**International Journal of Dental Research**
**www.dentaljournal.net**
**Online ISSN: 2664-9055, Print ISSN: 2664-9047**
**Received: 10-01-2022, Accepted: 25-01-2022, Published: 10-02-2022**
**Volume 4, Issue 1, 2022, Page No. 12-17**

# Comparison of dentoskeletal and soft tissue changes seen in class ii division imalocclusion using forsus fatigue resistant device, churro jumper and herbst appliance-A randomized clinical trial

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## Abstract
**Objective:** To compare dental, skeletal and soft tissue cephalometric changes in patients treated with Forsus fatigue resistant devices in Class II Division I malocclusion and its comparison with the Churro Jumper and the Herbst Appliance.
**Materials and Methods:** Thirty- two young adult patients (age 13 -17 years, overjet >6 mm) with a Class II Division 1 malocclusion were randomly divided into three groups: group 1 (G1) treated with Churro jumper, group 2 (G2) with a Herbst and group 3 (G3) with a Forsus. Dentoskeletal and soft tissue changes were analyzed on lateral cephalograms taken before (T1) and after (T2) and at the end of the treatment.
**Results:** All three appliances were useful in improving the overjet and interincisal relationships. Extrusion and mesial movement of the lower molar, together with lower incisor proclination, distalization and intrusion of the upper molars were noted in G1, G2, G3. More skeletal changes were seen with the Herbst appliance as compared to the Churro Jumper and the Forsus appliance. The nasolabial angle increased in the Herbst and the Forsus group. FORSUS™ is a product of 3M Unitek HERBST™ is a product of Dentaurum
**Conclusions:** All three fixed functional appliances provide adequate dental compensation for the Class II malocclusion. More of skeletal changes were seen with the Hersbt appliance as compared to the Churro Jumper and Forsus group.

**Keywords:** class II malocclusion, forsus, churro jumper, herbst, fixed functional appliance

## Introduction
Skeletal Class II malocclusion is the most frequent sagittal problem in orthodontics. The recommended therapeutic approach in growing patients is functional jaw orthopedics through the primary mechanism of mandibular advancement [1]. To avoid the need for patient compliance in such therapy a number of fixed interarch appliances have been developed, including the Herbst. The disadvantages of the Herbst appliance include the rigidity of the mechanism, the tendency of the appliance or its support system to break, and the requirement for complex laboratory work [2]. The Forsus Fatigue Resistant Device (FRD) is a non-compliant hybrid fixed functional appliance (FFA), an alternative interarch appliance for treating Class II malocclusion. A mandibular push rod attaches directly to the lower archwire distal to the canines and a telescoping spring attaches to the headgear tube with an L-pin or EZ module. Forces are unloaded when the patient's jaw opens, resulting in intrusive rather than extrusive force vectors. In contrast, Class II elastics load upon jaw opening, producing extrusive forces at their terminal ends and potentially undesirable side effects as the occlusal plane is rotated clockwise. The FRD exerts a continuous force with more elasticity and flexibility than the Herbst, permitting a greater range of mandibular opening and lateral movements during speech, chewing, and swallowing. Because muscular forces are distributed over a larger periodontal area, there is less inhibition of the jaw elevator muscles by the periodontal mechanoreceptors, allowing better stabilization of the mandible. Although the FRD was not designed as a functional appliance, our clinical experience has shown that it works effectively as one, when the mandible is advanced into a Class I position. There are very few documented literature citations about the treatment results obtained with the Forsus. Therefore, the present study was designed.

## Aims and Objectives
To evaluate dental, skeletal and soft tissue cephalometric changes in patients treated with The Forsus fatigue resistant device (FRD) in Class II Division I malocclusion and its comparison with the Churro Jumper and the Herbst appliance

## Materials and Method
Patients who reported to our department seeking orthodontic treatment were included in the study after they met our inclusion criteria. Informed consent was obtained for each patient.

**Inclusion criteria**

- Patients with skeletal and dental Angles Class II Div I malocclusion with a normal maxilla and retrognathic mandible
- Patient in active growth period or at the end of the growth spurt
- Positive VTO on clinical evaluation
- Overjet of more than 6 mm

**Exclusion Criteria**

- Patients with class I and class III malocclusion
- Patients with growth completed.
- Medically compromised patient

**Procedure**

A sample of 32 subjects age group 13-17 years with Class II Division 1 malocclusion (overjet larger than 6 mm, full Class II or end on molar relationship and ANB larger than 3mm) reported to our department seeking orthodontic treatment were included. Patients were randomly divided into 3 groups: group I had 10 subjects treated with Churro Jumper, group II had 10 subjects treated with the Herbst, and group III had 12 subjects treated with the Forsus (Fig 1, 2, 3). All treated patients were in the permanent dentition at the start of treatment, and they underwent a specific treatment protocol with 2 phase therapy. Phase I: alignment and leveling using preadjusted fixed appliances (0.022"slot MBT). Phase II: Bite jumping using fixed functional appliance with 0.021 X 0.025 inch stainless-steel archwires inserted in both arches. The mandibular archwire was consistently cinched distal to the molars. A mandibular push rod attaches directly to the lower archwire distal to the canines, and a telescoping spring attaches to the headgear tube with an L-pin or EZ module .The phase with the FFA was undertaken until Class II occlusion was overcorrected to an edge-to-edge incisor relationship. The mean duration of the FFA active phase was 5 to 6 months. Thereafter, fixed appliances were maintained in order to finalize the occlusion. Comprehensive treatment of Class II malocclusion was performed during the circumpubertal phases of skeletal development, as assessed with the cervical vertebral maturation method. Lateral cephalograms taken before (T1) and after (T2) treatment were analyzed. Tracings were done by the same person to avoid inter-examiner bias, using the following cephalometric linear and angular parameters were taken into consideration:

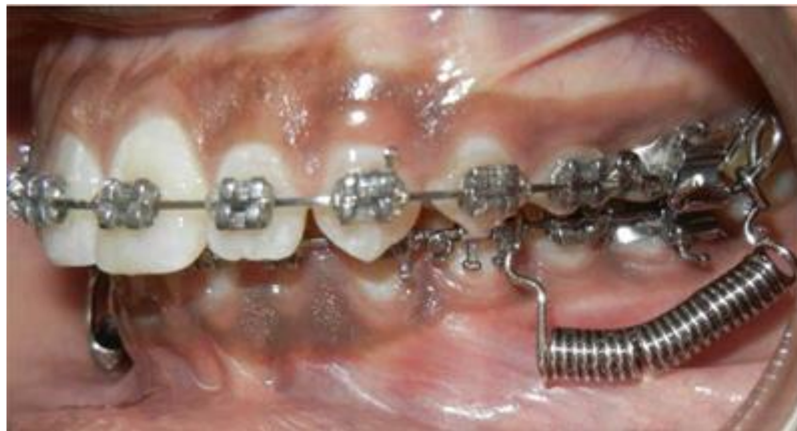

**Fig 1:** Churro Jumper

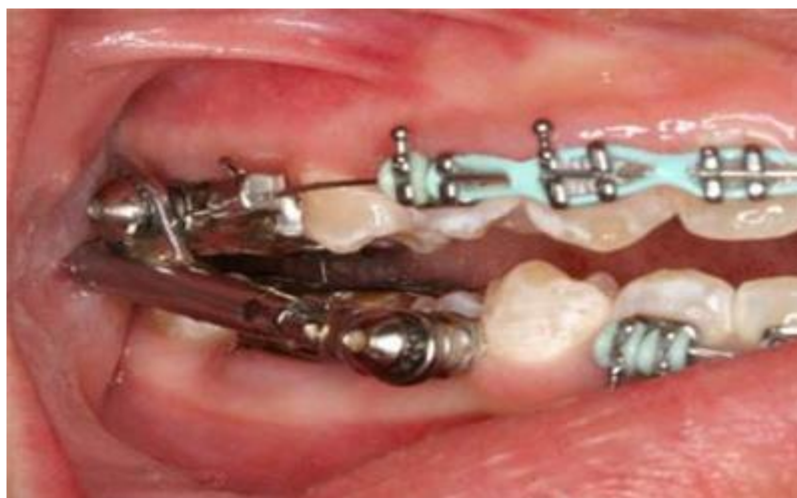

**Fig 2:** Herbst Appliance

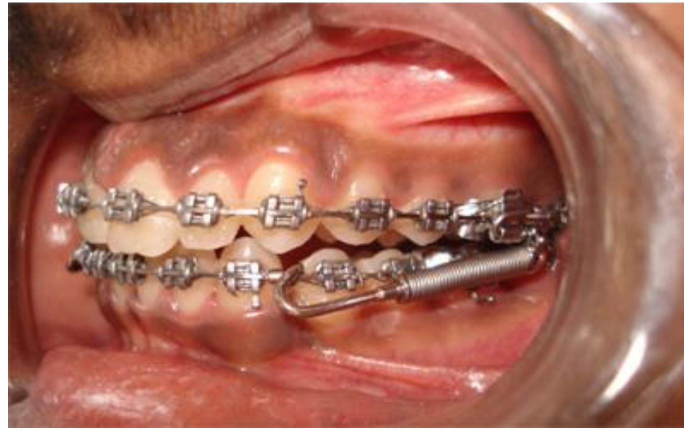

**Fig 3:** Forsus

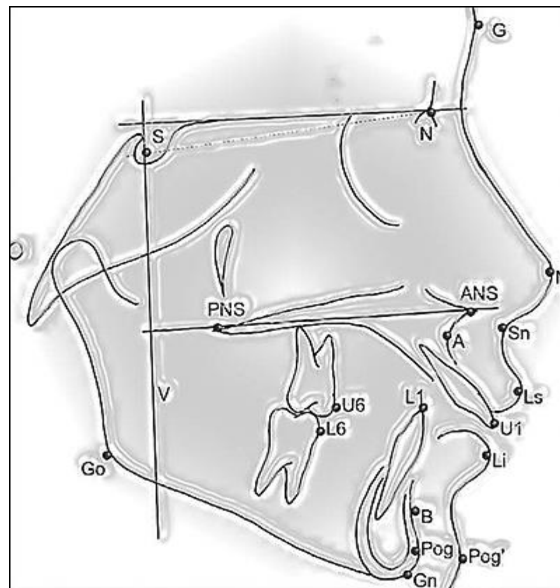


**Fig 4:** Cephalometric landmarks: Go indicates a point on the curvature of the angle of the mandible located by bisecting the angle formed by lines tangent to the posterior ramus and the inferior border of the mandible; Nt, most anterior point on the sagittal contour of the nose; U6, mesial cusp tip of maxillary first molar; L6, mesial cusp tip of mandibular first molar; U1, incisal tip of the maxillary central incisor; L1, incisal tip of the mandibular central incisor.

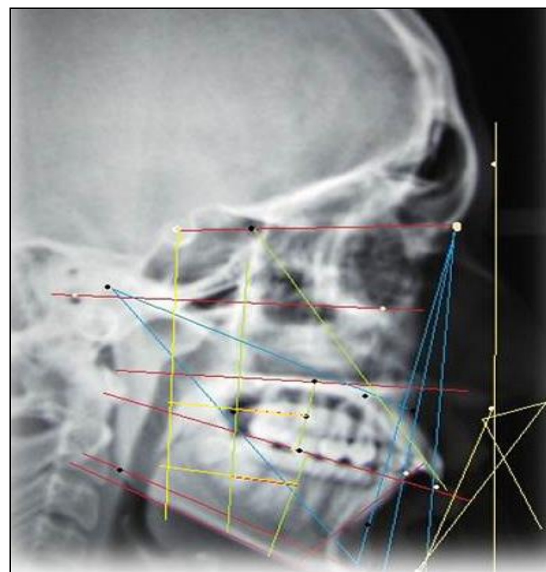

**Fig 5:** Cephalometric planes. 1: S-N plane; 2: Sella horizontal (Sh or constructed FH plane or x axis); 3: palatal plane (ANS-PNS); 4: mandibular plane (Go-Gn); 5: sella vertical (Sv or y axis); 6: Rickett'sesthetic plane (Nt-Pog'); 7: occlusal plane (OP).

### Statistical analysis

The data gathered was stored and analyzed using the SPSS v. 15.0 statistical analysis Program. Intergroup comparison using Kruskall Wallis ANOVA test. Descriptive analysis was done for all 3 groups for mean and standard deviation .Group wise comparison of each parameter using Wilcoxon signed rank test .A confidence level less than 5% was considered statistically significant (P<..05)

### Results

Table 1 shows pre-treatment and post-treatment skeletal, dental and soft tissue changes seen in subjects treated with Churro Jumper using ANOVA. Table 2 shows skeletal, dental and soft tissue changes seen with the Herbst appliance. Table 3 shows skeletal, dental and soft tissue changes seen in subjects treated with the Forsus.

**Table 1:** Skeletal, Dental, Soft tissue changes seen with churro jumper intergroup comparison using kruskall wallis anova and descriptive analysis

| group 1 pre treatment | N | Mean | Std. Deviation | post treatment | N | Mean | Std deviation | Z | Asymp. Sig. (2-tailed |
|---|---|---|---|---|---|---|---|---|---|
| 1 SNA | 10 | 79.10 | 3.381 | SNA | 10 | 78.9 | 3.281 | -.541 | .589 |
| SNB | 10 | 75.50 | 3.274 | SNB | 10 | 77.4 | 2.675 | -1.853 | .064 |
| ANB | 10 | 3.90 | 1.101 | ANB | 10 | 1.6 | 1.265 | -2.441 | .015 |
| wits | 10 | 3.500 | 2.8771 | wits | 10 | 0.1 | 1.3703 | -2.142 | .032 |
| N⊥ptA | 10 | -3.500 | 4.5765 | N⊥ptA | 10 | -1.9 | 4.0675 | -.912 | .362 |
| N⊥pog | 10 | -9.300000 | 10.011 | N⊥pog | 10 | -5.8 | 6.3034 | -.890 | .373 |
| CoA | 10 | 87.10 | 2.885 | CoA | 10 | 87.1 | 2.885 | .000 | 1.000 |
| CoGn | 10 | 103.80 | 3.425 | CoGn | 10 | 106.3 | 4.423 | -1.279 | .201 |
| DIFF | 10 | 16.80 | .919 | DIFF | 10 | 19.3 | 1.703 | -2.448 | .014 |
| GoGnSn | 10 | 23.200 | 4.8488 | GoGnSn | 10 | 23.3 | 3.86 | -.141 | .888 |
| occl Sn | 10 | 14.20 | 2.936 | occl Sn | 10 | 16.6 | 3.134 | -1.730 | .084 |
| ufh:lfh | 10 | .8180 | .16116 | ufh:lfh | 10 | 0.822 | 0.13181 | -.070 | .944 |
| PFH:AFH | 10 | 69.990000 | 4.6364378 | PFH:AFH | 10 | 70.475 | 3.379123 | -.178 | .859 |
| sum | 10 | 385.60 | 2.757 | sum | 10 | 386.4 | 2.875 | -.679 | .497 |
| U1 Sn | 10 | 111.40 | 6.653 | U1 Sn | 10 | 105.9 | 2.807 | -2.352 | .019 |
| IMPA | 10 | 102.50 | 10.448 | IMPA | 10 | 109.4 | 6.9314 | -1.072 | .284 |
| U1L1 | 10 | 120.00 | 13.081 | U1L1 | 10 | 112.9 | 8.346 | -1.581 | .114 |
| U1 Na° | 10 | 31.70 | 7.861 | U1 Na° | 10 | 28.4 | 3.978 | -.985 | .325 |
| U1 Na mm | 10 | 6.000 | 3.0912 | U1 Na mm | 10 | 4.4 | 1.5776 | -1.147 | .251 |
| L1 Nb° | 10 | 25.10 | 9.207 | L1 Nb° | 10 | 32.3 | 5.87 | -1.278 | .201 |
| L1 Nb mm | 10 | 4.000 | 3.0185 | L1 Nb mm | 10 | 6.3 | 2.6268 | -2.689 | .007 |
| U1 PP | 10 | 23.30 | 3.860 | U1 PP | 10 | 25.2 | 3.584 | -.919 | .358 |
| U6PP | 10 | 16.20 | 1.317 | U6PP | 10 | 17.7 | 3.802 | -1.179 | .238 |
| L1MP | 10 | 28.90 | 3.665 | L1MP | 10 | 29.9 | 7.279 | -.415 | .678 |
| L6MP | 10 | 25.80 | 4.940 | L6MP | 10 | 28.4 | 3.978 | -1.685 | .092 |
| U6Ptv | 10 | 23.70 | 4.900 | U6Ptv | 10 | 28.4 | 3.978 | -1.939 | .052 |
| L6Ptv | 10 | 23.10 | 4.581 | L6Ptv | 10 | 30.6 | 3.373 | -2.803 | .005 |
| GSnPg | 10 | 16.50 | 5.017 | GSnPg | 10 | 14.7 | 3.335 | -1.009 | .313 |
| CmSnLs | 10 | 104.40 | 11.047 | CmSnLs | 10 | 100.6 | 6.15 | -1.247 | .212 |
| E Line U | 10 | -1.000 | 2.7080 | E Line U | 10 | -2.1 | 0.3162 | -1.219 | .223 |
| E Line L | 9 | .000 | 2.4495 | E Line L | 10 | -0.4 | 1.1738 | -.339 | .734 |

**Table 2:** Skeletal, Dental, Soft tissue changes seen with Herbst intergroup comparison using kruskall wallis anova and descriptive analysis

| group 2 pre treatment | N | Mean | Std deviation | Post treatment | N | Mean | Std deviation | Z | Asymp. Sig. (2-tailed |
|---|---|---|---|---|---|---|---|---|---|
| 2 SNA | 10 | 79.80 | 3.084 | SNA | 10 | 80.10 | 2.885 | -.135 | .892 |
| SNB | 10 | 76.90 | 5.840 | SNB | 10 | 77.80 | 2.741 | -1.798 | .072 |
| ANB | 10 | 4.30 | .483 | ANB | 10 | 2.50 | .972 | -2.807 | .005 |
| wits | 10 | 1.100 | 2.1318 | wits | 10 | .450 | 1.4615 | -1.080 | .280 |
| N⊥ptA | 10 | -3.550 | 4.3362 | N⊥ptA | 10 | -1.900 | 2.9231 | -2.273 | .023 |
| N⊥pog | 10 | -8.900000 | 5.4863467 | N⊥pog | 10 | -4.200 | 3.4010 | -2.547 | .011 |
| CoA | 10 | 85.10 | 6.999 | CoA | 10 | 86.50 | 5.603 | -1.095 | .273 |
| CoGn | 10 | 101.40 | 7.919 | CoGn | 10 | 108.50 | 5.893 | -2.670 | .008 |
| DIFF | 10 | 16.70 | 5.813 | DIFF | 10 | 22.10 | 4.932 | -2.499 | .012 |
| GoGnSn | 10 | 28.600 | 5.6999 | GoGnSn | 10 | 28.40 | 5.147 | -.513 | .608 |
| occl Sn | 10 | 18.50 | 8.127 | occl Sn | 10 | 18.30 | 7.528 | -.460 | .645 |
| ufh:lfh | 10 | .7600 | .08433 | ufh:lfh | 10 | .7890 | .08749 | -.756 | .450 |
| PFH:AFH | 10 | 67.958000 | 5.1205334 | PFH:AFH | 10 | 67.980000 | 4.0115 | -.357 | .721 |
| sum | 10 | 389.30 | 6.165 | sum | 10 | 389.50 | 5.148 | -.241 | .809 |
| U1 Sn | 10 | 115.00 | 11.304 | U1 Sn | 10 | 105.90 | 2.644 | -1.992 | .046 |
| IMPA | 10 | 99.70 | 7.790 | IMPA | 10 | 102.750 | 9.1051 | -2.814 | .005 |
| U1L1 | 10 | 120.40 | 11.787 | U1L1 | 10 | 120.60 | 7.975 | -.051 | .959 |
| U1 Na° | 10 | 38.20 | 7.345 | U1 Na° | 10 | 29.10 | 3.446 | -2.807 | .005 |
| U1 Na mm | 10 | 11.200 | 2.8402 | U1 Na mm | 10 | 6.850 | 1.9156 | -2.601 | .009 |
| L1 Nb° | 10 | 26.90 | 8.517 | L1 Nb° | 10 | 29.50 | 7.792 | -1.608 | .108 |
| L1 Nb mm | 10 | 5.800 | 2.0440 | L1 Nb mm | 10 | 6.800 | 1.0328 | -1.411 | .158 |
| U1 PP | 10 | 28.00 | 2.108 | U1 PP | 10 | 26.50 | 3.629 | -1.070 | .285 |
| U6PP | 10 | 17.00 | 2.055 | U6PP | 10 | 18.90 | 1.595 | -2.203 | .028 |
| L1MP | 10 | 30.30 | 5.438 | L1MP | 10 | 32.90 | 6.707 | -1.409 | .159 |
| L6MP | 10 | 23.20 | 4.849 | L6MP | 10 | 30.70 | 8.028 | -1.838 | .066 |
| U6Ptv | 10 | 21.20 | 4.185 | U6Ptv | 10 | 25.80 | 3.645 | -2.255 | .024 |
| L6Ptv | 10 | 23.80 | 4.341 | L6Ptv | 10 | 32.50 | 6.485 | -2.314 | .021 |
| GSnPg | 10 | 19.50 | 4.927 | GSnPg | 10 | 15.50 | 3.240 | -1.951 | .051 |
| CmSnLs | 10 | 97.50 | 18.350 | CmSnLs | 10 | 100.90 | 6.822 | -.663 | .508 |
| E Line U | 10 | -.900 | 2.4244 | E Line U | 10 | -1.150 | 1.7958 | -.302 | .763 |
| E Line L | 10 | .100 | 3.0714 | E Line L | 10 | 1.900 | 1.2867 | -1.185 | .236 |

**Table 3:** Skeletal, Dental, Soft tissue changes seen with Forsus intergroup comparison using kruskall wallis anova and descriptive analysis

| Group 3 pretreatment | N | Mean | Std. Deviation | post treatment | N | Mean | Std deviation | Z | Asymp. Sig. (2-tailed |
|---|---|---|---|---|---|---|---|---|---|
| SNA | 12 | 79.58 | 2.906 | SNA | 12 | 78.42 | 2.392 | -1.230 | .219 |
| SNB | 12 | 75.25 | 2.734 | SNB | 12 | 76.00 | 2.335 | -1.023 | .306 |
| ANB | 12 | 4.33 | 2.060 | ANB | 12 | 2.33 | 1.303 | -2.479 | .013 |
| wits | 12 | 1.750 | 4.0536 | wits | 12 | -.042 | 2.5177 | -1.768 | .077 |
| N┴ptA | 12 | -1.875 | 4.2806 | N┴ptA | 12 | -2.750 | 4.0982 | -.178 | .859 |
| N┴pog | 12 | -10.65 | 3.5735137 | N┴pog | 12 | -8.542 | 2.5889 | -1.416 | .157 |
| CoA | 12 | 87.58 | 4.274 | CoA | 12 | 87.92 | 4.814 | -.119 | .905 |
| CoGn | 12 | 106.83 | 5.254 | CoGn | 12 | 109.50 | 4.908 | -1.430 | .153 |
| DIFF | 12 | 18.83 | 2.918 | DIFF | 12 | 21.08 | 2.999 | -2.486 | .013 |
| GoGnSn | 12 | 29.958 | 4.4336 | GoGnSn | 12 | 30.42 | 3.260 | -.537 | .591 |
| occl Sn | 12 | 18.08 | 4.316 | occl Sn | 12 | 18.08 | 4.100 | -.633 | .527 |
| ufh:lfh | 12 | .8083 | .09962 | ufh:lfh | 12 | .7750 | .06216 | -.954 | .340 |
| PFH:AFH | 12 | 66.275000 | 4.2606284 | PFH:AFH | 12 | 65.583333 | 3.2118625 | -.785 | .433 |
| sum | 12 | 392.08 | 5.316 | sum | 12 | 393.58 | 3.370 | -1.069 | .285 |
| U1 Sn | 12 | 113.00 | 7.311 | U1 Sn | 12 | 104.67 | 4.793 | -2.314 | .021 |
| IMPA | 12 | 100.67 | 6.065 | IMPA | 12 | 100.333 | 7.3526 | -.491 | .623 |
| U1L1 | 12 | 114.17 | 12.364 | U1L1 | 12 | 119.92 | 8.878 | -1.649 | .099 |
| U1 Na˚ | 12 | 32.83 | 8.993 | U1 Na˚ | 12 | 26.25 | 6.904 | -1.727 | .084 |
| U1 Na mm | 12 | 9.167 | 3.4794 | U1 Na mm | 12 | 5.542 | 1.3392 | -2.318 | .020 |
| L1 Nb˚ | 12 | 27.67 | 4.207 | L1 Nb˚ | 12 | 29.75 | 5.011 | -1.277 | .202 |
| L1 Nb mm | 12 | 6.042 | 1.7640 | L1 Nb mm | 12 | 6.833 | 1.7100 | -1.277 | .202 |
| U1 PP | 12 | 27.42 | 4.166 | U1 PP | 12 | 29.17 | 3.512 | -1.294 | .196 |
| U6PP | 12 | 21.42 | 4.420 | U6PP | 12 | 19.83 | 2.290 | -1.077 | .282 |
| L1MP | 12 | 34.33 | 4.334 | L1MP | 12 | 29.75 | 4.615 | -2.504 | .012 |
| L6MP | 12 | 36.58 | 6.201 | L6MP | 12 | 28.83 | 3.298 | -2.710 | .007 |
| U6Ptv | 12 | 37.83 | 4.745 | U6Ptv | 12 | 49.08 | 3.679 | -3.065 | .002 |
| L6Ptv | 12 | 40.08 | 3.942 | L6Ptv | 12 | 48.92 | 2.539 | -3.065 | .002 |
| GSnPg | 12 | 20.08 | 4.738 | GSnPg | 12 | 16.75 | 4.434 | -2.123 | .034 |
| CmSnLs | 12 | 102.92 | 17.532 | CmSnLs | 12 | 105.58 | 12.086 | -.471 | .638 |
| E Line U | 12 | 1.333 | 2.3963 | E Line U | 12 | -1.083 | 2.7122 | -2.501 | .012 |
| E Line L | 12 | 1.708 | 2.8160 | E Line L | 12 | 1.208 | 2.5357 | -.154 | .878 |

## Discussion

Functional appliances are a valuable means of correcting sagittal skeletal discrepancies caused by a retrognathic mandible. To what extent do these appliances bring about a clinically significant increase in growth still remains questionable but it is generally accepted that their use brings about a favorable change in the soft profile of the patient. In recent years, use of FFA has increased in patients with poor compliance. These appliances help to integrate functional and fixed phases into a single phase.

FRD recently introduced was found to be comfortable for the patient, did not suffer from breakages and seems to posture the mandible forward. Due to the paucity of scientific data the present study was planned.

In group I, correct molar relation and significant reduction in overjet was achieved by mesial movement of the mandibular molar (7.5mm). A significant decrease in the ANB was seen (2.3˚) and increased lower incisor proclination (11˚) and both LI to Nb. Linear and angular measurement increased by (2mm and 7˚ respectively) and extrusion of the lower molar. In group II, correction of the Cclass II molar relation was achieved by mandibular growth, Go-Gn was increased by 7.1mm and N┴Pog was increased to 4.7mm and mesial movement and extrusion of the lower molar by 8.7mm & 3mm respectively was seen.

Distalization and intrusion of the upper molar was seen by 4.6mm and 1.9mm Respectively. The lower incisor were proclined, IMPA was increased by 3˚. In group III, significant increase in ANB (2˚), and increase in mandibular length was seen. No significant change in size and position of the maxilla were seen.

The Maxillary incisor showed decreased proclination. Distalization & intrusion of the maxillary molar by 11.2mm & 3.3mm respectively. Mesialization and extrusion of the mandibular molar by 8.8 mmm & 6mm was achieved .Improvement in soft tissue profile G-Sn-Pg by 3.3˚ was seen.

Results of our study are in agreement with one done by Franchia[6] et al who concluded FRD group showed a significant restraint in the sagittal skeletal position of the maxilla (also at the soft tissue level), a significant increase in mandibular length, and a significant improvement in maxillo-mandibular sagittal skeletal relationships. The lower incisors were significantly proclined while the lower first molars moved significantly in a mesial and vertical direction.

Most of the studies on Herbst (Valant & Sinclair [9], Pancherz [8]) showed similar results and in agreement to what we achieved in our study. In our study correction of the Class II molar relation was achieved by an increase

in the mandibular length, mesial movement of molars and distal movement of upper arch with intrusion of molars and seems to have a Headgear-like effect on the upper dentition. Correction of the overjet was obtained by an increase in the size of the mandible, retraction of the maxillary incisors and proclination of the mandibular incisors. Greater skeletal effects for correction of Class II malocclusion was seen with the Herbst appliance. Correction achieved in the Churro jumper group was similar to that of the Forsus group with similar results.

**Clinical implication**

The FRD Appliance is ideally suited for use in patients with mandibular retrusion and minimal maxillary excess. Patient selected should ideally have a hypo to normodivergent growth pattern to accommodate the increase in lower anterior facial height. It should be avoided in a hyperdivergent growth pattern.

Due to the tendency of these appliances to procline the lower incisors, it should be ensured that they are not proclined at the beginning of the treatment.

Though these appliances bring about Class II correction largely through dentoalveolar effects, a favorable change in the soft tissue profile with reduction in facial convexity is seen.

**Limitations of this study**

The absence of age and gender matched groups, due to which it was not possible to quantify how much of a change produced was a part of the natural growth process. Results obtained from the current study have to be confirmed using a larger sample. No uniform distribution between male and female subjects, hence gender based comparison could not be carried out. Stability of the results needs to be established by conducting long term studies.

**Conclusion**

All the appliances can be used for correction of Class II malocclusion to achieve more of a skeletal change, the Herbst appliance is preferred but limitations with this appliance being rigidity and frequent breakage which may prolong treatment time and restrict jaw movement.

To achieve dentoalveolar changes and to overcome limitations of the Herbst appliance, the Forsus or Churro Jumper can be used, as the results achieved with both of them are similar.

Limitation of the Forsus is that it is expensive, whereas the Churro Jumper is fabricated chairside and it is cost effective.

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