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Evaluation of dental and facial changes after treatment of class II malocclusion patients with two types of fixed functional appliances (FFAs)

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Abstract

Objective: The objective of this study was to compare effects on soft tissue profile and dentoalveolar changes in class II patients after treatment with either Herbst appliance or Korn mandibular advancer as fixed functional appliances.

Materials and methods of study: The sample of study consisted of (30) patients divided into two groups (G1):group one included (15) patients was treated by Korn mandibular advancer appliance, and (G2): group two included (15) patients was treated by Herbst appliance. In both groups fixed functional appliances were applied concurrently with fixed orthodontic appliance. Lateral cephalograms were taken and analyzed before treatment and after treatment. Statistical analyses were used to analyze data by (Kolmogorov smirnov, K-S) and student's t tests. Statistical significance was set at $P<0.05$.

Results: For both FFAs, improvement of soft tissue profile was achieved after treatment, straightening of the profile was found in Herbst and Korn appliance patients. Significant reduction of overjet and overbite was noticed in both groups. Retrusion and posterior displacement of upper lip was observed in both groups. Nasolabial angle was decreased significantly in Herbst appliance but in Korn appliance improvement of this angle was noticed which increased insignificantly. Decrease in angle between upper incisor and palatal plane was significant in Herbst appliance more than Korn appliance.

Conclusions: Treatment related dental and facial changes included position of Lips, overjet and overbite could be regarded similar in class II patients treated with Herbst or Korn appliances. Treatment related change that was specific for Herbst appliance could be identified in Significant increase in angle between lower incisor and mandibular plane.

Keywords: Skeletal class II malocclusion, fixed functional appliances, herbst appliance, korn MA, soft tissue profile

Introduction

Class II malocclusion is the most common in patients need orthodontic treatment. It may be caused either by protrusion of maxilla, or by deficiency of growth and retrusion of mandible, and when the cause is a retrusion or deficiency in the growth of the mandible, functional appliances can be an option for treatment during the growth period that has been used as a treatment method for more than a century. Functional appliances are classified into removable and fixed that do not need the cooperation of the patient. [1, 2, 3] In addition to the skeletal and dental effects of functional appliances during treatment, aesthetic effects and soft facial tissue profile may result from correcting class II malocclusion [4]. There are many fixed functional appliances used in orthodontic treatment for class II malocclusion patients who have mandibular deficiency. Fixed functional appliances (FFAs) like Herbst appliance or Korn mandibular advancer exert an anteriorly directed force to the mandible through rigid mechanisms [5, 6]. Emil Herbst introduced "Retentions-Scharnier", later commonly called Herbst appliance, in 1909 at international dental congress in Berlin, Germany. As this appliance has become the most frequently used FFA for correction of class II malocclusion [7]. In (1934), Herbst summarized his (25) years of experience with this appliance in a set of three articles [8]. Thereafter, the Herbst appliance literally disappeared from orthodontic treatments for more than four decades until the year (1979), when Pancherz came in and reintroduced and continued development of Herbst appliance [7, 9]. The Herbst appliance rigidly connects the first upper molar with the mandibular first bicuspid on both sides through

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a telescopic mechanism (rod and tube) for permanent advancement of the mandible into a protruded position [7]. Marcel Korn introduced his appliance more than 40 years ago, which depends in its principle and the treatment mechanism on repositioning the mandible with muscle training and moving the teeth at the same time in children and adults. These concepts were employed easily with fixed functional appliances that were designed qualitatively to be effective, easy to use and comfortable For the patient [10]. A part from feasible dentoskeletal effects, treatment-related changes of the soft tissue profile have also been researched on many different fixed functional appliances (FFAs). [11, 12, 13]

There was limited information regarding soft tissues. Although some studies evaluating soft tissue changes were available for the Herbst appliance, information about the Korn MA was not available. This can be explained by assuming that the effects of treatment may differ according to the variation in the design of one appliance from another, and these were not investigated. Therefore, this research was to compare dentofacial effects in patients with skeletal class II malocclusion, who were successfully treated with Korn appliance or Herbst appliance by analyzing lateral cephalograms which were routinely obtained during orthodontic treatment.

Objective: To compare dentofacial effects in patients with skeletal class II malocclusion treated by two types of fixed functional appliances (Korn and Herbst appliances).

Materials and methods

Ethical approval was obtained for the study sample requiring anterior advancement of the mandible during treating class II malocclusion. The research sample was randomly divided into two main groups according to the appliance used: (Korn appliance, and Herbst appliance) The final research sample consisted of 30 patients were ages between 12-15 years, each group included 15 patients:

Group 1: Korn appliance group

It consisted of 15 patients (male and female), whose ages ranged from (12-15 years), treated by Korn fixed functional appliance (Korn® American Orthodontics) which used for mandibular advancement in treatment of skeletal class II malocclusion.

Group 2: Herbst appliance group

It consisted also of 15 patients (male and female), whose ages ranged from (12-15 years), treated by Herbst fixed functional appliance (Herbst® American Orthodontics) which used for mandibular advancement in treatment of skeletal class II malocclusion

Inclusion criteria included the following

1. All patients have permanent dentition with all permanent teeth (except The third molars)
2. No teeth were lost during the treatment period
3. No history of previous orthodontic treatment
4. ANB angle $\geq 4^\circ$ before treatment
5. Distal molar relationship of at least one - half cusp width
6. The age of the sample ranged between 12-15 years.

Exclusion criteria

1. presence of craniofacial deformities
2. loss or congenital agenesis of permanent teeth (except for third molars), or planned extraction protocol

The fixed functional appliances were applied to all patients in a single- step advancement protocol. the mandible was initially protruded into an edge-to-edge position. Functional treatment was done concurrently with fixed orthodontic appliance.

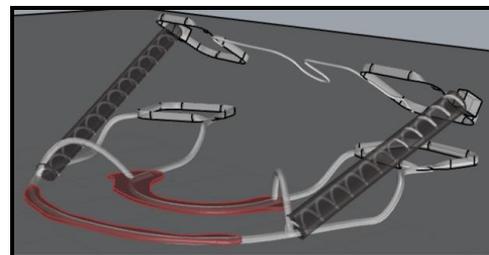


Fig 1: modified Korn appliance



Fig 2: Korn appliance Inside the patient's mouth



Fig 3: Herbst appliance inside the patient's mouth

Lateral cephalograms were performed before treatment (T1) and after removal of fixed functional appliance (T2). The Focus Film distance was (1.5) m. Head posture and maximal intercuspation were standardized. the time of exposure was (9s). Then the lateral cephalograms were digitized using (webceph) program.

(Artificial Intelligence Orthodontic & Orthognathic Cloud Platform. 2019)

The magnification factor was calculated by projection of a scale into each image. Lateral cephalometric radiographs were analyzed digitally and then remeasured after an interval of 1 month to detect method error.

The following linear and angular variables of soft tissues and some selected alveolar dental measurements were studied at each group and the variables were measured before treatment (T1) and after the end of functional treatment (T2) according to the following table:

Table 1: variables used in this study

Variable	Definition
Ls-E Line(mm)	The distance between the upper lip and the aesthetic line of Ricketts
Li-E Line(mm)	The distance between the lower lip and the aesthetic line of Ricketts
NasoLabial Angle	the angle formed between the tangent of the lower edge of the nose and the passing line from Sn to Ls.
L1FH(°)	The angle between the longitudinal axis of the lower incisor and the Frankfurt horizontal plane according to L. Tweed.
LIMP(°)	The angle formed between the longitudinal axis of the lower incisor and the mandibular plane according to Tweed.
UISPP(°)	The angle formed between the longitudinal axis of the upper incisor and the palatal plane.
OverJet(mm)	horizontal distance from the labial surface of the lower incisors to the labial surface of the upper incisors at the level of the edge of the upper central incisor.
OverBite(mm)	vertical dimension between the incisal edge of the upper incisors and incisal edge of the lower central incisor during centric occlusion.

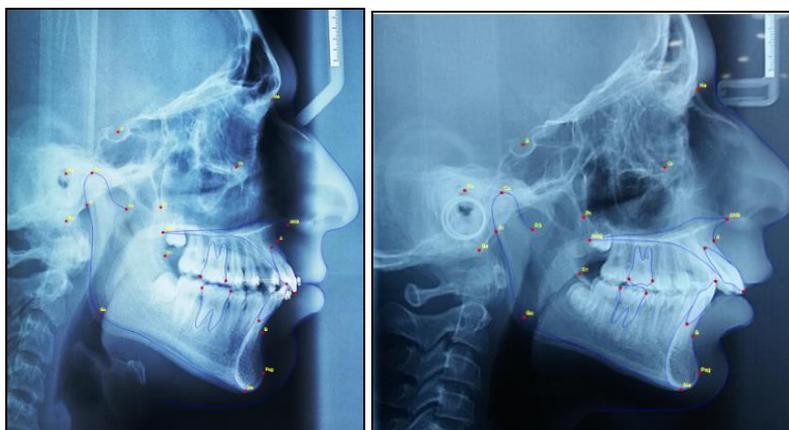


Fig 4: cephalometric landmarks before and after treatment by korn appliance

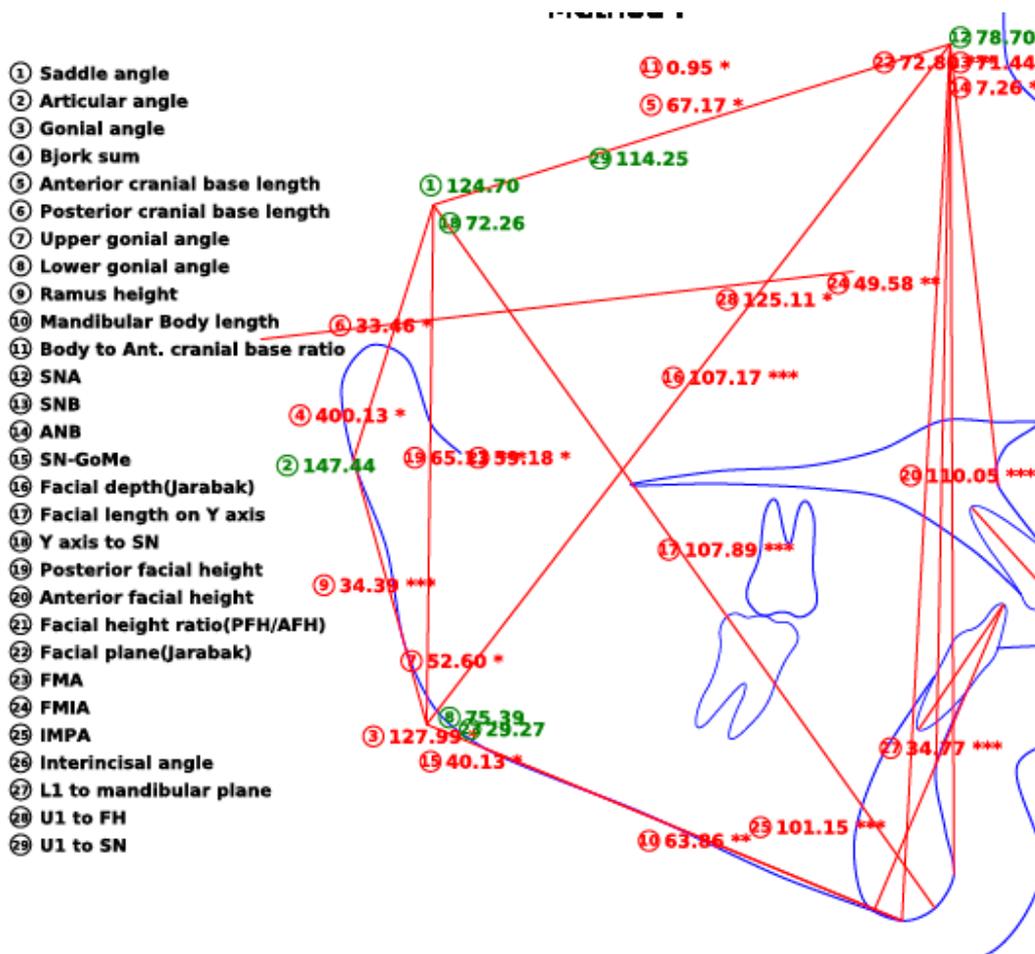


Fig 5: cephalometric measurements

Results

The (SPSS V20) software was used in order to carry out the analysis and investigation of Statistical Package For Social

Sciences

The objectives set out in the framework of this research, a significance level (0.05) was used, which accepted in social

sciences generally, and a confidence level equal to (0.95) was used to explain the results conducted in this study.

The following statistical analyses have been used

1. The normal distribution test using (Kolmogorov-Smirnov K-S,) to see if the data distribution was a normal distribution or not.

2. Arithmetic means and standard deviations.
3. independent sample t.test
4. Paired sample t.test

Korn appliance: The measurements were made before and after the functional treatment of the dentofacial variables at the following table:

Table 2: Values of the variables studied before starting treatment and after functional treatment when applying the Korn appliance.

The variable studied	values before treatment				values after functional treatment			
	N ₁	$\bar{x}_1 \pm SD_1$	Min	Max	N ₂	$\bar{x}_2 \pm SD_2$	Min	Max
Ls-E-Line (°)	15	0.41±2.09	-3.55	2.50	15	-0.95±1.7	-3.35	2.15
Li-E-Line (°)	15	1.28±2.54	-2.91	4.70	15	1.14±2.35	-2.51	3.89
UISPP (°)	15	114.4±5.33	109.00	127.00	15	112.8±2.91	110.00	120.00
Nasolabial. Angle	15	104.23±13.53	76.94	129.34	15	104.64±16.08	70.44	130.84
L1MP (°)	15	100.58±4.36	90.52	106.25	15	101.74±4.74	90.03	109.02
L1FH (°)	15	55.44±4.45	49.00	65.83	15	53.08±5.69	44.15	61.85
Overjet (mm)	15	7.21±2.18	4.25	12.26	15	4.28±1.56	1.61	6.58
Overbite (mm)	15	3.68±1.06	2.13	4.93	15	2.75±1.28	.55	4.09

N: number of patients. X: Mean. Sd: Standard deviation. Min: Minimum. Max: Maximum.

Student's t-test of the paired samples was performed to study the significance of differences in the mean of both dental and facial variables between the two time periods (before and

after treatment) in the korn appliance group. The results are shown in the following table:

Table 3: Results of the student's t- test when applying the Korn appliance

Studied variable	Differences					
	Mean	Standard deviation	Standard error	T	Sig	Significance of difference
Ls-E-Line (°)	-1.36	2.08	0.54	-2.52	0.024	*
Li-E-Line (°)	-0.15	1.51	0.39	-0.38	0.712	n.s
UISPP (°)	-1.60	5.90	1.52	-1.05	0.311	n.s
Nasolabial. Angle	0.41	12.22	3.16	0.13	0.899	n.s
L1MP (°)	1.16	3.07	0.79	1.47	0.165	n.s
L1FH (°)	-2.37	4.20	1.08	-2.18	0.047	*
Overjet (mm)	-2.92	2.45	0.63	-4.62	0.000	**
Overbite (mm)	-0.92	1.60	0.41	-2.23	0.043	*

n.s: No significant difference *: There is a Significant difference at the level of significance 0.05 **: There is a Significant difference at the level of significance 0.1

From the previous table, we noticed that at Sig <0.05 Ls.E-Line, L1-FH, overjet and overbite values significant decrease was occurred after functional treatment, while the rest of the variables did not differ significantly at sig > 0.5.

Herbst appliance

Dentofacial measurements performed before and after functional treatment were shown in the following table:

Table 4: Values of the studied variables before treatment and after functional treatment in Herbst appliance group.

Studied variable	Values before treatment				Values after functional treatment			
	N ₁	$\bar{x}_1 \pm SD_1$	Min	Max	N ₂	$\bar{x}_2 \pm SD_2$	Min	Max
Ls- E-Line (°)	15	0.13±0.01	.10	.15	15	-2.93±0.01	-2.96	-2.91
Li-E-Line (°)	15	-1.21±0.12	-1.50	-1.10	15	-3.16±0.01	-3.18	-3.14
UISPP (°)	15	117.53±1.64	115.00	121.00	15	114.27±1.75	112.00	118.00
Nasolabial. Angle	15	112.01±1.2	110.00	114.00	15	101.93±1.03	100.00	103.95
L1MP (°)	15	101.11±0.6	100.00	102.00	15	105.96±0.68	105.00	107.00
L1FH (°)	15	55.42±1.12	53.00	57.00	15	51.27±1.01	50.00	53.00
Overjet(mm)	15	8.48±0.76	7.00	9.13	15	4.74±0.79	4.00	6.00
Overbite(mm)	15	2.98±0.5	2.00	3.70	15	2.38±0.25	2.00	3.00

N: number of patients. X: Mean. Sd: Standard deviation. Min: Minimum. Max: Maximum.

Student's t-test of the paired samples was performed to study the significance of differences in the means of dentofacial

variables before and after treatment in Herbst appliance group. The results are shown in the following table:

Table 5: Results of student's t-test analysis when applying Herbst appliance.

Studied variable	Differences					
	Mean	Standard deviation	Standard error	T	Sig	Significance of differences
Ls-E-Line (°)	-3.06	0.02	0.00	-655.43	0.000	**
Li-E-Line (°)	-1.95	0.12	0.03	-64.56	0.000	**
UISPP (°)	-3.27	0.80	0.21	-15.84	0.000	**
Nasolabial. Angle	-10.08	1.38	0.36	-28.27	0.000	**
LIMP (°)	4.85	0.79	0.20	23.67	0.000	**
L1FH (°)	-4.14	1.82	0.47	-8.83	0.000	**
Overjet (mm)	-3.74	1.29	0.33	-11.24	0.000	**
Overbite (mm)	-0.59	0.56	0.14	-4.13	0.001	**

n.s.: No significant difference *: There is a Significant difference at the level of significance 0.05 **: There is a Significant difference at the level of significance 0.1

From previous table we observed that at Sig <0.05 for the variables UI.SPP, L1-FH, Overjet (mm), Overbite (mm) and for all soft tissue variables significant decrease was occurred.

Comparison between both appliances

The amount of difference in dentofacial variables in both groups was calculated.

The results are shown in the following table:

Table 6: comparison between the values of the variables in the two appliances.

Studied variable	Korn					Herbst				
	N ₁	\bar{x}_1	SD ₁	Min	Max	N ₂	\bar{x}_2	SD ₂	Min	Max
Ls-E-Line (°)	15	-1.36	2.08	-4.94	2.00	15	-3.06	0.02	-3.09	-3.03
Li- E-Line (°)	15	-0.15	1.51	-2.22	3.02	15	-1.95	0.12	-2.07	-1.68
UISPP (°)	15	-1.60	5.90	-12.00	11.00	15	-3.27	0.80	-4.00	-2.00
L1MP (°)	15	1.16	3.07	-4.01	8.06	15	4.85	0.79	3.00	6.00
L1FH (°)	15	-2.37	4.20	-9.00	3.10	15	-4.14	1.82	-6.07	-1.00
Nasolabial. Angle	15	0.41	12.22	-21.34	23.26	15	-10.08	1.38	-13.00	-8.00
Overjet (mm)	15	-2.92	2.45	-6.65	1.13	15	-3.74	1.29	-5.07	-1.00
Overbite (mm)	15	-0.92	1.60	-3.96	1.00	15	-0.59	0.56	-1.40	.40

N: number of patients. X: Mean. Sd: Standard deviation. Min: Minimum. Max: Maximum.

Student's t-test of samples used to study the significance of differences in the mean of dentofacial variables between Korn and Herbst groups was performed in the study sample.

Table 7: Student's t-test to compare the two appliances

Studied variable	T	Sig	Significance of difference
Ls-E-Line (°)	-3.16	0.004	**
Li-E-Line (°)	-4.60	0.000	**
UISPP (°)	-1.08	0.288	n.s
L1MP (°)	4.50	0.000	**
L1FH (°)	-1.50	0.144	n.s
Nasolabial. Angle	-3.30	0.003	**
Overjet (mm)	-1.14	0.262	n.s
Overbite (mm)	0.75	0.459	n.s

ns: There is no significant difference. *: There is significant difference at significance level of 0.05. **: There is significant difference at significance level of 0.1

From the previous table, we noticed significant improvement in variables of the L1.MP, Ls. E line, Li. E line and nasolabial Angle at significance level <0.05. But the remaining variables in both appliances did not differ significantly, noting that Korn appliance increased or decreased substantially in degrees less than Herbst appliance.

Results showed

- Both appliances had an effect in improving soft tissue profile after treatment in patients with skeletal class II malocclusion.
- Treatment with Herbst and Korn appliances resulted in statistically significant decrease in overjet and overbite.
- Retrusion and posterior lip shift in both groups were observed.

- An increase in the nasolabial angle occurred in Korn patients, whereas in Herbst patients, there was a statistically significant decrease.
- There was statistically significant decrease in the angle between the axes of the upper incisors and the palatal plane in Herbst patients more than those of Korn appliance.
- Statistically significant decrease was observed in the angle between the axes of the lower incisors and mandibular plane in Herbst appliance, whereas in Korn appliance no statistically significant change was observed.

Discussion

Soft tissue profile changes in patients treated with Herbst and Korn appliances by analyzing lateral cephalograms were not studied until 2017 which studied by Hourfar J and his colleagues [14]. Therefore our study can be considered a scientific addition. As expected, there are some studies that assessed the soft tissue changes of Herbst appliance, but there was no study of Korn appliance or a comparison between it and another fixed functional appliance. Similarly, in both groups, there was retrusion in the upper lip (Ls.E Line), but protrusion in the lower lip. This corresponds to the results of Hourfar and his colleagues in 2017 [14]. Our results were consistent with the results of the Meyer-Marcotty study and their colleagues in 2012 [15] who investigated treatment changes related to facial soft tissues after treatment with Herbst appliance. Also, our results were similar to the study of Ramos and colleagues in 2005 which showed retrusion in upper lip [16]. The extent of prediction of changes that can occur in the incisor inclination and its effect on the soft tissue profile remains a controversial topic and varies from patient

to patient.^[2, 15] The outcome of our study regarding dental and facial changes resulting from treatment with two types of fixed functional appliances were as follows:

LS- E-line

Our study showed significant differences between Korn and Herbst appliances in affecting the distance of the upper lip from the aesthetic Ricketts line, where there was statistically significant decrease in this value, which indicates the retrusion of the upper lip resulting from treatment with fixed functional appliances which tend to inhibit the forward movement of the upper lip which came in agreement with the study of Flores *et al.*, 2007^[17] and the resistance to the upper lip decreases in a desirable way due to the retrusion of the upper incisors which was consistent with the study of Nalbantgil *et al.*, 2005^[18], the study of Frye *et al.*, 2009^[19] and Hourfar *et al.*, 2017 work on Herbst appliance^[14].

LL- E-line

The differences in our study between Korn and Herbst appliances were significant in influencing the lower lip distance from the Ricketts aesthetic line.

Where there was statistically significant decrease in this value in Herbst appliance, whereas a decrease in this value in Korn appliance was not statistically significant. This differs with the results of Schaefer *et al.*, 2004^[20] as they did not find significant differences between Herbst and Twin-Block appliances and between Jasper Jumper and Bionator appliances, and also the result of Gaitode *et al.* study., 2010^[21] where their treatment did not affect both prominence of the nose, soft tissue Pog point, the length and thickness of the upper and lower lips and skeletal relationship in sagittal direction.

NasoLabial angle

There were significant differences between Korn and Herbst appliances in our study in affecting the nasolabial angle, as it decreased significantly in Herbst appliance while insignificantly increased in Korn appliance and this is inconsistent with study of Frye *et al.*, 2009^[19], which indicated no correlation between the nasolabial angle increase and the retrusion of upper incisors. Our results were similar to the study of Hourfar *et al.*, 2017 through the application of Herbst appliance and FMA, where the value of this angle increased significantly in Herbst appliance more than FMA appliance^[14].

Li-MP

Our study showed differences between Herbst and Korn appliances in affecting the angle of lower incisor with mandibular plane, where it was significantly increased in Herbst group, while in Korn appliance no statistically significant increase was observed. And our result was similar to the results of the study of Omblus *et al.*, 1997 on Herbst and Bass appliances which increased in Herbst appliance more than Bass appliance^[22] and with the study of Foncatti *et al.*, 2017 on Jasper Jumper appliance^[23].

L1-FH

The angle of lower incisor with Frankfort horizontal plane did not show a significant change between the Herbst and Korn appliances, as this angle decreased significantly in both appliances and our finding contradicted to result of Hourfar J *et al.*, 2017 who noticed lower lip retrusion in spite of proclination of lower incisors^[14]. The extent and predictability of changes in incisor's axial inclination on soft

tissue profile remain a matter to debate which came in agreement with Flores Mir. *et al.* 2006 when they investigated soft tissue changes with fixed functional appliances^[2].

Overjet

There was statistically significant decrease in overjet in both Herbst and Korn appliances. But when comparing the two appliances there was no noticeable difference between them, and this corresponds to the result of study of Foncatti *et al.*, 2017 on Jasper Jumper^[23] and with a study of Frye *et al.*, 2009 on FMA appliance^[19] and a study of Panherz, 1982 on Herbst appliance^[19].

Overbite

There was statistically significant decrease in overbite in both Herbst and Korn appliances after treatment, but when comparing the two appliances, no statistically significant difference was found and this came with agreement with the study of Foncatti *et al.*, 2017 on the Jasper Jumper^[23] and with the work of Panherz, 1997^[25] and De Almeida *et al.*, 2002^[26]. And we can explain that when anterior advancement of the mandible occurred this will cause in opening the bite resulting from extrusion of posterior lower teeth in vertical dimension and contributing in correcting the bite.

Conclusions and recommendations

1. Dentofacial effects resulting from the application of Herbst and Korn appliances in patients with skeletal class II malocclusion were similar, especially with regard to the position of the lips, overjet and overbite.
2. The results showed the effect on the soft tissue profile, as the nasolabial angle decreased significantly when applying Herbst appliance, while applying Korn appliance it was increased insignificantly.
3. There was a significant decrease in the distance of the upper lip from the Ricketts aesthetic line, that is, a significant retrusion in the upper lip in both appliances, which indicates that the two appliances used cause restrain the front movement of the upper lip
4. There was a significant decrease in the lower lip distance from the aesthetic Ricketts line in the Herbst appliance, while this distance was not affected in the Korn MA appliance.
5. Both appliances had a positive effect on overjet and overbite, but there were no significant differences between the two appliances.
6. There was an effect on the lower incisor angle with mandibular plane in both appliances, but the effect of the increase in Herbst appliance was more than that of Korn appliance.

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