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Efficiency of Skeletal Class II Malocclusion Treatment Using Herbst Appliance (Type II)

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ABSTRACT

Purpose: The aim of this study was to assess the skeletal and dentoalveolar treatment outcomes using Herbst type II appliance with multibracket system in treatment of skeletal Class II malocclusion. **Subject and Methods:** The present study was applied on ten female patients with age ranges 12-13 years old, with skeletal Class II Division 1 malocclusion (deficient mandible). The line of treatment was to use nonextraction fixed functional appliance (Herbst) type II with multibracket system. Pre and post-treatment lateral cephalometric radiograph were obtained, cephalometric analysis and superimposition was performed to assess changes in skeletal and dentoalveolar structure. **Results:** Class II correction was obtained mainly by dentoalveolar effects, which include statistically significant lingual inclination of the upper incisors and labial inclination of the lower incisors with mesializiation of the lower molars. There was relative mandibular length increase with maxillary restriction. $P \leq 0.05$. **Conclusions:** Skeletal Class II Divison 1 in adolescent patients can be effectively treated by Herbst type II with multibracket system. Both skeletal and soft tissue profile convexities are reduced as a result of dentoalveolar changes with mandible growth and forward movement.

KEYWORDS

Class II malocclusion,
Fixed functional appliance,
Herbst appliance

INTRODUCTION

The literature described Class II division 1 to have primarily a retrognathic mandible and a small percentage of prognathic maxilla with variable vertical dimensions [(1)]. The prevalence of Class II comes after

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Class I malocclusion in the Egyptian population with a 20.6% in age ranges of 11-14 years old [2].

The mandibular length deficiency is most significant at the adolescent growth spurt which is equivalent to 12-13yrs of age in females and 13-14yrs of age in males and it is maintained at the post-pubertal time. Class II dentoskeletal malocclusions do not appear to self-correct with development of the mandible, and even worsening of the deficiency in mandibular dimensions had been reported [3].

The non-extraction Class II treatment induced overall regularization of the skeletal relationships and Class II orthodontic treatment had a great impact on the dental relationship. Therefore, interventional therapy at the crucial time of Class II malocclusions has been advocated [3, 4].Functional appliances have become a common part of modern orthodontic practice, but their mechanism of action, specifically their ability to increase mandibular growth and thus result in a long-term improvement in the skeletal pattern, is still debatable [3, 4].

All removable appliances, for example: the Bimler\Bionator, Functional regulator, Twin block had proved effectiveness in Class II skeletal malocclusion treatment, the main issue with those kind of appliances is the patient cooperation as fixed appliances such as Herbst appliance offers significantly higher cooperation rates for adolescent patients [5]. The Herbst appliance was introduced in 1905 but it was recognized for its possibilities for mandibular growth stimulation and it revived interest in the late 1970s [6].

Several updates to the original design have emerged since then. The Herbst appliance with bonded upper and lower acrylic splints, the cast splint Herbst appliance in combination with the headgear, the Herbst appliance with a mandibular acrylic splint and stainless steel crowns on the first maxillary molars and a Herbst mechanism with ball and socket hinges with cast splints are all examples of the various appliance modifications [7].

The edgewise Herbst was the first to elicit the idea of integration between the stainless steel Herbst mechanism with upper and lower fixed multibracket appliance to maximize the skeletal effect [8]. The Integrated Herbst (IHA) was first proposed in 1997 as a straightforward way of combining the multiphase of the Herbst into a single efficient process at pubertal growth spurt [7].

The integrated Herbst idea then faded away till a recently introduced modification of Herbst , which is the type II Herbst appliance, it consists of a bilateral buccal rigid telescopic tube and rod that is screwed using a nut and small screw into the arch wire of a multibracket system [7].

Therefore, the Herbst appliance was proven historically effective in producing a skeletal effect in treating Class II malocclusion in conjugation with a multibracket system to save time, stabilize the occlusion, decrease the flaring of mandibular incisors and decrease the amount of relapse post treatment. So, this study was done to evaluate the dentoskeletal effect of Herbst type II appliance with multibracket system in the treatment of Class II skeletal malocclusion in adolescent female patients[9].

SUBJECT AND METHODS

This research included ten female patients ranging in age from 12 to 13 years old who had mild to moderate Skeletal Class II malocclusion and an ANB angle greater than 4 degrees. Before the research began, the patients and guardians were completely briefed about the procedures, and informed written consents were obtained. The Ethical Committee of Faculty of Dental Medicine for Girls, Al-Azhar University approved this research under the ethics code number of REC 17-103.

Sample size calculation:

Using the data obtained in Hägglund et al. (2008) the effective size was 1.707 (*G*Power 3.1.9.7)

Utilizing this number with error $\alpha = 0.05$ the following power analysis can be performed with a total sample of 10 patients after 15% dropout rate.

Input:	Output:
Tail(s) = Two	Noncentrality parameter δ = 4.517
Effect size dz = 1.707	Critical t = 2.447
α err prob = 0.05	Df = 6
Power (1-β err prob) = 0.95	Actual power = 0.961 Sample size = 7

The following diagnostic orthodontic records were obtained for each patient before treatment:

- Examination sheet.
- Upper and lower orthodontic study casts.
- Extra and intra-oral photographs.
- Digital Panoramic radiograph.
- Digital Lateral Cephalometric radiograph.

All participants underwent bonding of fixed orthodontic appliance (Mini 2000 Metal Bracket Ormco USA, Grēngloo Adhesive and Composite Kit Ormco USA). Sequential orthodontic arch wires were used starting from 0.012′ Ni-Ti up to 0.019×0.025′ St-St. arch wire (Modern orthodontics, USA).

Herbst type II appliance is a rigid hinge fixed functional appliance (telescopic tube and rod) to use on the upper and lower arch wire of a multibracket appliance. The Herbst II retention hinge is fitted with a special connector, which can be used for attaching hinges to the existing arch wire (the strongest possible) of a multibracket appliance. This produces maximum anchorage without having to rely on the cooperation of the patient (e. g. headgear) (Fig.1).

The connector (nut) of the hinge has a slot that is fitted onto the existing arch wire of the multibracket appliance and then secured to the arch wire with the screw supplied using a sterilizable hexagon socket screw key of 1.5 mm diameter. Various spacers (1-5mm) are available if activation is necessary. The patient is asked to bite in a Class I or edge to edge bite and the hinges and rod are shortened accordingly and respectively (Fig. 2).

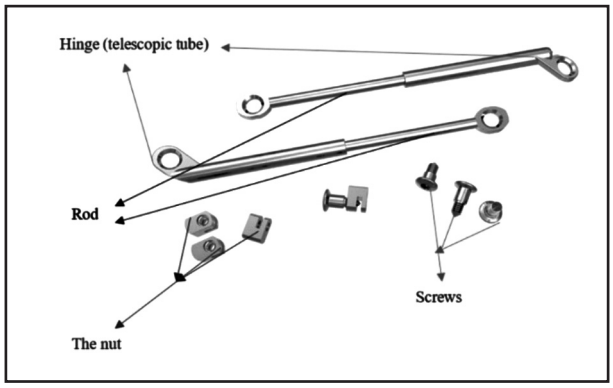

Figure (1) Herbst type (II) appliance kit.

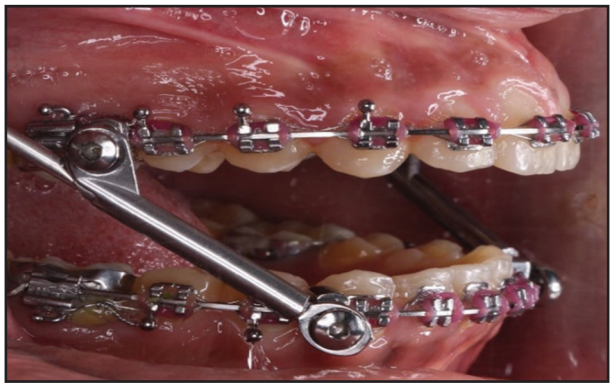

Figure (2) Herbst hinge fixed with special connectors and screws intraorally

The Herbst (type II) appliance was used until the patient's mandible could not be manipulated more posterior than one mm overjet inter-dental relationship. Molar relation and canine relation are corrected to Class I, then appliance was removed and 0.018″ St-St arch wire placed and the patient was instructed to use 3/16″ heavy inter-maxillary elastics for three months from the maxillary canines and first premolars to the mandibular first and second premolars for posterior occlusion settling.

The postoperative records included extra oral photographs, intra oral photographs and lateral cephalograms which were obtained after an average observation time of 6 to 8 months. Intra and inter-examiner assessment from pre and post cephalometric radiographs were recorded,

measured and compared using angular and linear measurements. The intra-examiner was done by re-measuring after 2 days. The inter-examiner was an orthodontic master postgraduate student at the Faculty of Dental Medicine, Al-Azhar University.

Digital superimposition of the tracings by WebCeph™ using the anterior cranial base (sella-nasion) line according to Björk (1955) was done to evaluate and visualize the treatment results (Fig. 3).

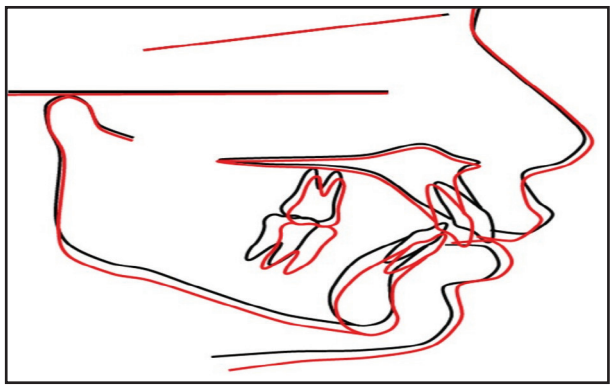

Figure (3) Superimposition of pretreatment tracing in (black) and post-treatment in (red)

Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests in addition to checking data distribution using histogram. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

RESULTS

The present study was done to assess the skeletal and dentoalveolar changes in Class II malocclusion subjects with fixed functional appliance therapy using Herbst (type II) with multibracket system.

Demographic data:

The present study was conducted on 10 female patients (100%). The mean and (standard deviation) values of age were 12 ±1 years old.

The number of recruited cases were 12 subjects with age ranges from 12-13 years old, where the dropout percentage was 15%, subject no.1 in the dropout encountered repeated loosening of the screws, falling off the device and losing its parts, therefore she was switched to camouflage treatment. Subject no.2 was inaccessible and out of contact during the pandemic of Covid-19.

All data showed normal (parametric) distribution. Numerical data were presented as mean and standard deviation (SD) values. For parametric data; paired t-test was used to compare between measurements pre- and post-treatment. For non- parametric data; Wilcoxon signed-rank test was used to compare between measurements pre- and post-treatment. Intra- and inter-observer agreement (reliability) was assessed using Cronbach's alpha and Intra-Class Correlation Coefficient (ICC). The significance level was set at $P \leq 0.05$.

Reliability analysis

Inter-observer reliability: There was good to perfect inter-observer reliability (agreement) regarding all measurements with Cronbach's alpha values ranging from 0.747 to 0.1.

Intra-observer reliability: There was very good to perfect intra-observer reliability (agreement) regarding measurements with Cronbach's alpha values ranging from 0.824 to 1.

Skeletal effects: (Table 1)

- There was a statistically significant decrease in mean SNA° and ANB° measurements post-treatment.
- There was a statistically significant increase in mean SNB° measurements post-treatment.
- There was a statistically significant increase in mean total mandibular length (Cd-Me) measurements post-treatment.

Table (1) *Mean, standard deviation, and paired t-test results for comparing pre- and post-treatment skeletal measurements*

Measurement	Pre-treatment (n = 10)		Post-treatment (n= 10)		Change		*P*-value	*Effect size (d)*
	Mean	SD	Mean	SD	Mean	SD		
SNA°	79.7	0.67	79	0.82	-0.7	0.67	0.00953*	0.935
SNB°	74.1	1.20	76.5	0.97	2.36	0.67	<0.0001*	2.201
ANB°	5.6	0.67	2.7	0.48	-2.9	0.57	<0.00001*	4.147
Total mandibular length (mm)	100.9	5.40	102.4	5.17	1.5	1.35	0.0066*	0.285

**: Significant at P ≤ 0.05 Sample size= 10 patients*

Dental effects: (Table 2)

- There was a statistically significant decrease in mean U1/SN° measurements post-treatment.
- There was no statistically significant U6-N vertical (mm) measurements post-treatment.
- There was a statistically significant decrease in mean L1/SN° measurements post-treatment.
- There was a statistically significant decrease in mean and L6-N (mm) post-treatment.
- There was a statistically significant decrease in mean overjet (mm) and overbite (mm).

Table (2): *Mean, standard deviation, and paired t-test results for comparing pre- and post-treatment dental measurements*

Dental measurem-ents	Pre-treatment (n = 10)		Post-treatment (n = 10)		Change		*P*-value	*Effect size (d)*
	Mean	SD	Mean	SD	Mean	SD		
U1/SN (°)	111.6	6.19	106.6	5.5	-5	3.29	0.0009*	0.854
U6-N vertical (mm)	25.7	3.8	25.2	2.86	-0.5	1.78	0.397	0.146
L1/SN (°)	35.9	3.03	33.3	2.87	-2.6	3.44	0.0404*	0.880
L6-N vertical (mm)	30.3	3.53	26	1.63	-4.3	2.49	0.00041*	1.563
Overjet (mm)	9.5	2.12	2.25	0.54	-7.25	1.90	<0.0001*	4.683
Overbite (mm)	4.9	0.73	1.4	0.56	-3.5	0.88	<0.00001*	5.317

DISCUSSION

Herbst type II is a rigid hinge mechanism that consists of a telescopic tube and rod that is fixed with screws to a nut positioned mesial to the upper first molars and distal to lower canines, it is used simultaneously with the multibracket appliance and it comes in a prefabricated standard size that can be customized to each patient chair side with no laboratory interference [8, 11].

The sample of the study consisted of 10 subjects with age range from 12 to 13 years, 100% females. This study examined the effects of a 6- to 8-month treatment with the Herbst (type II) appliance on dental and skeletal variables in a group of patients with a Class II skeletal malocclusion [11].

This research did not include a control group for ethical reasons. Since the selected age group is a crucial circumpubertal growth age identified as a biological duration correlated with the most beneficial therapeutic effects in Class II patients [11].

The study was performed on lateral cephalometric x-rays taken before and after treatment with Herbst (type II) and multibracket system (MB). There was very good to perfect inter- and intra-observer reliability (agreement) regarding all measurements. The correction of the Class II malocclusion, overjet and overbite was achieved by a combination of skeletal and dental treatment effects.

There was a statistically significant increase in mean SNB of 2.63°, which has been recorded in several previous studies, indicating that the degree of anterior mandibular displacement achieved is comparable to that provided by Herbst appliances of other designs [7,10,11]. But not with other rigid fixed functional appliances as the MARA or AdvanSync which demonstrated correction of the Class II malocclusion with dental effects of the mandibular incisor and molar and maxillary molar [12, 13]. Furthermore, post-treatment measurements showed statistically significant increase that directed the favorable anterior positioning of the mandible; the total mandibular length (Cd-Me) measurements post-treatment mean was increased by a mean of 1.5 mm, many reports have supported this finding [14, 15].

There was a statistically significant decrease in mean SNA° by 0.7° as it agrees with some reports that the Herbst appliance causes some maxillary restriction [16], however some studies mentioned that the maxillary restriction is insignificant [7, 17]. By default there was significant decrease in the ANB° by 2.9 with a mean of 2.7° post treatment which indicates the correction of the sagittal intermaxillary jaw relationship [10, 14-15].

Concerning the maxillary dentition; there was a statistically significant decrease in mean U1/SN° measurements post-treatment by a mean of -5°, which indicates the backward movement of the upper incisors and retoclination which is a general finding in fixed functional appliance therapy [12-15].

On the mandibular dentition; recent reports on different fixed functional appliances stated that the main effect in correction of the overjet in Class II malocclusions is the mandibular incisors proclination [16,17]. This study showed that there was statistically significant proclination by a mean of 2.6° which is in accordance to previous studies. There was a statistically significant decrease in mean L6-N vertical (mm) by a mean of -4.3 (mm) which is expressed as the mesial migration of the lower mandibular molars which is coincident with the findings of other researchers [14-17].

Subsequently, there was a statistically significant decrease in mean overjet by -7.25 (mm) which was a vital improvement in the sagittal dental relationship between the maxillary and mandible dentition and this is a very common effect of Herbst appliance [12-14]. Moreover, There was a statistically significant decrease in overbite (mm) by a mean of -3.65 (mm) which in accordance to other reports [14-17].

CONCLUSION

The following conclusions can be drawn based on the study's limitations and findings:

1. The Herbst type II appliance was efficient in treatment of skeletal Class II malocclusion (mandibular deficiency) in adolescent female patients.
2. The Herbst type II appliance had noteworthy changes in mandibular length and improvement of maxillomandibular relationship.
3. The Herbst type II appliance promotes restriction of anterior maxillary displacement.
4. Correction of dental overjet was achieved by dentoalveolar effects of Herbst type (II) which include mandibular incisors flaring and maxillary incisors retroclination.
5. Significant mesial movement of the mandibular molars was observed and it was able to correct the dental Class II malocclusion.

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RECOMMENDATIONS

Based on the results provided by the present study the following are recommended:

1. Further trials are recommended to compare males and females and the effect the gender difference.
2. Further clinical trials are supported to compare between Herbst-MB system and Herbst-MB anchored to miniplates to minimize dental effects and obtain the optimal skeletal effect.
3. More clinical trials are encouraged to use 3D radiographs to inspect the effect of Herbst-MB on the TMJ and condyle.
4. A research to test patient experience before, during, and using the Herbst type (II) appliance is recommended.

Declaration of Conflicting Interest

The authors declare no conflict of interest in preparing this article.

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