particular group designated.

Diagnostic records included pre- and post-treatment intraoral and extraoral photographs, high quality impressions, and CBCT scans of all the patients at the beginning and after achievement of either class I molar relation or/ an interval of 8 months in all groups.

Methodology

In group I, treatment was started with AdvanSync appliance (Ormco Co, Glendora, Calif) which allowed simultaneous fixed orthodontic appliance treatment. The treatment protocols of the AdvanSync appliance included stepwise activation which was judged by the severity of overjet. Appliance was activated with 2–4 mm spacers every 3 months duration until an overcorrection was achieved. At each appointment, appliance breakage (if any), appliance fit, molar relation, midline shift, and occlusal disturbance were evaluated.

In group II, the Herbst appliance splints were inserted with the plungers and tubes engaged in order to check the length of lower plungers as they exit the distal end of upper sleeves. Appliance was tested for protrusive opening and lateral movements. group III patients had nonextraction treatment with fixed appliances using class II elastics and was selected to match the sample for chronological age, skeletal age (using CVMI staging) and time interval between the pretreatment and post-treatment scans.

CBCT Analysis

On Sagittal section of MPR view, keeping the skull oriented at FH and pterygoid vertical planes, z-axis was selected to be passing along midsagittal plane through nasion, anterior nasal spine, and menton. Following measurements were then taken on the sagittal section of MPR view and 3D surface rendered view (Fig. 1 and 2).

Method Error

To determine accuracy of the method, 10 randomly chosen CBCTs were reoriented and remeasured 2 weeks apart by one investigator using the same landmarks and variables included in this study. Measurements were calculated using the intraclass correlation coefficient, and they showed high reliability (between 0.887 and 0.997) and were all within 1 mm of the original. The average error did not exceed 0.3 mm. The descriptive analysis and comparability among the three groups in regard to Age, CVMI status, and sample size were done using one way ANOVA test, *Post Hoc* Tukey test, and Chi-square test. The *p*-value signifies that the mean values in all three groups were statistically nonsignificant ($p \geq 0.05$) and the groups were well matched before treatment (Table 1).

Statistical Analysis

Data collected was tabulated using Microsoft excel. Data was analysed using SPSS (Statistical Package for Social Sciences) version 20. [IBM SPASS statistics (IBM corp. Armonk, NY, USA released 2011)]. Descriptive statistics of the explanatory and outcome variables was calculated by mean, standard deviation for quantitative variables, frequency, and proportion was calculated for qualitative variables. Chi-square test by cross tabulation was used to compare frequencies. Normality of the data was assessed using Shapiro Wilk test. Comparison of means of various parameters at baseline and postintervention was carried out using paired *t*-test. Comparison of means of three groups was carried out using one-way ANOVA. *Post hoc* Tukey's test for data meeting the homogeneity of variance and *post hoc* Games Howell test for data violating the assumption of homogeneity of variances was used. Any *p*-value less than 0.05 was considered to be significant for all analyses (two-tailed).

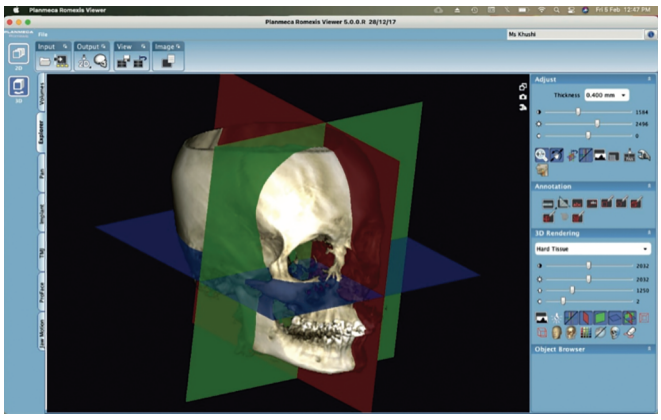


Fig. 1: Skull orientation in all three planes (Sagittal, Vertical, Transverse)

Intraexaminer reliability was determined based on the calculation of the intraclass correlation coefficient (ICC), with a 5% level of significance ($p \leq 0.050$) and the calculation of 95% confidence intervals. Bland-Altman agreement analysis was also employed. Measures were in agreement as the bias (difference between measures) was less than 5°, and when 95% of the measures of the subjects were within the upper and lower limits of agreement.

Results

Group I, II, and III were compared for skeletal and dentoalveolar changes following Advansync, Herbst and fixed mechanotherapy with class II elastics, ,respectively. Skeletal changes (T2–T1) of all the three groups were compared using One way ANOVA and *Post hoc* Tukey test (Table 2). A significant improvement was found in SNB values of all the three groups. Herbst group showed the maximum increment (1.71°) followed by AdvanSync (1.2°) and fixed mechanotherapy (0.06°).

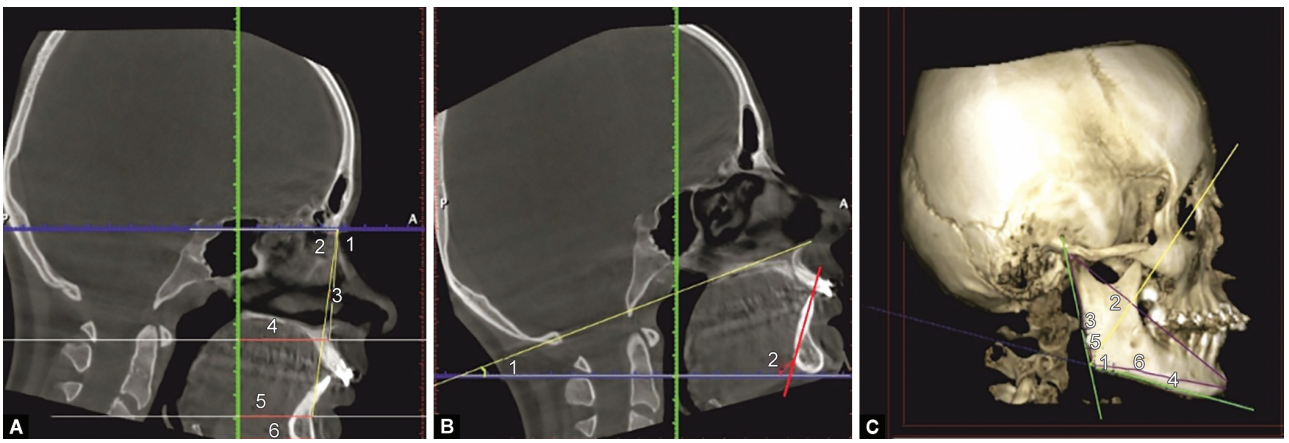
AdvanSync restricted maxillary growth ''headgear effect'' as indicated by SNA. A very high statistically significant ($p \leq 0.001$) difference was found in ANB value and WITS appraisal among the three groups. Group I showed the highest reduction in ANB value and WITS appraisal postintervention showing maximal skeletal advancement of point B followed by group II and then group III. Both AdvanSync and Herbst groups showed significant increase in the total lengths of the mandible (Co-Pog) though statistically not significant (Table 2).

The intergroup comparison of dentoalveolar changes (T2–T1) of all the three groups showed a very high statistically significant ($p < 0.001$) increase in IMPA angle in group I and II. A high statistically significant ($p < 0.01$) reduction in U1-FH angle was observed when we compared all the three groups. Group I showed maximum reduction in U1-FH followed by group III and group II indicating reduction in axial inclination of upper central incisor. A very high statistically significant ($p \leq 0.001$) reduction in overjet was also observed when we compared all the three groups (Table 3).

Discussion

A number of treatment modalities have been developed for treatment of class II malocclusion which include extractions, orthopaedic correction using headgear, removable, or fixed inter arch/ intra arch functional appliances and orthognathic surgeries. The functional appliances used during active growth period are intended to produce maximum skeletal growth. However it is difficult to quantify the exact amount of skeletal and dental change after the treatment with different functional appliances. This study was conducted to know the mode of action and to quantify the skeletal and dental changes produced as a treatment effect of the two fixed functional appliances and to compare it with fixed mechanotherapy.

The changes in AdvanSync and Herbst group were a combination of appliance therapy and pubertal peak of growth. However, available data that examine extent of dentoalveolar vs skeletal adaptation in class II correction with the use of functional appliances are controversial.[13] Reduction in SNA angle in Advansync group and fixed mechanotherapy group indicated a restraining effect on maxillary growth and was supported by a reduction in point A to PT vertical distance in AdvanSync and fixed mechanotherapy group by 0.2 mm and 0.13 mm ,respectively



Figs 2A–C: Dentoskeletal parameters used in the study. (A) Sagittal section of MPR view showing (1) SNA, (2) SNB, (3) ANB, (4) A- PT vertical, (5) B- PT vertical, (6) Pog- PT vertical. (B) Sagittal section of MPR view showing 1) PP- MP Angle, 2) IMPA. (C) 3D surface rendered view showing (1) Gonial angle, (2) Co- Pog, (3) Co-Go, (4) Go-Gn, (5) Upper gonial angle, (6) Lower gonial angle

Table 1: Descriptive analysis and comparability among Group I (Advansync), Group II (Herbst), Group III (fixed mechanotherapy) regarding age, CVMI status, and sample size

			CVMI	
Group	*Sample size*	*Age*	*Stage 3*	*Stage 4*
Group I	15	12.67 ± 0.617	7	8
Group II	15	12.8 ± 0.676	6	9
Group III	10	13 ± 0.667	4	6
Total	40	–	17	23

Not Significant- $p \geq 0.05$
Tests used are ANOVA, *Post hoc* Tukey HSD test, Chi-square test

showing the distal displacement of point A. Jayachandran et al.[14] and Al-Jewair et al.,[15] also concluded that the major skeletal effects of AdvanSync appliance was restriction of maxillary growth and short-term orthopedic effect of the appliance.

There was significant improvement in SNB contributed by forward displacement of mandible this was mainly due to growth stimulation in the condylar cartilage in response to the bite jumping mechanism in AdvanSync and Herbst appliance.[16-19] This was

Table 2: Intergroup comparison of skeletal treatment changes (T2-T1) of Group I (AdvanSync), Group II (Herbst), and Group III (Fixed mechanotherapy)

		Group I		*Group II*		*Group III*		*One-way ANOVA*	*Group I vs Group II*	*Group I vs Group III*	*GroupII vs Group III*
S. NO.	*Variable*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*p-value*	*p-value*	*p-value*	*p-value*
1	SNA (°)	–1.62	2.52	–0.51	2.75	–0.76	1.18	0.421	>0.05	>0.05	>0.05
2	A-PT vertical (mm)	–0.2	1.81	0.47	2.13	–0.13	2.44	0.652	>0.05	>0.05	>0.05
3	SNB (°)	1.2	3.3	1.71	2.91	0.06	0.71	0.341	>0.05	>0.05	>0.05
4	Co-Pog (mm)	2.33	3.55	3.21	1.77	2.26	3.27	0.635	>0.05	>0.05	>0.05
5	Pog- PT vertical (mm)	1.08	3.06	4.84	3.92	0.59	3.24	0.005**	0.014*	0.935	0.013*
6	B-PT vertical (mm)	1.39	3.52	4.49	3.66	0.33	2.62	0.009**	0.043*	0.724	0.013*
7	Go-Gn (mm)	0.72	5.37	2.93	2	0.09	3.17	0.054	>0.05	>0.05	>0.05
8	Co-Go (mm)	3.65	4.11	0.13	4.49	2.59	3.3	0.067	>0.05	>0.05	>0.05
9	Gonial angle (°)	–0.71	3.92	0.78	2.26	1.96	2.98	0.12	>0.05	>0.05	>0.05
10	Lower gonial angle (°)	0.52	3.93	2.69	2.54	1.34	2.64	0.178	>0.05	>0.05	>0.05
11	ANB (°)	–3.57	1.57	–1.96	1.78	–0.82	0.88	0.0001***	0.017*	0.0001***	0.173
12	WITS (mm)	–5.02	1.85	–3.38	1.09	–1.11	1.22	0.0001***	0.01**	0.0001***	0.001***
13	Na-Me (mm)	1.91	3.24	3.67	2.57	3.22	2.62	0.233	>0.05	>0.05	>0.05
14	S-Go (mm)	1.71	2.63	1.49	2.25	0.83	1.46	0.625	>0.05	>0.05	>0.05
15	ANS-Me (mm)	2.5	2.39	3.07	2.77	1.11	2.21	0.168	>0.05	>0.05	>0.05
16	PP to MP angle (°)	–1.75	3.35	-0.46	3.19	0.65	1.8	0.15	>0.05	>0.05	>0.05
17	FMA (°)	0.51	2.45	0.14	1.11	0.67	1.74	0.76	>0.05	>0.05	>0.05

Not Significant- $p \geq 0.05$; Significant (*) $p \leq 0.05$; Highly Significant (**) $p \leq 0.01$; Very Highly Significant (***) $p \leq 0.001$

Table 3: Intergroup comparison of dental treatment changes (T2-T1) of Group I (AdvanSync), Group II (Herbst), and Group III (Fixed mechanotherapy)

		Group I		*Group II*		*Group III*		*One-way ANOVA*	*Group I vs Group II*	*Group I vs Group III*	*GroupII vs Group III*
S. NO.	*Variable*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*p-value*	*p-value*	*p-value*	*p-value*
1	U1-FH angle (°)	–7.32	6.14	–0.89	3.79	–3.27	7.03	0.012*	0.009**	0.197	0.56
2	U1-PT vertical (mm)	–1.09	4.02	0.11	2.46	–2.48	4.99	0.261	>0.05	>0.05	>0.05
3	U6 MB cusp tip -PT vertical (mm)	–0.95	4.46	0.02	2.71	1.32	1.82	0.261	>0.05	>0.05	>0.05
4	U6-FH (mm)	0.31	1.63	0.81	1.53	0.98	1.37	0.516	>0.05	>0.05	>0.05
5	IMPA (°)	8.41	6.09	5.97	4.87	–0.13	3.78	0.001***	0.404	0.001***	0.017*
6	L1-PT vertical (mm)	3.11	3.38	4	2.86	–0.27	2.72	0.005**	0.706	0.026*	0.004**
7	L6 MB cusp tip-PT vertical (mm)	3.65	3.95	5.31	3.32	1.42	2.58	0.03*	0.388	0.26	0.022*
8	L6-FH (mm)	0.53	2.56	2.65	3.73	1.1	1.29	0.126	>0.05	>0.05	>0.05
9	FMIA (°)	–2.33	21.46	–4.67	8.74	–2.31	7.42	0.888	>0.05	>0.05	>0.05
10	Overjet (mm)	–5.21	2.01	–4.33	1.63	–1.37	1.17	0.0001***	0.342	0.0001***	0.000***

Not Significant- $p \geq 0.05$; Significant (*) $p \leq 0.05$; Highly Significant (**) $p \leq 0.01$; Very Highly Significant (***) $p \leq 0.001$

reflected by increase in point B- PT vertical distance in both groups. Also, linear distance between Pog and Pt vertical increased in patients treated with both AdvanSync and Herbst appliances which was due to forward displacement of mandible as well as increase in mandibular length following after the functional appliance therapy. Petrovic et al.[17] showed that additional growth of the condylar cartilage was due to hyper propulsion effect of the fixed functional appliances which stimulated the prechondroblastic zone cells.

An increase in mandibular length was observed which was equivalent to the growth-related changes as all the patients were in peak pubertal growing age. An increase in mandibular basal length (Go-Gn) was observed in Herbst group which showed mandibular skeletal growth whereas AdvanSync and fixed mechanotherapy groups showed negligible effect. Maximum increment in ramal height (Co-Go) was also observed in AdvanSync group. Study done by Sidhu et al.[20] has also reported similar effects of the Herbst appliance on mandibular growth.

An anticlockwise rotation of the mandible in AdvanSync group was observed which could be attributed to headgear effect of the appliance which favours an autorotation of the mandible in upward and forward direction. Whereas the Herbst group and fixed mechanotherapy group showed backward rotation of the mandible as the gonial angle increased in these groups owing to growth rotations. Maximum increase in lower facial height was also seen in Herbst group, supporting a clockwise rotation of the mandible.[20]

A strong linear relationship exists between the mandibular forward growth and the dentoalveolar complex.[21] Martin et al.[22] found an association between amount of the forward movement of mandible and incisor proclination. Moreover, the telescopic system of fixed functional appliances exerts a downward and forward force vector on the mandibular dentoalveolar complex which leads to mesialisation of mandibular dentition. In the present study, there was reduction in U1-FH angle in AdvanSync and in fixed mechanotherapy group showing distal tipping of the incisors leading to a significant correction in overjet. In addition there was a maxillary restraining effect in the AdvanSync group which added to the total correction of the axial inclination of upper incisors. Palatal displacement of upper incisors with respect to pterygoid vertical were the observations in AdvanSync and fixed mechanotherapy groups.

In Herbst and fixed mechanotherapy group, the upper first molar distance from pterygoid vertical was increased indicating mesialisation of maxillary molars. Johnston[23] described a continuous forward natural growth vector which could push the maxillary dentition forward through maxillomandibular intercuspal locking. Also mesialisation of lower molars with respect to pterygoid lead to correction of molar relation in this study. Pancherz[24] documented a hypothesis that when the jaws are separated there is an increase in the passive tension of the stretched muscles which delivers proportional amount of mesially directed force on the lower incisor to the vertical opening done. An increase in IMPA angle was observed in AdvanSync and Herbst ,respectively though the later group had more control over lower incisor inclination because of the acrylic splint design used in the present study.

AdvanSync treatment resulted in a total improvement of overjet by 5.79 mm; out of which 1.59 mm (27.5%) was due to skeletal changes and 4.2 mm (72.5%) was due to dental changes. Overall dental contribution in class II molar correction was 74.3% with AdvanSync appliance treatment. Herbst treatment resulted in a total improvement of overjet by 7.91 mm which was a contribution of 50.8 % skeletal changes and 49.2 % dentoalveolar changes. Treatment effects produced by Herbst appliance resulted in the overall improvement of the dentofacial structures in class II malocclusion patients with small mandible, with almost 50.8% skeletal and 49.2 % dental contribution. While in fixed mechanotherapy group overjet correction of 2.67 mm was observed with 17.3% skeletal and 82.7% dental contribution in overjet correction.

This is first randomised clinical trial comparing the effects of AdvanSync and Herbst appliance on dentoskeletal structures using CBCT. Further studies with increased number of patients and comparison with control sample are encouraged to find out growth changes in this field. The limitation of this study is smaller sample size and the different growth period of the patients as the patients taken in this study fall in two different CVMI stages (3,4), which might lead to bias in the results obtained.

Conclusion

It was concluded from the present study that there was a significant increase in SNB angle in both AdvanSync group and Herbst group whereas negligible change were observed in fixed mechanotherapy. Total mandibular length (Co-Pog) was increased in subjects treated with both AdvanSync and Herbst appliance by 2.33 mm and 3.21 mm, respectively. In AdvanSync group, there was a total overjet correction of 5.79 mm out of which 27.5% was due to skeletal change and 72.5 % was due to dental change. The Herbst group showed an improvement in overjet by 7.91 mm which was contributed by 50.8% skeletal and 49.2% dental changes.

Acknowledgment

We are highly indebted to Oral Medicine and Radiology Department for their great support throughout study.

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