Original Article

Treatment effects of skeletally anchored Forsus FRD EZ and Herbst appliances:

A retrospective clinical study

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ABSTRACT

Objective: To evaluate the skeletal, dentoalveolar, and soft tissue effects of the Forsus FRD appliance with miniplate anchorage inserted in the mandibular symphyses and to compare the findings with a well-matched control group treated with a Herbst appliance for the correction of a skeletal Class II malocclusion due to mandibular retrusion.

Materials and Methods: The sample consisted of 32 Class II subjects divided into two groups. Group I consisted of 16 patients (10 females and 6 males; mean age, 13.20 ± 1.33 years) treated using the Forsus FRD EZ appliance with miniplate anchorage inserted in the mandibular symphyses. Group II consisted of 16 patients (9 females and 7 males; mean age, 13.56 ± 1.27 years) treated using the Herbst appliance. Seventeen linear and 10 angular measurements were performed to evaluate and compare the skeletal, dentoalveolar, and soft tissue effects of the appliances using paired and Student's *t*-tests.

Results: Both appliances were effective in correcting skeletal class II malocclusion and showed similar skeletal and soft tissue changes. The maxillary incisor was statistically significantly more retruded in the skeletally anchored Forsus FRD group ($P < .01$). The mandibular incisor was retruded in the skeletally anchored Forsus FRD group ($-4.09^\circ \pm 5.12^\circ$), while it was protruded in the Herbst group ($7.50^\circ \pm 3.98^\circ$) ($P < .001$).

Conclusion: Although both appliances were successful in correcting the skeletal Class II malocclusion, the skeletally anchored Forsus FRD EZ appliance did so without protruding the mandibular incisors. (*Angle Orthod.* 2016;86:306–314.)

KEY WORDS: Skeletal anchorage; Forsus FRD EZ; Herbst; Class II malocclusion

INTRODUCTION

Class II malocclusion is commonly observed in orthodontic practice, its frequency being reported as approximately one-third of the patients seeking orthodontic therapy.[1–3] According to McNamara,[4] the most common characteristic of this malocclusion is mandibular retrusion, rather than maxillary protrusion or other combinations.

Several types of removable and fixed functional appliances are used for the treatment of Class II malocclusion due to mandibular retrusion. Since the success of functional therapy via removable appliances depends mainly on patient cooperation, fixed functional appliances have been chosen by numerous clinicians[1,5–15] in order to accelerate mandibular growth. Those studies have proven the efficiency of fixed functional appliances; however, protrusion of mandibular incisors was also reported to be a common finding that limits the skeletal effects of the appliance used.[16,17]

The use of miniscrew and miniplate anchorage in orthodontics has reduced the undesirable effects of many appliances.[18–21] Few studies[16,17,22,23] have shown the use of the Herbst and Forsus Fatigue Resistant Device (FRD) with miniscrew anchorage. Those

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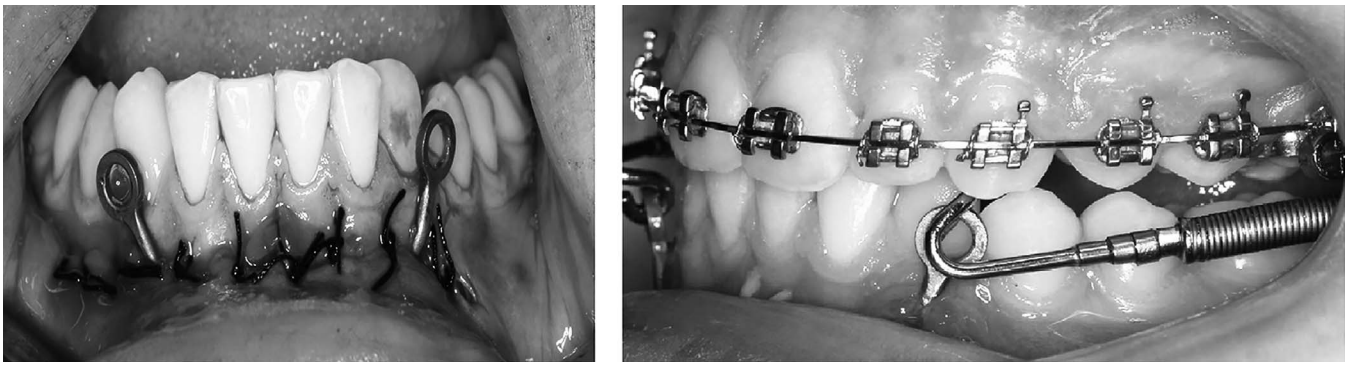


Figure 1. Miniplates inserted in mandibular symphysis and application of the skeletally anchored Forsus FRD appliance.

studies[16,22,23] have shown that the skeletal response to the Herbst appliance was increased by minimizing the protrusion of the mandibular incisors, while the overjet and molar correction in patients treated with the Forsus FRD combined with miniscrew anchorage were totally dentoalveolar.[17] Recently, a skeletal Class II malocclusion was successfully treated using the Forsus FRD appliance with miniplate anchorage bilaterally inserted in the mandibular symphyses.[24] This new approach was shown to be an effective method for correcting skeletal Class II malocclusion due to mandibular retrusion via a combination of skeletal and dentoalveolar changes.[25] However, those changes were not compared with a well-matched control group of various fixed functional appliances.

The aim of the present study was to evaluate the skeletal, dentoalveolar, and soft tissue effects of the Forsus FRD appliance with miniplate anchorage inserted in the mandibular symphyses and to compare the findings with a well-matched control group treated by a Herbst appliance for the correction of skeletal Class II malocclusion due to mandibular retrusion.

MATERIALS AND METHODS

The patients and parents had signed an informed consent form allowing the authors to use their data for scientific purposes, and the study was approved by the local ethics committee.

The sample size for the study was calculated based on a formula described by Pandis,[26] a significance level of .05, and a power of 80% to detect a clinically meaningful difference of 2 mm ($\pm$1.98 mm) for the distance from point B to a vertical reference line (VRL) between the groups. Power analysis showed that 32 patients were needed for the study.

Two authors simultaneously scanned the archives to determine the study samples according to inclusion and exclusion criteria as follows[25,27]: (1) skeletal and dental Class II malocclusion due to mandibular retrusion (SNB $< 78^\circ$ and ANB $> 4^\circ$), (2) overjet larger than 5 mm; (3) normal or low-angle growth pattern (SN-MP$<38^\circ$); (4) permanent dentition with no extraction or hypodontia except third molars; (5) no clinical signs or symptoms of temporomandibular disorder.

Group I consisted of 16 patients (10 females and 6 males; mean age, 13.20 $\pm$ 1.33 years) treated by one clinician (T.U.) using the Forsus FRD EZ appliance with miniplate anchorage inserted in the mandibular symphyses. After a 0.019 $\times$ 0.025-inch stainless steel archwire was inserted and cinched back in the maxillary arch, two miniplates (Stryker, Leibinger, GmbH & Co KG, Freiburg, Germany) were placed bilaterally on the mandibular symphysis by means of three miniscrews (diameter, 2 mm; length, 7 mm) made of titanium, then the appliance was adjusted to the miniplates without leveling the mandibular arch as described in the literature (Figure 1).[25] Group II consisted of 16 patients (9 females and 7 males; 13.56 $\pm$ 1.27 years) treated in a clinic using the cast-type Herbst I appliance (Figure 2). In all patients, there was a one-time, full mandibular activation to a Class I canine relationship. Activation of both appliances was done if needed.



Figure 2. Application of the Herbst appliance.

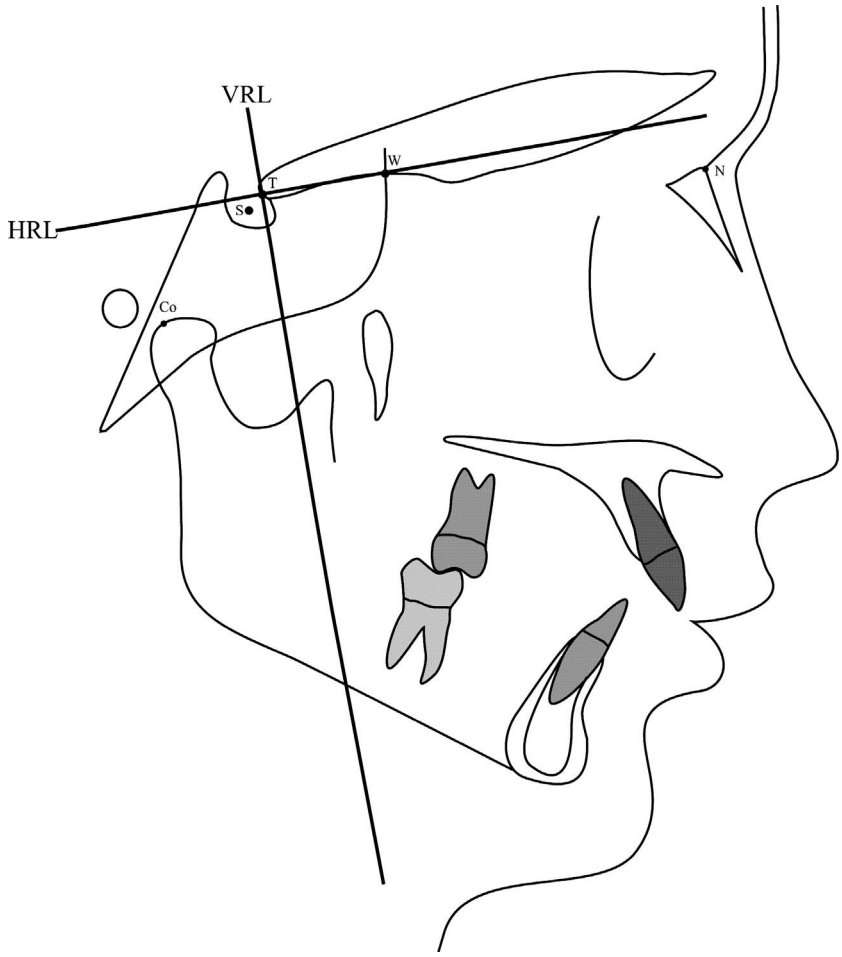


Figure 3. Reference planes used in the study.

Cephalometric lateral films were taken with cephalostats (Siemens Nanodor 2, Siemens AG, Munich, Germany and Planmeca Proline, Planmeca Co Ltd, Helsinki, Finland, respectively) in a standard position at the beginning (T1) and immediately after fixed functional therapy (T2) using either a skeletally anchored Forsus FRD EZ or Herbst I appliance. A line passing through tuberculum sella (intersection of the mandibular contours of the anterior clinoid processes and the anterior wall of the sella) and wing point (intersection of the contour of the ala major with the jugum sphenoidale) was used as the horizontal reference line (HRL) and a perpendicular line passing through tuberculum sella as a vertical reference line (VRL) (Figure 3). After calibration, all radiographs were blindly traced by one researcher (S.K.B.) with a random queue of the cephalometric films and without knowing the group of the patient. Seventeen linear and 10 angular measurements were made to evaluate and compare the skeletal, dentoalveolar, and soft tissue effects of the appliances using NemoCeph NX 2006 (Nemo Tec, Madrid, Spain) (Figures 4 and 5).

Statistical Analysis

To examine the errors associated with digitizing and measuring, 20 radiographs were selected randomly and all procedures such as landmark identification, tracing, and measuring were repeated 4 weeks after the first examination by the same author (SKB). According to the Houston test, performed to assess reliability of the measurements, the values were greater than 0.91, confirming the reliability.

All statistical analyses were performed using the SPSS software package program (SPSS for Windows 98, version 10.0, SPSS Inc, Chicago, Ill). The significance level was set at $P < .05$ for all tests. The parametric tests were used for statistical evaluation since the Shapiro-Wilks test showed normally distributed variables ($P > .05$). Changes observed in each group were evaluated using a paired *t* test and compared using Student's *t*-test. Gender distribution in each group was tested by means of a Pearson chi-square test. Due to the few samples, comparison of the genders in relation to changes was performed

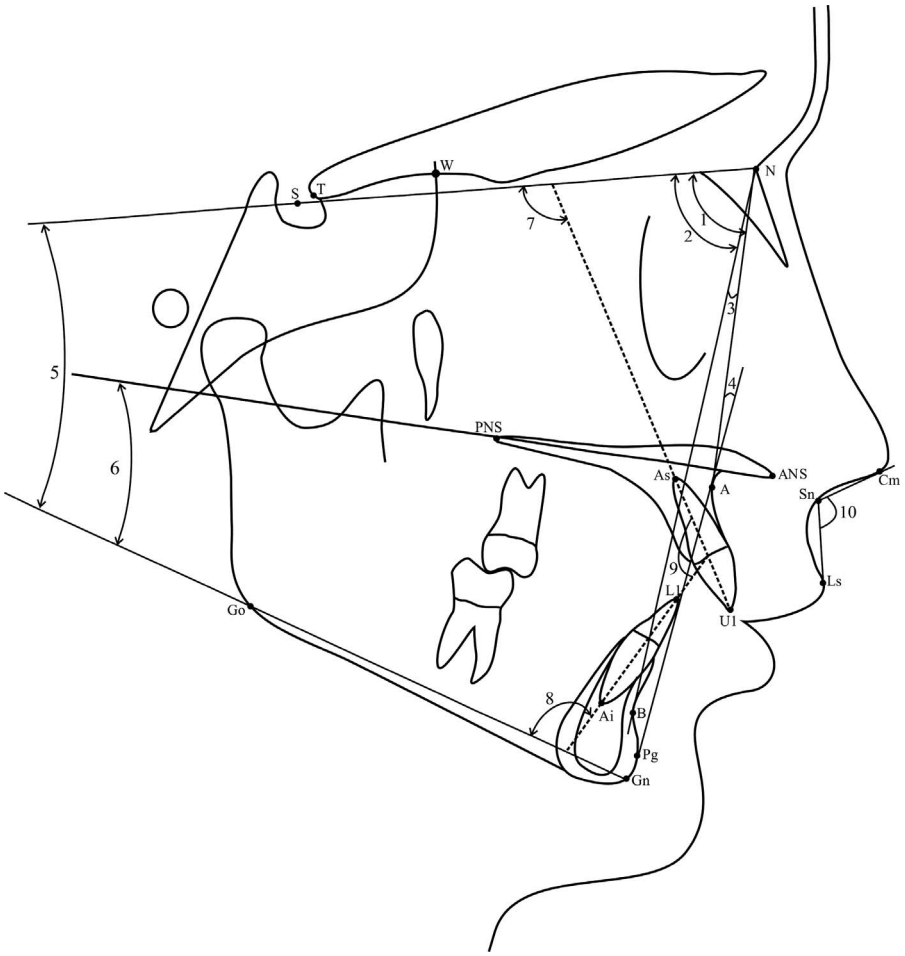


Figure 4. Angular measurements used in the study (°); (1) SNA, (2) SNB, (3) ANB, (4) Convexity, (5) SN-MP, (6) PP-MP, (7) U1-SN, (8) IMPA, (9) U1-L1, (10) Soft tissue convexity.

using a Mann-Whitney *U* test, and the data were pooled since no gender difference was found ($P > .05$). Chronological ages, treatment durations, and initial cephalometric values were compared using Student's *t*-test.

RESULTS

Such comparisons showed that the groups were well matched (Table 1). No statistically significant difference was found between the skeletally anchored Forsus FRD EZ and Herbst groups for treatment durations (7.27 ± 0.84 months and 7.73 ± 0.86 months, respectively), chronological ages prior to functional therapy (13.20 ± 1.33 years and 13.56 ± 1.27 years, respectively), or gender distribution ($P > .05$).

Table 2 shows the results of Student's *t*-test comparing the initial measurements of both groups. No statistically significant differences were observed between groups ($P > .05$).

Changes occurring during the skeletally anchored Forsus FRD EZ and Herbst appliances and the statistical comparison of these changes are shown in Tables 3 and 4, respectively. In the skeletally anchored Forsus FRD group, skeletal Class II was corrected mainly by mandibular changes (SNB, 2.01° ± 1.31°, $P < .001$; Co-Gn, 4.59 ± 4.15 mm, $P < .05$; B-VRL, 2.43 ± 1.97 mm, $P < .001$; Pog-VRL, 2.37 ± 1.15 mm, $P < .001$). In the Herbst group, the skeletal Class II relation was corrected by a decrease in SNA (−1.14° ± 1.23°; $P < .05$) and an increase in SNB (1.85° ± 1.16°; $P < .001$), Co-Gn (4.75 ± 4.55 mm; $P < .01$), B-VRL (2.44 ± 1.93 mm; $P < .001$), and Pog-VRL (2.32 ± 1.61 mm; $P < .001$). Combined movements of maxilla and mandible caused a significant improvement in the intermaxillary sagittal relationship in both groups ($P < .001$). In addition, a significant increase was observed for the SN-GoMe angle in the Forsus group (1.5°; $P < .01$). Both maxillary and mandibular incisors were significantly retruded in the

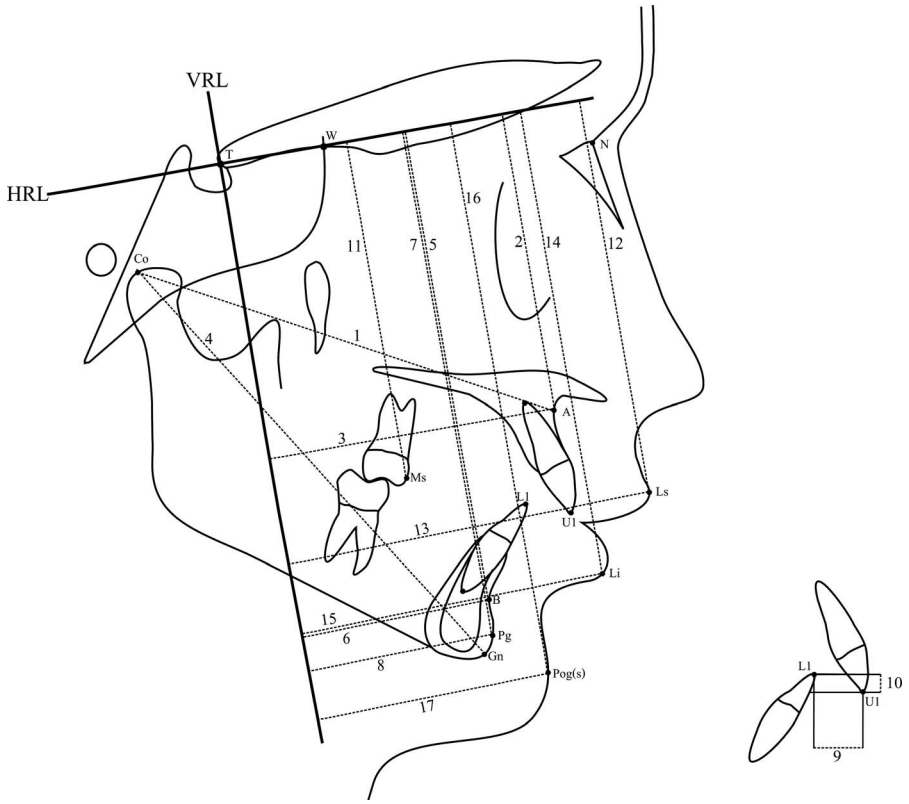


Figure 5. Linear measurements used in the study (mm); (1) Co-A, (2) A-HRL, (3) A-VRL, (4) Co-Gn, (5) B-HRL, (6) B-VRL, (7) Pog-HRL, (8) Pog-VRL, (9) overjet, (10) overbite, (11) Ms-HRL, (12) Ls- HRL, (13) Ls- VRL, (14) Li- HRL, (15) Li- VRL, (16) Pog(s)-HRL, (17) Pog(s)-VRL.

skeletally anchored Forsus FRD group ($P < .001$ and $P < .01$, respectively), while maxillary incisor retrusion and mandibular incisor protrusion were observed in the Herbst group ($P > .05$ and $P < .05$, respectively). Overjet and overbite measurements were significantly decreased in both groups ($P < .001$). The lower lip and soft tissue pogonion significantly moved forward ($P < .001$), the upper lip moved insignificantly backward ($P > .05$), and the nasolabial angle was decreased in both groups.

Comparison of the groups showed that both appliances produced similar effects, except for dentoalveolar changes. The maxillary incisor was statistically significantly more retruded in the skeletally anchored Forsus FRD group than that of the Herbst group ($P < .01$). The mandibular incisor was retruded in the skeletally anchored Forsus FRD group ($-4.09^\circ \pm 5.12^\circ$), while it was protruded in the Herbst group ($7.50^\circ \pm 3.98^\circ$) ($P < .001$). Those changes also affected the U1-L1 measurement between groups ($P < .01$).

Table 1. Descriptive Data of Patients Included in the Groups*

Group	Mean Age, (y)	Female/Male	Observation in Months
Herbst (n = 16)	13.56 ± 1.27	9/7	7.73 ± 0.86
Forsus FRD EZ (n = 16)	13.20 ± 1.33	10/6	7.27 ± 0.84
P	NS[a]	NS[b]	NS[a]

* FRD indicates fatigue resistant device; NS, nonsignificant.
[a] Results of Student's *t*-test.
[b] Results of Pearson chi-square test.

DISCUSSION

Skeletal Class II malocclusions due to mandibular retrusion can be treated with removable or fixed functional orthodontic appliances such as the twin block, bionator, Andresen activator, Herbst, twin force bite corrector, Jasper Jumper, MARA, and Forsus FRD EZ appliances.[1,9–11,13,28–30] However, all those appliances cause protrusion of the mandibular incisors, thus limiting the skeletal contribution to overjet correction.[1,9,13,31] Several attempts have been made using modifications in design, negative-torqued mandibular incisor brackets, sectional arches, and miniscrews to eliminate such protrusion and to improve the skeletal contribution to overjet correction.[17,22,32,33] In that effort, the use of miniscrews was successful in minimizing the protrusion; unfortunately, the results showed that they were unsuccessful in improving the skeletal contribution.[17]

Table 2. Initial Cephalometric Values for Herbst and Forsus FRD EZ Groups*

	Herbst Group		Forsus FRD EZ Group		
Measurements	Mean	SD	Mean	SD	*P*
Maxillary					
SNA (°)	80.33	2.55	81.43	2.99	NS
Co-A (mm)	83.49	4.82	82.53	4.74	NS
A-HRL (mm)	56.85	7.46	53.91	5.89	NS
A-VRL (mm)	53.19	5.52	53.59	5.13	NS
Mandibular					
SNB (°)	74.56	2.67	75.25	4.05	NS
Co-Gn (mm)	107.87	6.28	105.55	5.77	NS
B-HRL (mm)	86.49	6.93	83.36	7.40	NS
B-VRL (mm)	40.63	8.32	41.10	8.51	NS
Pog-HRL (mm)	97.80	8.08	95.44	7.23	NS
Pog-VRL (mm)	40.62	8.86	41.18	9.41	NS
Maxillomandibular					
ANB (°)	5.77	1.33	6.19	1.79	NS
Convexity (°)	9.16	3.81	10.32	3.50	NS
Vertical					
SN-MP (°)	30.63	4.98	30.49	3.80	NS
MP-PR (°)	22.81	4.20	22.27	3.20	NS
Dental					
U1-SN (°)	105.53	7.32	106.62	4.10	NS
IMPA (°)	87.79	7.39	91.64	4.83	NS
U1-L1 (°)	132.17	7.26	130.46	8.50	NS
Overjet (mm)	7.69	2.43	7.45	1.88	NS
Overbite (mm)	3.53	1.69	4.12	1.50	NS
U6-HRL (mm)	65.30	5.47	64.38	4.46	NS
Soft tissue					
Nasolabial (°)	103.35	8.83	104.64	11.29	NS
Ls-HRL (mm)	67.76	7.82	66.27	7.35	NS
Ls-VRL (mm)	66.78	6.50	67.50	6.25	NS
Li-HRL (mm)	78.77	8.04	77.32	7.04	NS
Li-VRL (mm)	60.48	7.74	61.69	7.93	NS
Pog (s)-HRL (mm)	98.44	8.07	95.64	7.33	NS
Pog (s)-VRL (mm)	52.60	8.26	51.91	9.73	NS

* FRD indicates fatigue resistant device; SD, standard deviation; HRL, horizontal reference line; VRL, vertical reference line; NS, not significant due to Student's *t*-test.

Recently, use of the Forsus FRD EZ appliance with miniplates inserted in the mandibular symphysis was shown to be an effective method for eliminating mandibular incisor protrusion and increasing the skeletal contribution.[24,25] According to our knowledge, this new technique has not been compared with a well-matched control group treated with a Herbst appliance, which is a widely used fixed functional appliance. Therefore, this retrospective study aimed to evaluate and compare the treatment effects of the Herbst appliance and the skeletally anchored Forsus FRD EZ appliance using miniplates inserted in the mandibular symphysis.

Since the findings can be affected by patient characteristics as well as growth of the maxilla and mandible, it is important to compare the groups based on age and gender distribution, treatment duration, and dentoskeletal pattern. The patients in both groups had similar gender distribution, chronological ages prior to treatment, and duration of the functional treatment as statistical comparisons confirmed the similarity ($P > .05$). In addition, the patients in both groups had skeletal Class II malocclusion due to mandibular retrusion with normal vertical growth pattern before treatment, confirming matching of the groups ($P > .05$). Therefore, the factors that might affect the findings were almost eliminated.

Our findings showed that both fixed appliances were effective in correcting the skeletal Class II malocclusion due to mandibular retrusion; in fact, similar skeletal and soft tissue changes were observed in both groups. Forward growth of the maxillae was inhibited in both groups, and this "high-pull-headgear" effect has also been reported in several studies using fixed functional appliances.[9,10,25] Forward and downward displacement of the mandible was increased, represented by the SNB angle, Co-Gn, B-VRL, B-HRL, Pog-VRL, and Pog-HRL distances. Those changes improved the maxillomandibular relationships in the Herbst and skeletally anchored Forsus FRD EZ groups (ANB, $-3.00° \pm 1.18°$ and $-2.53° \pm 1.08°$; and convexity, $-5.21° \pm 3.03°$ and $-4.05° \pm 2.69°$, respectively) ($P < .001$). These findings were similar to those reported by several authors.[14,15,24,25,34] Both appliances caused a slight increase in the SN-GoGn angle, while previous studies showed that this angle was maintained during fixed functional appliance treatment.[1,13,35] The upper lip moved backward, and the lower lip and soft tissue pogonion moved forward and downward in both groups, contributing to the skeletal and dentoalveolar changes.

Comparison of the groups showed that the main difference between them was found in the maxillary and mandibular incisor inclinations. In the skeletally anchored Forsus group, the maxillary incisors were significantly more retruded ($-11.05°$) thanthe Herbst group ($-1.85°$). The decrease in the U1-SN angle in the skeletally anchored Forsus group was high compared with previous studies using fixed functional appliances.[1,9,12–14] Aslan et al.,[17] using the miniscrew-anchored Forsus, reported similar changes for maxillary incisor inclination ($-8.9° \pm 5.7°$). As previously shown by Celikoglu et al.[24] and Unal et al.,[25] the mandibular incisors were found to be retruded in the skeletally anchored Forsus group ($-4.09 \pm 5.12°$), possibly because of the pressure of the maxillary incisors and lower lip.[25] Since those patients with skeletal malocclusion have protruded mandibular incisors before treatment, this finding might be useful for their functional treatment. On the other hand, the Herbst group showed statistically significant protrusion

Table 3. Comparison of Changes Observed In Each Group*

	Herbst Group					Forsus FRD EZ Group				
	(T1)		(T2)			(T1)		(T2)		
Measurements	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*
Maxillary										
SNA (°)	80.33	2.55	79.19	2.76	.003	81.43	2.99	80.91	3.03	.190
Co-A (mm)	83.49	4.82	82.87	4.99	.426	82.53	4.74	82.77	6.25	.870
A-HRL (mm)	56.85	7.46	58.24	6.47	.114	53.91	5.89	54.72	4.59	.227
A-VRL (mm)	53.19	5.52	52.27	5.69	.031	53.59	5.13	53.02	5.03	.232
Mandibular										
SNB (°)	74.56	2.67	76.41	2.53	.000	75.25	4.05	77.26	3.84	.000
Co-Gn (mm)	107.87	6.28	112.61	7.43	.001	105.55	5.77	110.15	4.17	.026
B-HRL (mm)	86.49	6.93	90.51	7.28	.000	83.36	7.40	88.53	5.53	.000
B-VRL (mm)	40.63	8.32	43.06	8.42	.000	41.10	8.51	43.53	8.96	.000
Pog-HRL (mm)	97.80	8.08	101.80	8.31	.000	95.44	7.23	99.96	5.67	.001
Pog-VRL (mm)	40.62	8.86	43.05	8.29	.000	41.18	9.41	43.76	9.28	.000
Maxillomandibular										
ANB (°)	5.77	1.33	2.77	1.55	.000	6.19	1.79	3.65	2.32	.000
Convexity (°)	9.16	3.81	3.95	2.81	.000	10.32	3.50	6.27	4.19	.000
Vertical										
SN-MP (°)	30.63	4.98	31.87	4.78	.069	30.49	3.80	32.49	4.66	.008
MP-PP (°)	22.81	4.20	22.21	5.56	.554	22.27	3.20	23.80	4.79	.124
Dental										
U1-SN (°)	105.53	7.32	103.69	6.30	.413	106.62	4.10	95.57	6.30	.000
IMPA (°)	87.79	7.39	95.29	5.38	.000	91.64	4.83	87.55	6.70	.008
U1-L1 (°)	132.17	7.26	127.06	5.80	.019	130.46	8.50	138.57	9.64	.072
Overjet (mm)	7.69	2.43	2.61	0.85	.000	7.45	1.88	2.90	0.84	.000
Overbite (mm)	3.53	1.69	1.57	1.15	.000	4.12	1.50	1.83	1.15	.000
U6-HRL (mm)	65.30	5.47	64.33	5.16	.139	64.38	4.46	62.24	3.87	.007
Soft tissue										
Nasolabial angle (°)	103.35	8.83	106.34	8.18	.043	104.64	11.29	113.94	13.36	.007
Ls-HRL (mm)	67.76	7.82	69.66	6.49	.060	66.27	7.35	67.08	6.14	.262
Ls-VRL (mm)	66.78	6.50	65.66	6.58	.164	67.50	6.25	65.87	6.24	.059
Li-HRL (mm)	78.77	8.04	81.76	6.71	.004	77.32	7.04	77.89	6.83	.509
Li-VRL (mm)	60.48	7.74	63.16	8.40	.000	61.69	7.93	63.41	7.98	.000
Pog (s)-HRL (mm)	98.44	8.07	102.90	7.19	.000	95.64	7.33	98.52	5.99	.001
Pog (s)-VRL (mm)	52.60	8.26	55.03	8.19	.000	51.91	9.73	54.17	9.75	.000

* FRD indicates fatigue resistant device; SD, standard deviation; HRL, horizontal reference line; VRL, vertical reference line; *P*, results of paired *t*-test.

of the mandibular incisors, as many studies have previously described.[5,6,16,22]

Despite the successful treatment outcomes of the skeletally anchored Forsus group, this new approach has some disadvantages including the risk of miniplate failure, the necessity of a second operation for removal of the miniplates at the end of treatment, and the increased cost of treatment necessities including two miniplates and six miniscrews. Therefore, we suggest that a careful assessment be made to choose the optimal treatment for those patients needing functional treatment. It should be noted that a prospective study using different fixed functional appliances with larger samples might be needed to discuss and compare these findings, since the present study was limited by its retrospective design.

CONCLUSIONS

Within the limitations of this retrospective study,

- Both fixed appliances are effective in correcting skeletal class II malocclusion due to mandibular retrusion; in fact, similar skeletal and soft tissue changes were observed in both groups. In the skeletally anchored Forsus group, changes were due to the changes in SNB; however; in the Herbst group, the changes were related to changes in both SNA and SNB.
- The maxillary incisor was statistically significantly more retruded in the skeletally anchored Forsus group.
- The mandibular incisor was retruded in the skeletally anchored Forsus group, while it was protruded in the Herbst group.

Table 4. Statistical Evaluation of the Changes Obtained in Herbst and Forsus FRD EZ Groups*

	Herbst Group		Forsus FRD EZ Group		
Measurements	Mean	SD	Mean	SD	*P*
Maxillary					
SNA (°)	−1.14	1.23	−0.52	1.46	.214
Co-A (mm)	−0.63	4.82	0.24	5.59	.600
A-HRL (mm)	1.40	3.21	0.80	2.46	.575
A-VRL (mm)	−0.92	1.48	−0.58	1.78	.569
Mandibular					
SNB (°)	1.85	1.16	2.01	1.31	.726
Co-Gn (mm)	4.75	4.55	4.59	4.15	.945
B-HRL (mm)	4.02	2.50	5.17	3.12	.273
B-VRL (mm)	2.44	1.93	2.43	1.97	.990
Pog-HRL (mm)	3.99	2.44	4.52	4.44	.690
Pog-VRL (mm)	2.43	1.68	2.58	1.08	.769
Maxillomandibular					
ANB (°)	−3.00	1.18	−2.53	1.08	.270
Convexity (°)	−5.21	3.03	−4.05	2.69	.277
Vertical					
SN-MP (°)	1.24	2.43	2.00	2.51	.407
MP-PP (°)	−0.60	3.85	1.53	3.63	.129
Dental					
U1-SN (°)	−1.85	8.48	−11.05	5.25	.001
IMPA (°)	7.50	3.98	−4.09	5.12	.000
U1-L1 (°)	−5.11	7.51	8.11	16.18	.008
Overjet (mm)	−5.08	2.33	−4.55	1.89	.496
Overbite (mm)	−1.96	1.28	−2.29	1.68	.554
U6-HRL (mm)	−0.97	2.40	−2.14	2.64	.215
Soft tissue					
Nasolabial (°)	2.99	5.21	9.30	11.33	.060
Ls-HRL (mm)	1.91	3.60	0.80	2.67	.349
Ls-VRL (mm)	−1.11	2.94	−1.62	3.06	.644
Li-HRL (mm)	2.99	3.41	0.57	3.26	.057
Li-VRL (mm)	2.69	1.73	1.72	1.09	.079
Pog (s)-HRL (mm)	4.46	3.45	2.87	2.76	.176
Pog (s)-VRL (mm)	2.43	1.10	2.26	1.41	.709

* FRD indicates fatigue resistant device; SD, standard deviation; HRL, horizontal reference line; VRL, vertical reference line; P, results of Student's *t*-test comparing groups.

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