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Effects of Forsus Fatigue Resistant Device Therapy Compared With Twin Block Therapy

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Abstract

Background: Class II orthopaedic / functional appliances are used for correction of mandibular deficiencies where they cause mandibular repositioning by moving the mandible forward and / or downward.

Aims and Objectives: To evaluate and compare the dento-alveolar, skeletal and soft tissue changes by using lateral cephalograms in skeletal Class II subjects with retrognathic mandible who were treated either with the Forsus fatigue resistant device or Twin Block.

Methodology: Standardized pre-treatment and post-functional treatment lateral cephalograms of total 30 subjects having skeletal Class II was obtained (15 subjects in each group).The data was statistically compared by using paired and independent sample 't' test.

Results: The Twin Block group caused more effective mandibular advancement than Forsus group while the Forsus showed more maxillary restriction than Twin Block. Thus, anteroposterior correction was significant in both groups. However, for the skeletal changes there was no significant difference in the effectiveness between the two groups. Upper incisor retraction was more in Forsus group over the Twin Block appliance, which was statistically significant between the two groups. The upper molars intruded in the Forsus group and extruded in Twin Block group. Both groups helped in improving soft tissue convexity significantly. These soft tissue changes reflected the dento-alveolar and skeletal changes. However, there was no significant difference in effectiveness between the two groups regarding soft tissue changes.

Conclusion: Both the appliances were equally effective in correcting skeletal Class II malocclusion in growing children by forward positioning of the mandible and by restriction of maxillary growth.

Keywords: Forsus FRD; mandibular advancement; Mandibular retrognathism; Skeletal Class II; Twin Block Appliance.

Introduction

Class II malocclusions have been of extensive interest to Orthodontists as they constitute a significant percentage (1.9% - 14.6%) of the Indian population. [1] Class II orthopaedic / functional appliances are used for correction of mandibular deficiencies where they cause mandibular repositioning by moving the mandible. [2]

Fixed functional appliances are not dependant on patient compliance and now play an important role in Class II correction. [3]The Forsus (3M Unitek, Monrovia, Calif) is a relatively recent semi rigid fixed functional appliance. [4] Forsus Fatigue Resistant Device (FRD) is an effective in Class II corrector by causing a combination of skeletal changes and dento-alveolar correction. They show variable effects associated with mandibular growth. [5]

The Twin Block (TB) was developed by William J. Clark of Fife, Scotland. [6]Occlusal inclined planes formed by Upper and lower acrylic bite blocks interlock at 70 degree angle which guide the mandible downward and forward. [7] Studies have concluded that 60-70 percent of Class II correction was by orthodontic tooth movement, only 30-40 percent was orthopaedic. [8]

Thus, uncertainty regarding the mechanism of correction by Twin Block and Forsus appliance still exists. Moreover, it was necessary to evaluate and compare the dentoalveolar, skeletal and soft tissue changes between Twin Block and Forsus.

Materials and Methods

Study design

A retrospective study carried out by obtaining lateral cephalograms, clinical records and case history records of 30 skeletal Class II patients was obtained.15 subjects in Twin Block and 15 subjects in Forsus FRD group. Standardized pre-treatment (T1) and post-functional treatment (T2) lateral cephalograms of each individual subject were taken from the orthodontic departmental archives. These digital lateral skull radiographs were taken with Planmeca Promax (Planmeca, Finland, Inc). The study was approved by the ethical board committee of our University. (ABSM/EC96/2015)

Inclusion criteria:

- Skeletal Class II individuals with SNA $\geq$ 80 and SNB $\leq$ 77
- ANB $\geq$ 4 degrees
- Average to horizontal growth pattern
- Angle's Class II molar relationship
- Overjet $\geq$ 5mm.
- Minimal or no crowding at start of treatment
- Adequate pre-treatment and post-functional treatment records of patients treated with Forsus fatigue resistant device and Twin Block appliance.
- Growth period before or at the peak stage or near the end of puberty growth stage indicated from cervical vertebral maturation (before or at stage 4) and hand wrist radiographs (before MP3 capping).
- The appliance being worn at least for 6 months

Exclusion criteria:

- Poorly defined cephalometric landmarks.
- Craniofacial anomalies
- Extraction treatment

Cephalometric analysis: [9, 10]

Lateral cephalograms were traced on to 0.003 inch acetate paper with 2H lead pencil and the landmarks were identified. Measurements were made manually on pre-treatment and post-functional treatment lateral cephalograms. The magnifications were standardized. Cervical vertebral maturation by Baccetti's method [11] and hand wrist radiographs were obtained and analysed for the growth status at the start of the treatment by Fishman's method. [12]

The following angular and linear parameters are seen in **Figures 1-5.**

Figure 1: Angular measurements of Skeletal Parameters on Lateral Cephalogram: 1- Saddle angle, 2- Articular angle, 3- Gonial angle

Figure 2: Linear and Angular Measurements of Skeletal Parameters on Lateral Cephalogram: 1- Co-A, 2- Co-Gn, 3- Go-Co, 4- Go-Pog, 5- ANB (SNA-SNB)

Figure 3: Angular and linear measurements of Skeletal Parameters on Lateral Cephalogram: 1: Y- axis, 2: Pal – MP angle, 3: S-Go, 4: N-Me 5.Jaraback's ratio: S-Go/N-Me

Figure 4: Angular and linear measurements of Dental Parameters on Lateral Cephalogram: 1- U1-SN angle, 2- IMPA angle, 3: U6-SN (mm), 4- S ⊥ OP, 5- U6-S ⊥ OP, 6- L6- S ⊥ OP, 7-L6-MP, 8-U1- SN (mm), 9- L1- MP (mm)

Figure 5: Angular and linear measurements of Soft tissue Parameters on LateralCephalogram: 1-Facial angle, 2- Upper lip thickness, 3- Lower lip to H-line, 4- H-line angle

Statistical Analysis

The data was analyzed with SPSS software version 22. The collected information was summarised by using descriptive statistics in the form of frequency and percentages. Mean along with Standard deviation was also calculated. To compare the outcome measures before and after functional treatment in both the groups paired sample 't' test was used. To compare the effects between Twin Block appliance and Forsus fatigue resistant device independent sample 't' test was used.

Results

The present study was undertaken with the intention of evaluating treatment effects between Twin Block and Forsus FRD.

Standardized pre-treatment and post-functional treatment lateral cephalograms of each subject was obtained (15 subjects (10 males, 5 females) in Twin Block and 15 subjects (5 males, 10 females) in Forsus FRD group. **(Table 1)**

The mean age prior to treatment was 13.13 ± 0.83 years for Forsus group and 12.33 ± 0.98 years for Twin Block group. **(Table 2)**

Intra-group Comparison: (Table 3 and 4)

Significant skeletal changes were observed at T2 in both groups. Jarabacks ratio decreased significantly by 0.42 % and 0.76 % in TB and FRD respectively. SNA decreased and SNB increased signifcantly in both groups. (SNA: 0.67^0 and 1.47^0; SNB: 2.67^0 and 2.33^0 in TB and Forsus respectively). The effective mandibular length, ramal length and mandibular body length increased significantly in both groups. (Co-Gn: 2.20 mm and 1.90 mm; Go-Co: 0.93 mm and 1.47 mm; Go-Pog: 2.13 mm and 2.20 mm in TB and Forsus respectively)

Significant dental changes were observed at T2 in both groups. Upper incisor retracted and extruded in both groups significantly. (I-SN (angle): 5.13 ^{0} and 10.97 ^{0}; I-SN (mm): 1.40 mm and 1.30 mm in TB and Forsus respectively). Lower incisors intruded in both groups significantly (L1-MP: 1.73 mm and 1.50 mm in TB and Forsus respectively). Upper molar extruded (U6-SN) in TB group by 0.97 mm and intruded in the Forsus group by 0.90 mm. Upper and lower molar to vertical reference plane showed that in both groups the upper molars distalized significantly and lower molars mesialised signifcanltly. (U6- S⊥ OP: 0.97 mm and 1.36 mm; L6-S⊥OP: 4.30 mm and 3.63 mm in TB and Forsus respectively). The Wits appraisal decreased significantly in both the groups (AO-BO: 2.73 mm and 2.53 mm in TB and Forsus respectively. Overjet and Overbite decreased significantly in both groups.

(Overjet: 5.43 mm and 5.40 mm; Overbite: 1.80 mm and 1.76 mm in TB and Forsus respectively).

Significant soft tissue changes were observed at T2 in both groups. Lower lip to H-line increased significantly in Twin-Block group. H-angle decreased significantly in both groups. (H-angle: 3.07^0 and 2.27^0 in TB and Forsus respectively)

Inter-group comparison: (Table 5)

Forsus showed significantly more upper incisor retraction compared to the TB group. The upper molars intruded in TB group while they extruded in the Forsus group. These were the significant dento-alveolar changes between the groups. There were no significant skeletal and soft tissue changes between the two groups.

Discussion

The current study is a retrospective study evaluating the treatment effects of Twin Block and Forsus. The primary differences between the removable and fixed appliance is compliance related. The mode of action of fixed functional appliances is that they cause minimal vertical opening with maximum bite advancement over the removable appliances. However, their breakage rate is more compared to removable appliances. Removable appliances are associated with excessive vertical opening which interferes with normal jaw movement, thus making it difficult for the patient to use it full time. [13,14] To overcome compliance related problems with conventional approach such as headgear, elastics and functional appliances, fixed functional appliances were introduced.[15] Removable appliances generally apply intermittent force while fixed appliances exhibit a continuous force. The appliances also differ on duration of treatment whether it is short term or long term. The time a patient wears the appliance in a day is very critical in assessing the treatment progress. Evaluating the growth status for ideal treatment timing is of utmost importance and should be considered when selecting such appliances. Pre-pubertal or at the pubertal spurt is the preferred timing for Class II correction. It is very important to assess growth direction, magnitude of growth and growth related changes on a long term basis. [16]

In this study standardized pre-treatment and post-functional treatment lateral cephalograms of each subject was obtained.15 subjects in Twin Block and 15 subjects in Forsus FRD group were selected on the basis of inclusion criteria.

There were no significant cranial base changes when compared between the two groups. These results were similar to studies by Hanoun et al[2], Spalj et al[17] where they used the cranial base angle for measurement. There was a slight increase in the gonial angle in both groups but was not statistically significant. This was in accordance to studies by Cacciatore et al[18] where they reported an increase in Gonial angle by Forsus FRD, however the change was not significant. However, a study by Tumer et al[19] reported a significant increase in gonial angle in patients treated by Twin Block. Posterior displacement of articulare (due to spheno-occipital synchondrosis growth) rather than changes at gonion or menton could be the reason for its increase.[20,21] Another reason can be condylar growth directed sagittally or change in muscle function that could lead to resorption at gonial region.[22]

Vertical changes were assessed by Jaraback's ratio, Pal-Mp angle and Y-axis. Jaraback's ratio showed a significant decrease in case of both appliances, however between the groups there was no significant difference. There were no significant changes seen with the Pal-Mp angle and Y-axis.

In this study both groups showed significant decrease in SNA angle. The maxillary growth restriction (SNA) was more in Forsus compared to the Twin Block group.[23-25] The reason attributed to this for both appliances can

be the intermittent or full time force applied on the maxilla. Point A is influenced by dento-alveolar changes. In this study, incisors are tipped lingually and apices are moved labially. As a result of reshaping of alveolus, there should be an advancement of point A, but it decreased. So more amount of maxillary restriction might have occurred which went undetected because of dento-alveolar changes.[26] Both groups showed decrease in length of midface (Co-A), but the change was not significant. Their action on the midface does not show enough evidence in literature. 2 However, increase of this measure is to be expected in growing children. A systematic review and Meta – analysis by Nucera et al[27] revealed functional appliances shows slight inhibitory effect on the sagittal growth of the maxilla in the short term only.

In this study, primary inclusion criteria was skeletal class II malocclusion with retrognathic mandible. So any improvement in facial profile can be attributed due to an increase in SNB angle .There was a significant increase of SNB angle in both the groups, with the Twin Block group showing greater mandibular advancement.[23,24] Mandibular ramus (Co-Go), body (Go-Pog) and effective mandibular length (Co-Gn) increased significantly in both groups. Mills and McCulloch[28], Lund and Sandler[29] and Illing et al[30], reported extra mandibular growth with Twin Block appliance. This could be attributed to the following reason; normal growth enhancement, forward posturing of mandible by the appliance and downward and backward rotation of mandible. In a study by Franchi et al[25] there was a net increase in 2 mm of mandibular length in Forsus group when compared to untreated sample. However, they concluded that growth increment did not affect the position of the chin. They correlated this with short treatment duration (average 6 months).

There was a significant reduction in ANB angle in both groups. The reason for this is mainly due to forward positioning of mandible (increase in SNB angle) and mild decrease in SNA angle.[5,7,25,28,29,31]But there was no significant post treatment changes seen in ANB using Forsus FRD in the study conducted by Fulya Ozdemira.[32] To rule out any errors with identification of Nasion as reference point, maxillo-mandibular apical base changes were analysed with the help of Wits appraisal. The Wits appraisal significantly reduced in both groups. This also indicates the skeletal correction has occurred by anterior displacement of point B. Thus, this change in the maxillo-mandibular relationship helped to achieving better aesthetics and facial convexity.[24,33]

A significant decrease in the inclination of upper incisors (U1 to SN) was seen in both groups. It was significantly more profound in Forsus group. However, it is contradictory to a study by Hanoun et al [2] where Twin Block has shown more upper incisor retraction. Most authors attribute this to the labial bow and duration of appliance wear. However, operator factor must be taken into consideration. Authors believe that the presence of brackets could limit the retraction of incisors.2 Upper incisor retraction in Forsus group occurred due to distalising force on maxillary arch. The linear distance of Upper incisor to Sella – Nasion (U1-SN in mm) increased significantly in both groups. Thus the incisors extruded during the treatment for both groups.[23,24,34] However, in one study by Tarvade et al[33]the upper incisor in Forsus group intruded. Thus, in our study overall the upper incisors extruded and were lingually tipped.

Lower incisor proclination (IMPA) was seen in both group as per other studies, but was insignificant. The proclination was less compared to other studies. Other studies reported more proclination in Forsus group contradictory to our study.[24,33] Various methods have been suggested during fixed orthodontic treatment to reduce the lower incisor proclination such as use of a

lingual arch and using negative torque brackets for lower incisors, cinching the wire and using thicker dimension wires.[25,35] For the Twin Block group acrylic capping has been suggested.[2,36] Nowadays, miniscrew anchorage is also considered to prevent this effect.[37] The duration of treatment is an important factor to be considered. Linear distance of lower incisor to mandibular plane (L1 – MP) in both groups showed a decrease. This indicated the lower incisors intruded in both groups.[22,24,34] This is due to forward and downward force on the mandible.34 However, in a study by Tarvade et al,[33] the Twin Block showed extrusion of lower incisors which was not significant and significant extrusion of lower incisors in Forsus group.

Upper molars were distalized (U6- S ⊥ OP) significantly in both groups. However, in Twin Block group they extruded (U6 – SN) while in Forsus group they intruded.[24,34] In another study, the Forsus group showed extrusion of molars however.[33] Inspite of the bite-block in Twin Block, the mesiobuccal cusp was taken as the reference which extruded during the study probably due to the distal force leading to its tipping.[29] Moreover, normal molar eruption is in a downward and forward direction. It has been seen that Frankel and Activator restrict upper molar eruption compared to the untreated samples inspite of wire components and bite blocks, but still there is a net extrusive force due to molar eruption. Moreover, intermittent wear in some cases could have reduced the intrusive effect of the bite blocks.[38] In case of Forsus, the centre of resistance of maxillary teeth lies above and ahead of the force component, so the distalising force could have led to intrusion of upper molars.

The Lower molars mesialised and extruded (L6- S ⊥ OP and L6-MP) significantly in both groups.[24,33] In Twin Block the lower molars are made to erupt by selective trimming of the upper bite block so this led to eruption of lower molars.[29] The lower molars in Forsus group extruded due to a mesially directed force.[18] Overjet and Overbite reduced significantly in both groups.[23,24]

Soft tissue changes were assessed by Facial angle, H angle, Upper lip thickness and lower lip to H line. Changes in the facial angle and Upper lip thickness were statistically insignificant for both groups. Facial angle increased minimally probably due to anterior and downward movement of the chin. This in turn improves the facial convexity. These changes can be attributed to the underlying skeletal changes.[24] However, some authors believe that facial profile improvement do not necessarily follow the underlying dental or skeletal changes.[39,40,41] Upper lip thickness did not show any change in spite of considerable incisor retraction as seen in study by Haynes et al.[42] Authors claim that though the incisors showed retraction, it was more of tipping at the incisal edge with slight backward movement at the cervical area.[43] According to Ramos et al[44] bodily retraction of the incisors results in more upper lip retraction. H angle decreased significantly in both groups leading to a decrease in facial convexity.[45]

Lower lip to H- line increased significantly only in the Twin Block group. This was similar to a study by Tumer et al.[19] The reason attributed for this is the greater mandibular advancement in Twin Block group and proclination of lower incisors. Thus, these appliances tend to cause an overall forward movement in the lower face. Very few studies have extensively compared soft tissue changes between Twin Block and Forsus.46 Cephalometric studies are not enough to give a complete assessment on soft tissue facial profile. It should be evaluated clinically, by photographs and by recent advances such as stereo photogrammetry or laser scanning.[47,48,49]

The duration of appliance wear, patient co-operation, mode of action, age factor and inherent growth pattern in both the group could lead to errors. These limitations should be considered and more long term studies with larger sample are suggested.

Conclusions

With the inherent limitations in the study, following conclusions may be drawn from this study:

1. Both the appliances were equally effective in correcting skeletal Class II malocclusion in growing children by forward positioning of the mandible and by maxillary restriction.

2. The significant skeletal changes seen in both groups were advancement of mandible and restriction of maxillary growth. These favoured anteroposterior correction. However, for the skeletal changes there was no significant difference in the effectiveness between the two groups.

3. The changes in the upper incisor angulation was significantly different between the two groups, with the Forsus showing more incisor retraction. The upper molars extruded in Twin Block group and intruded in the Forsus group, being a significant difference between the two groups.

4. The soft tissue changes reflected the dento-alveolar and skeletal changes. However, there was no significant difference in effectiveness between the two groups regarding soft tissue changes.

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Table 1:Gender distribution in groups

	Group		
	FRD	TB	Total
Male	5	10	15
Female	10	5	15
Total	15	15	30

Table2: Mean age and standard deviation for both groups

FRD	N	15
	Mean	13.13
	Std. Deviation	.83
TB	N	15
	Mean	12.33
	Std. Deviation	.98

Table 3: Comparison of the outcome measures before and after functional treatment in subjects who received Twin Block treatment by using paired sample‘t’ test

	Pre treatment		Post treatment			
Variable	Mean	S.D	Mean	S.D	“t”	P- value
Skeletal						
N-S-Ar	127.60	6.23	128.03	6.57	0.672	0.513
S-Ar-Go	140.53	7.33	139.67	6.46	0.859	0.405
Ar-Go-Me	124.90	6.61	126.03	6.65	1.340	0.202
Jarabacks ratio	64.96	2.55	64.54	2.53	3.572	0.003*
SNA	82.17	1.48	81.50	1.48	3.696	0.002*

SNB	75.53	1.51	78.20	1.42	7.391	<0.001*
ANB	6.63	1.45	3.30	1.13	8.069	<0.001*
Pal-MP	22.47	5.10	21.93	5.33	0.649	0.527
Go-Pog	70.47	5.00	72.60	5.59	5.870	<0.001*
Go-Co	53.07	4.18	54.00	3.70	3.500	0.004*
Co-Gn	105.47	9.27	107.67	8.73	5.145	<0.001*
Co-A	88.40	6.14	88.30	6.24	0.350	0.731
Y-axis	65.47	5.04	66.00	3.87	0.798	0.438
Dentoalveolar						
I-SN (angle)	114.80	8.50	109.67	6.98	3.612	0.003*
I-SN (mm)	66.37	2.96	67.72	3.04	16.039	<0.001*
IMPA	104.60	6.17	107.13	6.88	1.632	0.125
L1- MP (mm)	40.80	2.03	39.07	1.76	8.918	<0.001*
U6-SN (mm)	61.27	2.93	62.23	2.92	7.790	<0.001*
U6- S⊥OP	39.23	1.91	38.27	2.10	7.790	<0.001*
L6-MP (mm)	27.13	1.62	28.57	1.43	12.128	<0.001*
L6- S⊥OP (mm)	38.10	1.85	42.40	2.07	26.815	<0.001*
AO-BO	4.33	1.28	1.60	1.12	3.422	0.001*
OVERJET	8.73	1.28	3.30	0.62	19.730	<0.001*
OVERBITE	4.43	0.53	2.63	0.58	13.208	<0.001*
Soft tissue						
FACIAL ANGLE	88.07	3.69	89.00	3.89	1.230	0.239
H-ANGLE	24.27	2.21	21.20	3.28	5.432	<0.001*
UPPER LIP THICKNESS	15.07	1.91	15.33	1.80	0.718	0.484
LOWER LIP TO H-LINE	0.63	1.89	2.23	1.41	3.335	0.001*

* Indicates significant value

Table 4: Comparison of the outcome measures before and after fixed functional treatment in subjects who received Forsus Fatigue Resistant Device treatment by using paired sample‘t’ test

	Pre treatment		Post treatment			
Variable	Mean	S.D	Mean	S.D	“t”	P- value
Skeletal						
N-S-Ar	125.40	4.88	124.40	3.16	0.863	0.403

S-Ar-Go	139.23	5.36	139.40	5.22	0.152	0.881
Ar-Go-Me	124.97	6.34	125.00	7.40	0.042	0.967
Jarabacks ratio	66.63	3.34	65.87	3.26	3.928	0.002*
SNA	83.07	1.43	81.60	1.99	3.232	0.006*
SNB	76.13	0.74	78.47	1.55	5.857	<0.001*
ANB	6.93	1.61	3.13	1.69	8.945	<0.001*
Pal-MP	24.87	4.14	26.13	6.00	1.727	0.106
Go-Pog	71.33	5.86	73.53	6.09	4.785	<0.001*
Go-Co	57.67	6.64	59.13	6.58	2.621	0.020*
Co-Gn	110.30	8.33	112.20	9.12	3.439	0.004*
Co-A	90.93	7.62	90.67	7.01	0.541	0.597
Y-axis	65.27	3.63	66.13	3.52	1.857	0.084
Dentoalveolar						
I-SN (angle)	114.97	9.14	104.00	9.53	5.025	<0.001*
I-SN (mm)	68.33	2.99	69.63	2.99	10.217	<0.001*
IMPA	105.53	8.19	106.33	5.25	0.353	0.729
L1- MP (mm)	40.63	1.70	39.13	1.62	10.247	<0.001*
U6-SN (mm)	64.13	2.51	63.23	2.58	6.874	<0.001*
U6- S⊥OP (mm)	38.80	1.53	37.43	1.61	8.271	<0.001*
L6-MP (mm)	27.57	1.27	29.03	1.11	11.820	<0.001*
L6- S⊥OP (mm)	37.53	1.64	41.16	1.52	21.089	<0.001*
AO-BO	4.17	2.39	1.63	1.56	3.317	0.001*
OVERJET	8.60	0.83	3.20	0.68	23.488	<0.001*
OVERBITE	4.30	0.37	2.53	0.58	13.817	<0.001*
Soft tissue						
FACIAL ANGLE	88.00	3.36	88.33	3.60	0.428	0.675
H-ANGLE	22.00	3.87	19.73	3.26	2.605	0.021*
UPPER LIP THICKNESS	15.47	1.41	15.07	2.66	0.858	0.405
LOWER LIP TO H- LINE	2.40	2.24	3.03	1.29	1.380	0.167

* Indicates significant value

Table 5: Comparison of the effectiveness (pre-post) between the Twin Block and Forsus Fatigue Resistant Device treatment groups by using independent sample 't' test

	Twin Block (n=15)		Forsus Fatigue Resistant Device (n=15)			
Variable	Mean	S.D	Mean	S.D	"t"	P- value
Skeletal						
N-S-Ar	-0.43	2.5	1.00	4.49	1.081	0.289
S-Ar-Go	0.87	3.90	-0.17	4.24	0.694	0.493
Ar-Go-Me	-1.13	3.27	-0.03	3.04	0.952	0.349
Jarabacks ratio	0.42	0.45	0.76	0.75	1.511	0.142
SNA	0.67	0.70	1.47	1.76	1.638	0.113
SNB	-2.67	1.40	-2.33	1.54	0.620	0.540
ANB	3.33	1.60	3.80	1.64	0.788	0.438
Pal-MP	0.53	3.18	-1.27	2.84	1.635	0.113
Go-Pog	-2.13	1.41	-2.20	1.78	0.114	0.910
Go-Co	-0.93	1.03	-1.47	2.17	0.861	0.397
Co-Gn	-2.20	1.66	-1.90	2.14	0.429	0.671
Co-A	0.10	1.11	0.27	1.91	0.293	0.772
Y-axis	-0.53	2.58	-0.87	1.81	0.409	0.686
Dentoalveolar						
I-SN	5.13	5.50	10.97	8.45	2.240	0.033*
I-SN (mm)	-1.40	0.33	-1.30	0.49	0.648	0.522
IMPA	-2.53	6.01	-0.80	8.76	0.631	0.533
L1- MP (mm)	1.73	0.75	1.50	0.57	0.959	0.346
U6-SN (mm)	-0.97	0.48	0.90	0.50	10.348	<0.001*
U6- S⊥OP (mm)	0.97	0.48	1.36	0.63	1.936	0.063
L6-MP (mm)	-1.43	0.45	-1.47	0.48	0.195	0.847
L6- S⊥OP (mm)	-4.30	0.62	-3.63	0.66	2.832	0.008*
AO-BO	2.73	1.21	2.53	1.86	0.350	0.729
OVERJET	5.43	1.06	5.40	0.89	0.093	0.927
OVERBITE	1.80	0.53	1.76	0.50	0.178	0.860

Soft tissue						
FACIAL ANGLE	-0.93	2.94	-0.33	3.02	-0.552	0.585
H-ANGLE	3.07	2.19	2.27	3.37	0.771	0.447
UPPER LIP THICKNESS	-0.27	1.44	0.40	1.80	1.119	0.273
LOWER LIP TO H- LINE	-1.60	1.55	-0.63	1.55	1.707	0.099

* Indicates significant value