Original Research Article

Effects Of Bionator, Twin Block And Dynamax Appliance On Facial Hard And Soft Tissues Of Patients Undergoing Orthodontic Treatment

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Abstract

Purpose: To Compare the effects of Bionator, Twin block and Dynamax appliance on facial hard and soft tissues of patients undergoing orthodontic treatment.

Materials and Methods: An Observational Prospective longitudinal study was conducted with 63 samples segregated into three groups of 21 each. Pre and Post treatment diagnostic records were collected in terms of Case history, Study models and Lateral cephalogram. Standard operating procedure for bite registration was followed.

Results: In the Bionator, Twin block and the Dynamax group it was observed that there were significant changes seen in molar relation, canine relation and overjet. Difference in mean for overbite was significant in all the three groups. Statistically the change in U1-NA was not significant within the groups but the Dynamax appliance showed a little more reduction in the upper incisor inclination which may be because of the anterior torqueing spring used on the upper central incisors. However, the changes with L1-NB and IMPA were statistically not significant when compared with the group of Dynamax appliance.

Conclusions:

Patients who received treatment with the Twin block appliance exhibited more significant changes in molar and canine relation and greater reduction in overjet while with Dynamax appliance more skeletal changes were observed with less lower incisor proclination.

In vertical plane more changes were seen with the Bionator appliance may be due to remodelling of the condyle in the vertical plane.

Bionator and Twin block were more fracture resistant and rigid due to more acrylic covering than the Dynamax appliance.

Key- words: Class II malocclusion, Skeletal changes, Dental changes, Bionator, Twin block, Dynamax

Introduction

An essential distinction exists between the terms "Orthodontics" and "Functional Jaw Orthopaedics" (FJO). They represent a fundamental alteration in approach to the correction of dentofacial abnormalities[1].

It was in 1879 when Kingsley[2]first introduced the concept of "Jumping bite" by use of vulcanite anterior inclined plane in upper arch. Various functional appliance were developed starting right from Pierre Robin in 1902[3] who developed a simple Monobloc appliance for the use in mandibular retrognathia and for functional jaw expansion. At the same time Viggo Andresen developed the Activator appliance which was also a single block appliance with acrylic covering in the upper and lower arch with bite blocks for mandibular advancement.

However, the major problems with these appliances were their bulk, discomfort, retention and lack of tactile sensation resulting in lesser patient compliance and treatment output.One of the reasons for the development of Bionator by Balters in the 1950'0s, was to reduce the bulkiness of the appliance hence increasing the patient compliance.

The golden era of Functional Jaw Orthopaedics started with the development of Twin Block appliance by William Clarke in 1977[4]. But the major problem with twin block was lack of retention with the mandibular component and proclination of

lower anterior teeth[5]. Thus, a much rigid component as well as patient compliant appliance was needed. This led to the invention of the Dynamax appliance.

In 2003, Dr Neville M Bass came up with new myofunctional appliance, The Dynamax appliance system for treatment of skeletal Class II disharmony characterized by lower jaw retrusion. The Dynamax appliance held all the characteristics of Bass appliance yet was simple to construct and less bulky. The Dynamax appliance was possibly named as it was thought to be a Dynamic multifunctional appliance with maximum benefit. The Dynamax appliance is supposed to protract the mandible passively, i.e. the mandible is placed forward by patients own musculature rather than by appliance itself and its held in that position. One of the advantages Dynamax appliance is supposed to have is it exerts minimal force on the lower dentition. This reduces the lower incisor proclination during the treatment[5-6].

The major advantage with this appliance was its lower component which is fixed and permits rigid fixation of lower jaw in sagittal as well as transverse dimension which has thought to eliminate disadvantages of Twin block appliance.

There are many studies in literature comparing the outcome of Bionator and Twin Block appliance. Literature search has revealed four studies which have compared the outcome of Twin Block and Dynamax appliance but there are no studies comparing the effects of all the three appliances.

Hence, an attempt has been made in this study to compare and evaluate the results of Bionator, Twin Block and Dynamax appliance while assessing the facial hard tissue and soft tissue changes by using study models and lateral cephalometric evaluation.

Aim And Objectives

Aim:

To Compare the results of Bionator, Twin block and Dynamax appliance on facial hard and soft tissues of patients undergoing orthodontic treatment.

Objectives:

1. To compare the before and after treatment results of Bionator, Twin block and Dynamax appliance in terms of differences in clinical findings post treatment.
2. To compare the before and after treatment results of Bionator, Twin block and Dynamax appliance in terms of differences in facial hard tissue changes post treatment.
3. To compare the before and after treatment results of Bionator, Twin block and Dynamax appliance in terms of differences in facial soft tissue changes post treatment.

Materials And Methods

The present Observational, Longitudinal study was done in 2 years. The study was accepted by IEC and was conducted in Orthodontic and Dentofacial Orthopaedic Division, Rural Dental College, Loni.

Outpatients from the department were selected based on eligibility criteria The total sample in the study consisted of 63 subjects. The samples were further divided randomly into 3 groups of 21 each by systemic random sampling technique to eliminate the bias in the study(Table 1).

Table 1: Age and gender distribution within the study groups

Group	Appliance type	Sample size	Average age of the samples in the group	Gender distribution
Group A	The Bionator appliance	21	12 years ± 0.88	Male: 10 Female: 11
Group B	The Twin Block appliance	21	11.7 years ± 0.94	Male: 9 Female: 12
Group C	The Dynamax appliance	21	12.5 years ± 0.67	Male: 12 Female: 9

Following were the **Inclusion criteria** for the selected subjects in the study

1. All the patients who have Convex facial profile with Skeletal Class II Profile suggestive of Angles Class II Division 1 Malocclusion confirmed Clinically and by Cephalometry
2. All patients of growing age (confirmed by CVMI index) having all their teeth with almost well aligned individual dental arches.
3. Patients of either gender.
4. All patients who understand the treatment plan and are ready to give written informed consent.
5. The functional cephalometric analysis done for all these subjects indicating the use of functional jaw Orthopedics for skeletal correction.

Exclusion criteria.

1. Patients with systemic and psychological disorders.
2. Patients demanding two step bite correction.
3. Patients with laterognathia and laterocclusion.
4. Patients of Class II malocclusion with severe proclination of lower incisors.
5. Patients with complaints of nasal obstruction.
6. Patients with chronic ulcers in oral cavity.
7. Patients with chronic periodontitis.
8. Patients with condylar hypoplasia or TMJ disorders.
9. Previously orthodontically treated patients.
10. Patients whose growth phase has ceased.

Methodology

I. Collection of diagnostic records

All the essential diagnostic records were obtained which were needed for the study.

1. Case history with clinical examination
2. Dental impressions which were further poured with plaster to make study models and working models
3. Lateral cephalogram
4. Intraoral and extraoral photographs of the patients

II. Analysis of Diagnostic records

1. Assessment of pre-treatment clinical examination and study models

Clinical evaluation was done for following changes before treatment with all three appliances

- Molar relation
- Canine relation
- Overjet
- Overbite

2. Assessment of pre-treatment Lateral cephalogram

The lateral cephalogram of all the subjects included in this study were taken at intervals of 0-8 months. The obtained lateral cephalograms were subjected to the following landmarks and planes.

Sella (S), Nasion (N), Point A (Supraspinale), Point B (Subspinale), Pogonion (Pog), Gonion (Go), Gnathion (Gn), Menton (Me), Orbitale (O), Articulare (Ar), Condylion (Co), Anterior Nasal spine (ANS), Posterior nasal spine (PNS), Ptmpoint(pterygomaxillary fissure), U1, L1, Mandibular plane (tweeds), Mandibular plane (Steiner's), N perpendicular and E line

Composite analysis was fabricated considering measurement from various analysis like Steiner's analysis, Downs analysis, Tweeds analysis, McNamara analysis, Rakosi analysis and Soft tissue analysis.

A. Hard tissue measurements

1. Angular measurements

SNA, SNB, ANB, Y axis, Saddle angle, Articular angle, Gonial angle, Go-Gn- SN, U1-NA, L1-NB, IMPA (Incisor Mandibular Plane Angle)

2. Linear measurements

N perp ptA, N perp Pog, LAFH (Lower Anterior Facial Height), Maxillary unit (Co- pt A), Mandibular unit (Co- Gn)

B. Soft tissue measurements

U lip to E line, L lip to E line

III. Bite registration protocol

A. Registration of bite for the Bionator appliance

- A well extended and properly made alginate impression is required.
- Before registering the bite, the subject was instructed about opening and closing of the mandible in the anterior position.
- The modelling wax was warmed and used for bite registration
- Anteriorly the mandible was advanced to more than the minimum of 4mm and vertically the bite was opened to minimum of more than freeway space of the patient. With the bite registration process, the appliance induced activation of myotatic reflex in the muscles of mastication.

B. Registration of bite for the Twin Block appliance

- The wax construction bite was registered for the mandible protruding to the point 3mm distal to the most protrusive position. Vertically the bite was registered 2-3mm beyond the postural rest position of the mandible.

- With the registered bite in position, the appliance induced activation of myotatic reflex in the muscles of mastication.

C. Registration of bite for the Dynamax appliance

- All the necessary steps for the registration of the construction bite were monitored during the procedure
- Initial advancement for bite registration was carried out more than 4mm and vertically the bite was registered 2-3mm within the postural rest position of mandible.

IV. Fabrication of the appliances

A. Fabrication of the Bionator appliance (Figure 1)

Figure 1: The Bionator Appliance

- The working models of the patient with the wax bite were mounted on the three-point articulator
- Palatal bar is made from 1.2mm wire which extends from a line joining the distal surface of the first permanent molars to middle of the 1st premolars and is kept 1mm away from the palatal mucosa
- Labial bow is made from 0.9mm wire and starts above the contact point between cuspid and upper 1stbicuspid and runs vertically. The frontal portion of the bow should be at paper thickness away from the incisors.
- The labial bow has 2 components: Anterior part which is the labial wire and the lateral parts which are the buccinator bends which help in keeping the soft tissue away helping in development of dentition transversely.

Acrylization

- The wire components were stabilized on the mounted cast on articulator.
- The wire components were then acrylized using cold cure acrylic by sprinkle on method.
- Lower horseshoe shaped acrylic lingual plate is fabricated from distal of last erupted molar on one side to another.

  Maxillary arch lingual extension is given that covers molar and bicuspid region.
- The bite blocks were acrylized connecting the maxillary and mandibular acrylic component.

Figure 2: The Twin-Block Appliance

B. Fabrication of the Twin Block appliance (Figure 2)

- Models were mounted on an articulator with construction bite in place.
- In Maxillary components adams clasps or delta clasps were fabricated on 1st permanent molars for retention and labial bow was fabricated from canine to canine region (Labial bow was removed in case of transversely deficient maxillary and an expansion screw was added in the palatal area).
- In Mandibular wire components adams clasps or delta clasps were fabricated on 1st premolars with ball end clasps between incisors for additional retention.

Acrylization

- Maxillary and mandibular wire components were acrylized separately. The upper bite block was angled from mesial surface of upper second premolar and the flat position then passed over remaining posterior teeth. Lower block was angled from mesial surface of lower first premolar and extended mesially to cover the premolar and if required merged into the lower incisal capping area.The angulation of the inclined plane was kept at 70 degrees.

C. Fabrication of the Dynamax appliance (Figure 3)

- The working models along with wax bite was mounted on the three-point articulator

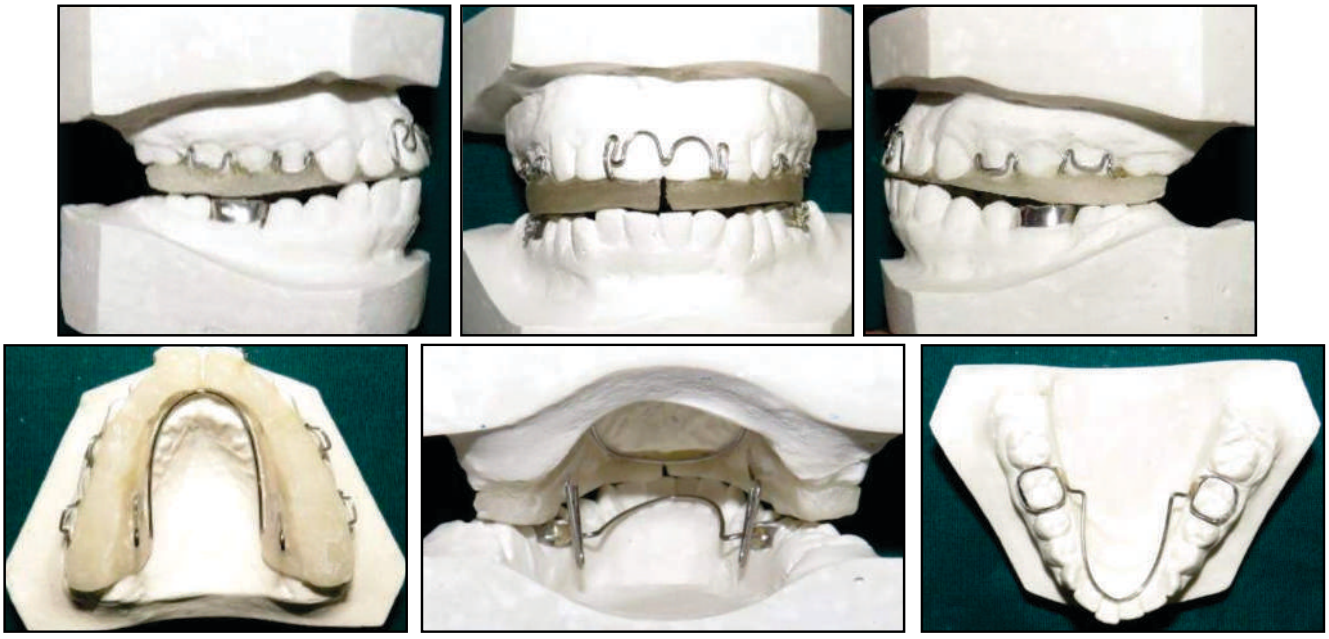

Figure 3: The Dynamax Appliance

- Preformed stainless steel bands were placed on mandibular permanent molars and alginate impression were made.
- Adams clasp was fabricated on upper first permanent molars with 22G wire and a torqueing spring was fabricated with 23G stainless steel wire on the incisors to prevent the excessive palatal tipping of the incisors.
- The bilateral vertical springs were fabricated from a single 18G wire. The wire extended from one vertical spring to other covering the palatal area. Upper arch expansion is delivered by pulling the two parts of the maxillary appliance 2-3mm apart.
- The height of vertical springs was measured on the casts mounted on the articulator from the occlusal surfaces of the maxillary molars upto 2-3mm short of the floor of mouth. The vertical springs are usually 14mm long.

Acrylization

- The wire bending was stabilized on the casts mounted on the articulator.
- The wire components were then acrylized using cold cure acrylic by sprinkle on technique.
- The bite blocks of maxillary arch were extended from 1st permanent molar up to mesial aspect of 1st premolar which prevented the eruption of the maxillary posteriors.
- Anterior bite platform in maxillary anterior region was given from canine to canine region to allow the eruption of lower posteriors and preventing the eruption of lower anterior teeth.

V. Appliance delivery

A. Appliance delivery for the Bionator (Figure 4)

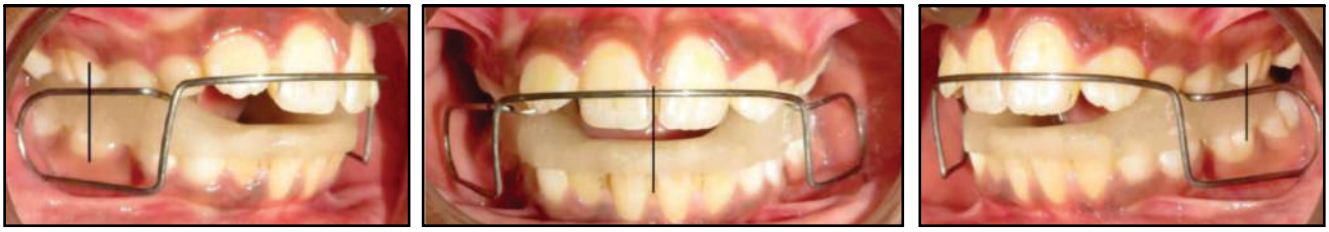

Figure 4:The Bionator Appliance– Intraoral pictures

- After acrylization, finishing and polishing was carried out to smoothen the acrylized surfaces of the appliance. Proper fitting of the appliance was checked in the patient intraorally
- All necessary instructions were given to the patient regarding the wear of the appliance and the usage. The patient was recalled after 2 weeks and counselled for any discomfort or pain wearing the appliance. Thereafter patient was recalled after 6 weeks. Any broken or loosen part of the appliance was immediately repaired.

Figure 5:The Twin-Block Appliance – Intraoral pictures

B. Appliance delivery for the Twin Block (Figure 5)

- After acrylization, finishing and polishing was carried out to smoothen the acrylized surfaces of the appliance. Proper fitting of the appliance was checked in the patient intraorally
- All necessary instructions were given to the patient regarding the wear of the appliance and the usage. The patient was recalled after 2 weeks and counselled for any discomfort or pain wearing the appliance. Thereafter patient was recalled after 6 weeks. Any broken or loosen part of the appliance was immediately repaired.
- Patient was instructed to wear the appliance even while eating as Twin block is a bi-block appliance. Initially the patient was told to be on a soft diet and then gradually eating normal diet to get accustom to the appliance.

Figure 6: The Dynamax Appliance– Intraoral pictures

C. Appliance delivery for the Dynamax appliance (Figure 6)

- Instructions were given to the patient regarding the maintenance of the appliance and oral hygiene of the patient. The patient was instructed to avoid hard and sticky food that may dislodge or either break the vertical springs and lower lingual arch.
- All necessary instructions were given to the patient regarding the wear of the appliance and the usage. The patient was recalled after 2 weeks and counselled for any discomfort or pain wearing the appliance. Thereafter patient was recalled after 6 weeks. Any broken or loosen part of the appliance was immediately repaired.

Progressive advancement of mandible can be carried out by opening of the vertical springs in the subsequent appointments.

VI. Collection of post treatment records

- Follow up was done for every subject after four weeks and for each follow up the patient was questioned verbally regarding the appliance wear and if any discomfort present or not
- The treatment was considered successful if the overjet has reduced by 50% of 6mm in eight months
- After treatment patients study models, facial photographs and cephalometric records were again recorded for comparison as per standard orthodontic treatment protocol.

VII. Assessment of post treatment records

- All the analysis which were done pretreatment were repeated on the post treatment study models and lateral cephalogram.
- The master chart for the cephalometric analysis was prepared in detail.

VIII. Comparison of pre and post treatment records (Figure 7, 8, 9, 10, 11, 12)

- All the pretreatment study models and the cephalometric findings were compared with post treatment findings using the same parameters.
- The superimposition of each subject was done with before and after treatment cephalograms to evaluate the cephalometric changes.
- The master charts were prepared for the before and after treatment findings of theall three appliances and the results were compared for the desired objectives.

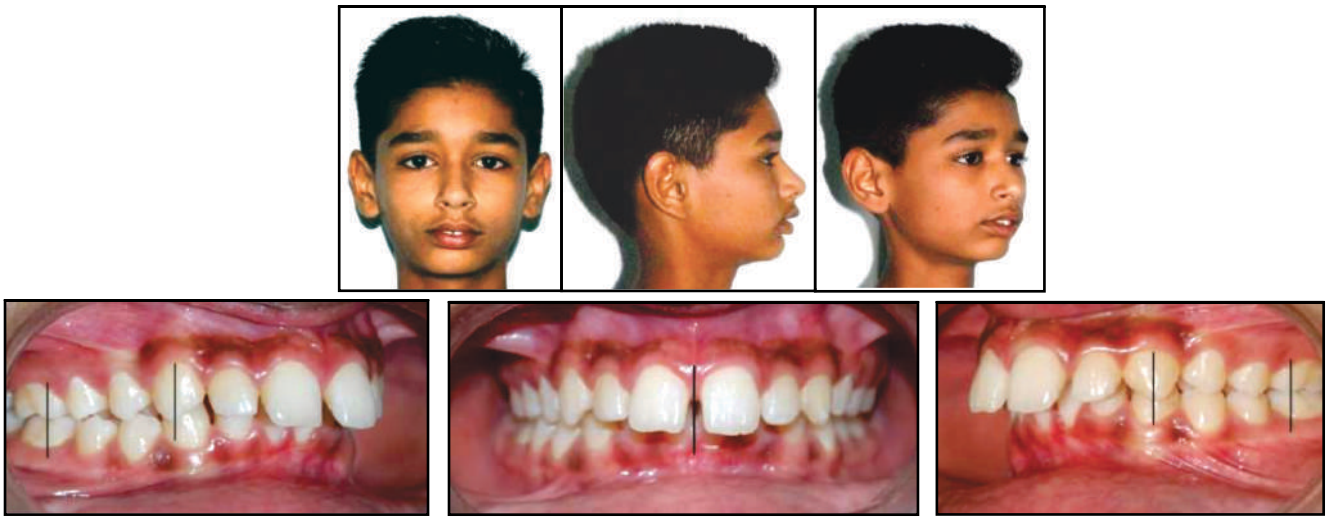

Figure 7: Pre Treatment Extra oral and Intraoral Photographs of the Bionator Appliance

Figure 8: Post Treatment Extraoral and Intraoral Photographs of the Bionator Appliance

Figure 9: Pre Treatment Extraoral and Intraoral Photographs of Twin Block Appliance

Figure 10: Post Treatment Extraoral and Intraoral Photographs of Twin Block Appliance

Figure 11: Pre Treatment Extraoral and Intraoral Photographs of Dynamax Appliance

Figure 12: Post Treatment Extraoral and Intraoral Photographs of Dynamax Appliance

Statistical Analysis:

The data was gathered and entered into a Microsoft Excel spreadsheet. Statistical analysis was performed using SPSS version 20 on a Windows platform. For comparing quantitative data pre treatment and post treatment observations, an unpaired t-test was utilized for all variables in the study.

Results

Assessment of study models "Pre-treatment Vs Post treatment"

1. Group I- The Bionator group

The linear distance of both the molar and canine on right and left side decreased after the treatment. The mean before and after treatment values of molar on right were (4.90 ± 0.98) and (0.04 ± 0.93) respectively while the mean before and after treatment values on the left side were (5 ± 0.88) and (0.02 ± 1.00) respectively. Similarly, the mean before and after treatment values of canine on right side were (3.23 ± 1.19) and (1.45 ± 0.65) respectively and for canine on left side were (3.16 ± 1.30) and (1.54 ± 0.68) respectively (Table 2).

Table 2: Comparison between mean values of linear change in molar relationship, canine relationship, overjet and overbite pre and post treatment with the Bionator appliance

Variables	Bionator Pre treatment	Bionator Post treatment	q value	P value	Significance
Right Molar (mm)	4.90 ± 0.98	0.04 ± 0.93	16.417	<0.0001	Extremely significant
Left Molar (mm)	5 ± 0.88	0.02 ± 1.00	17.059	<0.0001	Extremely significant
Right Canine (mm)	3.23 ± 1.19	1.45 ± 0.65	15.854	<0.0001	Extremely significant
Left Canine (mm)	3.16 ± 1.30	1.54 ± 0.68	14.62	<0.0001	Extremely significant
Overjet (mm)	5.71 ± 1.01	2.02 ± 0.43	15.27	<0.0001	Extremely significant
Overbite (mm)	4.35 ± 0.83	2.64 ± 0.47	8.13	<0.0001	Extremely significant

The mean before and after treatment values for overjet were (5.71 ± 1.01) and (2.02 ± 0.43) respectively while the mean before and after treatment values for overbite were (4.35 ± 0.83) and (2.64 ± 0.47) respectively (Table 2).

2. Group II- The Twin Block group

The linear distance of both the molar and canine on right and left side decreased after the treatment with the Twin block appliance. The mean before and after treatment values of molar on right were (5 ± 1.22) and (0.26 ± 0.87) respectively while the mean before and after treatment values on the left side were (5.16 ± 0.99) and (0.04 ± 1.06) respectively. The mean before and after treatment values of canine on right side were (3.42 ± 1.39) and (2.09 ± 0.78) respectively and for canine on left side were (3.31 ± 1.34) and (2.14 ± 0.61) respectively(Table 3).

The mean before and after treatment values for overjet were (6.26 ± 0.90) and (2.21 ± 0.64) respectively while the mean before and after treatment values for overbite were (4.02 ± 0.94) and (2.73 ± 0.58) respectively (Table 3).

Table 3: Comparison between mean values of linear change in molar relationship, canine relationship, overjet and overbite before and after treatment with the Twin Block appliance

Variables	Twin block Pre treatment	Twin block Post treatment	q value	P value	Significance
Right Molar (mm)	5 ± 1.22	0.26 ± 0.87	16.02	<0.0001	Extremely significant
Left Molar (mm)	5.16 ± 0.99	0.04 ± 1.06	16.466	<0.0001	Extremely significant
Right Canine (mm)	3.42 ± 1.39	2.09 ± 0.78	15.859	<0.0001	Extremely significant
Left Canine (mm)	3.31 ± 1.34	2.14 ± 0.61	16.882	<0.0001	Extremely significant
Overjet (mm)	6.26 ± 0.90	2.21 ± 0.64	16.726	<0.0001	Extremely significant
Overbite (mm)	4.02 ± 0.94	2.73 ± 0.58	5.31	<0.0001	Extremely significant

3. Group III- The Dynamax group

The linear distance of both the molar and canine on right and left side decreased after the treatment with the Dynamax appliance. The mean before and after treatment values of molar on right were (4.78 ± 0.75) and (0.28 ± 0.90) respectively while the mean before and after treatment values on the left side were (4.85 ± 0.63) and (0.19 ± 0.85) respectively. Similarly, the mean before and after treatment values of canine on right side were (3.26 ± 1.17) and (2.02 ± 0.40) respectively and for canine on left side were (3.14 ± 1.17) and (2.19 ± 0.43) respectively (Table 4).

The mean before and after treatment values for overjet were (6.61 ± 0.61) and (2.97 ± 0.64) respectively while the mean before and after treatment values for overbite were (4.52 ± 0.60) and (3.11 ± 0.54) respectively(Table 4).

Table 4: Comparison between mean values of linear change in molar relationship, canine relationship, overjet and overbite before and after treatment with The Dynamax appliance

Variables	Dynamax Pre treatment	Dynamax Post treatment	q value	P value	Significance
Right Molar (mm)	4.78 ± 0.75	0.28 ± 0.90	19.794	<0.0001	Extremely significant
Left Molar (mm)	4.85 ± 0.63	0.19 ± 0.85	21.66	<0.0001	Extremely significant
Right Canine (mm)	3.26 ± 1.17	2.02 ± 0.40	19.441	<0.0001	Extremely significant
Left Canine (mm)	3.14 ± 1.17	`2.19 ± 0.43	19.534	<0.0001	Extremely significant
Overjet (mm)	6.61 ± 0.61	2.97 ± 0.64	18.847	<0.0001	Extremely significant
Overbite (mm)	4.52 ± 0.60	3.11 ± 0.54	7.927	<0.0001	Extremely significant

Table 5: Comparison of means of differences between Pre-treatment and Post treatment values of linear change in molar relation, canine relation, overjet and overbite in the Bionator (B), the Twin Block (TB) and the Dynamax (D) groups (NS= Not significant)

Variables	Bionator difference	Twin block difference	Dynamax difference	q value	P value	Significance
Right Molar (mm)	4.85 ± 1.27	5.26 ± 1.45	5.07 ± 1.38	B vs TB- 1.519 TB vs D- 0.714 D vs B- 0.804	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
Left Molar (mm)	4.97 ± 1.15	5.21 ± 1.16	5.04 ± 1.26	B vs TB- 0.893 TB vs D- 0.625 D vs B- 0.268	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
Right Canine (mm)	4.69 ± 1.01	5.52 ± 1.16	5.28 ± 1.04	B vs TB- 3.127 TB vs D- 0.893 D vs B- 2.234	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
Left Canine (mm)	4.71 ± 1.68	5.45 ± 1.57	5.33 ± 1.23	B vs TB- 2.770 TB vs D- 0.446 D vs B- 2.323	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
Overjet (mm)	3.69 ± 1.08	4.04 ± 1.10	3.64 ± 0.76	B vs TB- 1.340 TB vs D- 1.519 D vs B- 0.178	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
Overbite (mm)	1.71 ± 0.88	1.28 ± 1.04	1.40 ± 0.78	B vs TB- 1.608 TB vs D- 0.446 D vs B- 1.162	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS

Assessment of Lateral cephalograms "Pre-treatment Vs Post treatment"

Various cephalometric parameters showed significant changes post-treatment, including SNB angle, ANB angle, saddle angle, articular angle, gonial angle, Y- axis, (Go-Gn)SN, N perp to Pog, LAFH, and Co-Gn length in both the groups(Table 6, Table 7, Table 8).

On intergroup comparison, the Dynamax group exhibited little changes in IMPA compared to the Twin block and Bionator. Overall, all three treatment modalities showed significant improvements in various dental and skeletal parameters, with the Dynamax group demonstrating slightly greater changes in certain aspects (Table 9).

Table 6: Comparison between mean values of cephalometric values before and after treatment in the Bionator group

Variables	Pre treatment	Post treatment	T value	P value	Significance
SNA (°)	81.54 ± 0.85	81.45 ± 0.83	0.366	p > 0.05	Non significant
SNB (°)	75.50 ± 0.94	78.85 ± 0.74	12.76	p < 0.0001	Extremely significant
ANB (°)	6.04 ± 0.74	2.59 ± 0.53	17.282	p < 0.0001	Extremely significant
Saddle angle (°)	116.57 ± 1.39	121.71 ± 2.07	9.449	p < 0.0001	Extremely significant
Articular angle (°)	138.33 ± 1.34	143.55 ± 1.77	10.733	p < 0.0001	Extremely significant
Gonial Angle (°)	126.43 ± 1.51	129.60 ± 1.19	7.547	p < 0.0001	Extremely significant
Yaxis (°)	64.19 ± 0.79	66.41 ± 0.84	8.774	p < 0.0001	Extremely significant
(Go-Gn) – SN (°)	28.50 ± 0.72	32 ± 0.72	15.652	p < 0.0001	Extremely significant
U1-NA (°)	24.85 ± 0.91	24.40 ± 0.90	1.617	p > 0.05	Non significant
L1-NB (°)	28.95 ± 1.54	30.07 ± 1.12	2.692	p < 0.05	Significant
IMPA (°)	100.02 ± 2.85	102 ± 2.67	2.452	p < 0.05	Significant
N perp ptA (mm)	-0.66 ± 1.23	-0.59 ± 1.37	0.176	p > 0.05	Non significant
N perp Pog (mm)	-9.81 ± 1.60	-5.69 ± 0.46	11.283	p < 0.0001	Extremely significant
LAFH (mm)	57.19 ± 1.18	61.73 ± 0.80	14.547	p < 0.0001	Extremely significant
Maxillary unit (Co-ptA) (mm)	85.50 ± 1.24	86.45 ± 1.36	2.359	p > 0.05	Significant
Mandibular unit (Co-Gn) (mm)	101.33 ± 1.44	106 ± 1.20	12.032	p < 0.0001	Extremely significant
U lip -E Line (mm)	4 ± 0.65	4.11 ± 0.58	0.62	p > 0.05	Non significant
L lip - E line (mm)	4.33 ± 0.71	2.35 ± 0.47	10.55	p < 0.0001	Extremely significant

Table 7: Comparison between mean values of cephalometric values before and after treatment In the Twin Block group

Variables	Pre treatment	Post treatment	T value	P value	Significance
SNA (º)	82.09 ± 0.60	81.61 ± 0.47	2.846	P value	Highly significant
SNB (º)	75.21 ± 098	79.69 ± 2.31	8.172	p < 0.01	Extremely significant
ANB (º)	6.88 ± 0.78	1.92 ± 2.22	9.629	p < 0.0001	Extremely significant
Saddle angle (º)	119.05 ± 2.37	123.21 ± 1.12	7.263	p < 0.0001	Extremely significant
Articular angle (º)	139.29 ± 2.21	143.43 ± 1.68	6.821	p < 0.0001	Extremely significant
Gonial Angle (º)	125.50 ± 1.58	128.21 ± 0.88	6.832	p < 0.0001	Extremely significant
Yaxis (º)	64.50 ± 1.85	66.42 ± 0.96	4.222	p < 0.0001	Extremely significant
(Go-Gn) – SN (º)	29.92 ± 1.95	33.28 ± 0.71	5.181	p < 0.0001	Extremely significant
U1-NA (º)	25.26 ± 1.86	25 ± 1.58	0.49	p < 0.0001	Non significant
L1-NB (º)	28.78 ± 2.02	29.88 ± 1.2	2.128	p > 0.05	Significant
IMPA (º)	101.21 ± 2.18	103.31 ± 2.08	3.183	p < 0.05	Highly significant
N perp ptA (mm)	0.78 ± 1.39	0.95 ± 1.18	0.418	< 0.01	Non significant
N perp Pog (mm)	10.40 ± 1.44	5.61 ± 0.68	13.699	p > 0.05	Extremely significant
LAFH (mm)	57.90 ± 2.25	61.81 ± 0.73	7.56	p < 0.0001	Extremely significant
Maxillary unit (Co-ptA) (mm)	85 ± 1.65	85.23 ± 1.57	0.477	p < 0.0001	Non significant
Mandibular unit (Co-Gn) (mm)	101.4 ± 1.82	106.21 ± 1.58	8.941	p > 0.05	Extremely significant
U lip -E Line (mm)	3.11 ± 0.75	3.7 ± 1.10	1.224	p < 0.0001	Non significant
L lip - E line (mm)	4.81 ± 1	1.92 ± 0.48	11.837	p > 0.05	Extremely significant

Table 8: Comparison between mean values of cephalometric values before and after treatment in the Dynamax group

Variables	Pre treatment	Post treatment	T value	P value	Significance
SNA (º)	81.47 ± 0.67	81.45 ± 0.75	0.107	p > 0.05	Non significant
SNB (º)	75.42 ± 0.97	78.23 ± 0.7	10.701	p < 0.0001	Extremely significant
ANB (º)	6.04 ± 0.96	3.21 ± 0.56	11.675	p < 0.0001	Extremely significant
Saddle angle (º)	119.45 ± 1.71	123 ± 1.65	6.841	p < 0.0001	Extremely significant
Articular angle (º)	139.93 ± 3.54	143.64 ± 1.38	4.468	p < 0.0001	Extremely significant
Gonial Angle (º)	124.52 ± 2.25	126.55 ± 1.94	3.111	p < 0.01	Highly significant
Yaxis (º)	64.21 ± 1.38	65.64 ± 0.85	4.027	p < 0.0001	Extremely significant
(Go-Gn) – SN (º)	28.9 ± 1.53	31.16 ± 0.84	5.912	p < 0.0001	Extremely significant
U1-NA (º)	25.19 ± 1.65	24.50 ± 1.52	1.406	p > 0.05	Non significant
L1-NB (º)	28.47 ± 1.82	28.52 ± 0.99	0.105	p > 0.05	Non significant
IMPA (º)	101.52 ± 2.12	101.57 ± 2.05	0.073	p > 0.05	Non significant
N perp ptA (mm)	1.35 ± 1.17	1.23 ± 1.14	0.332	p > 0.05	Non significant
N perp Pog(mm)	10.21 ± 1.34	6.07 ± 0.63	12.738	p < 0.0001	Extremely significant
LAFH (mm)	57.78 ± 1.39	61.38 ± 1.98	6.79	p < 0.0001	Extremely significant
Maxillary unit (Co-ptA) (mm)	85.50 ± 1.04	85.83 ± 1.04	1.034	p > 0.05	Non significant
Mandibular unit (Co-Gn) (mm)	101.88 ± 1.61	106.21 ± 1.23	9.763	p < 0.0001	Extremely significant
U lip -E Line (mm)	4.42 ± 2.35	4.38 ± 2.23	0.067	p > 0.05	Non significant
L lip - E line (mm)	4.97 ± 2.61	2.88 ± 0.65	3.564	p < 0.0001	Extremely significant

Table 9: Comparison of means of differences between pre-treatment and post treatment cephalometric values of the Bionator (B), Twin Block (TB) and Dynamax (D) groups

Variables	Bionator	Twin Block	Dynamax	q value	P value	Significance
SNA (º)	0.09 ± 0.30	0.4 ± 0.58	0.02 ± 0.79	B vs TB- 0.944 TB vs D- 1.122 D vs B- 0.177	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
SNB (º)	3.35 ± 0.91	4.47 ± 2.72	2.80 ± 1.04	B vs TB- 2.776 TB vs D- 4.134 D vs B- 1.358	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
ANB (º)	3.45 ± 0.90	4.9 ± 2.69	2.83 ± 1.09	B vs TB- 3.721 TB vs D- 5.256 D vs B- 1.535	B vs TB- ns TB vs D- * D vs B- ns	B vs TB- NS TB vs D- S D vs B- NS
Saddle angle (º)	5.14 ± 2.37	4.16 ± 2.34	3.54 ± 2.54	B vs TB- 1.654 TB vs D- 1.535 D vs B- 3.957	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
Articular angle (º)	5.21 ± 1.88	4.14 ± 2.36	3.71 ± 3.47	B vs TB- 2.658 TB vs D- 1.063 D vs B- 3.721	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
GonialAngle (º)	3.16 ± 1.74	2.7 ± 1.70	2.02 ± 1.88	B vs TB- 1.122 TB vs D- 1.713 D vs B- 2.835	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
Yaxis (º)	2.21 ± 1.06	1.92 ± 1.70	1.42 ± 1.40	B vs TB- 0.708 TB vs D- 1.240 D vs B- 1.949	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
(Go-Gn) – SN (º)	3.5 ± 1.09	2.35 ± 1.81	2.26 ± 1.63	B vs TB- 2.835 TB vs D- 0.236 D vs B- 3.071	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
U1-NA (º)	0.45 ± 1.18	0.26 ± 0.98	0.69 ± 0.88	B vs TB- 0.525 TB vs D- 1.183 D vs B- 0.657	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS

Table (Cont.): Comparison of means of differences between pre-treatment and post treatment cephalometric values of the Bionator (B), Twin Block (TB) and Dynamax (D) groups

Variables	Bionator	Twin Block	Dynamax	q value	P value	Significance
L1-NB (º)	1.11 ± 1.78	1.09 ± 2.17	0.04 ± 2.17	B vs TB- 0.065 TB vs D- 2.882 D vs B- 2.958	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
IMPA (º)	2.09 ± 2.61	2.09 ± 1.52	0.04 ± 0.96	B vs TB- 0.0 TB vs D- 5.653 D vs B- 5.653	B vs TB- ns TB vs D- ** D vs B- ns	B vs TB- NS TB vs D- HS D vs B- HS
N perp ptA (mm)	0.07 ± 0.39	0.16 ± 1.01	0.11 ± 1.01	B vs TB- 0.657 TB vs D- 0.788 D vs B- 0.131	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
N perp Pog(mm)	4.11 ± 1.68	4.78 ± 1.38	4.14 ± 1.45	B vs TB- 1.840 TB vs D- 1.775 D vs B- 0.657	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
LAFH (mm)	4.54 ± 1.52	3.90 ± 2.31	3.59 ± 2.51	B vs TB- 1.775 TB vs D- 0.854 D vs B- 2.629	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
Maxillary unit (Co-ptA) (mm)	0.95 ± 1.58	0.23 ± 0.68	0.33 ± 0.57	B vs TB- 2.039 TB vs D- 0.271 D vs B- 1.767	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
Mandibular unit (Co-Gn) (mm)	4.92 ± 2.09	4.71 ± 2.25	4.33 ± 2.45	B vs TB- 0.611 TB vs D- 1.087 D vs B- 1.699	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
U lip -E Line (mm)	0.11 ± 0.35	0.35 ± 0.93	0.04 ± 0.54	B vs TB- 1.359 TB vs D- 0.883 D vs B- 0.475	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS
L lip - E line (mm)	1.97 ± 0.43	2.88 ± 1.17	2.09 ± 2.80	B vs TB- 2.583 TB vs D- 2.243 D vs B- 0.339	B vs TB- ns TB vs D- ns D vs B- ns	B vs TB- NS TB vs D- NS D vs B- NS

Discussion

The term "Functional Jaw Orthopaedics" explains the concept of treatment that aims to improve not only dental and orthopaedic relationships in the stomatognathic system but also facial balance[1]. Many researchers in the past have evaluated various functional appliances in cases with retruded lower jaw. The repositioning of the lower jaw was achieved with the help of either removable functional or fixed functional appliances. Although many factors were involved while comparing removable appliances with fixed functional appliances[7] like duration of appliance wear (intermittent vs continuous), ideal treatment timing mode of bite jumping (considering the vertical opening), but the changes were dependent on biological variables of the individual opting for the treatment.

In all three appliances it was observed that there were significant changes seen in molar relation, canine relation and overjet with pre and post treatment values. Difference in mean for overbite was significant in all the three groups. Among them, the Bionator appliance showed the highest changes in the overbite correction (1.71 ± 0.88) than the other two groups. This was due to opening of gonial and articular angle during the Bionator therapy as Bionator causes increase in ramal height causing overbite to decrease(Table 5).

SNA angle changes were not significant with the Bionator as well as the Dynamax group but the difference in mean was significant with the Twin block group (0.4 ± 0.58) suggesting that the forward growth of maxilla is restricted. When the mandible is positioned anteriorly there is always a reciprocal distal force on the maxilla which restricts the forward growth of the maxilla. This is known as the "Headgear effect"[8]. Similar finding was observed in one of the systematic reviews in 2015[9] where they stated that the Twin Block appliance causes some restrictive effect on the maxilla as a reciprocal force during mandibular advancement stated as the headgear effect(Table 9).

SNB and ANB angle changes were extremely significant with all three groups due to change in sagittal relationship of maxilla and mandible. The Twin block group showed higher change in the SNB and ANB angle (Table 9). One such study by Siara-olds et al[10] compared the long-term outcome of Bionator with Twin block appliance. The results stated that the SNB increased more in the Twin Block group compared to the other groups suggesting changes in the ANB angle also. Change in SNB is due to mandibular advancement and the change in ANB is due to combination of mandibular advancement and maxillary restriction or maxillary distalization[11].

Changes in Saddle angle, Articular angle and Gonial angle were extremely significant with the Bionator, the Twin Block and the Dynamax group with pre and post treatment values (Table 9). Moreover, higher changes in vertical plane were observed with Bionator appliance as seen in some studies[12]. Changes in the vertical plane with the Bionator appliance is of great importance in patients with horizontal growth pattern.

Change in Y axis and Go-Gn to SN were also significant within the groups with pre-treatment and post treatment values but were not significant when the readings of groups were compared with each other (Table 9). The changes in Y axis and Go-Gn to SN plane were increased and the changes observed were due to increase in vertical plane and favourable in patients with horizontal growth pattern[13].

Statistically the change in U1-NA was not significant within the groups but the Dynamax appliance showed a little more reduction in the upper incisor inclination which was because of the anterior torqueing spring used on the upper central incisors (Table 9). There were statistically significant changes seen with L1-NB and IMPA values with the Bionator and the Twin block group[10].

Most functional appliances apply a protrusive effect on lower jaw dentition because the appliance contacts the lower teeth. This is because the musculature pulls the mandible back against the appliance[14].Hence a marked increase in proclination of the lower incisors is usually seen. To prevent this unwanted proclination lower incisal capping is suggested with these appliances. However, the changes with L1-NB and IMPA were statistically not significant with the Dynamax appliance (Table 9) as the lower component of the Dynamax appliance only consists of lingual arch with no acrylic covering the dentition so simultaneous correction of lower arch with edgewise appliance is possible which can control the lower incisor proclination as similarly stated in one of the study by Dr Neville Bass in 2003[5].

Bass NM in one of his study[6] stated that due to no acrylic component in the mandibular arch touching the mandibular incisors no unwanted force is transferred over to the incisors from lingual arch thus in the dynamax appliance proclination of mandibular incisors is not seen compared to the other functional appliances. Thus, in patients with limited overjet for advancement of mandible where the entire overjet needs to be utilized the Dynamax appliance can be an appliance of choice providing more of skeletal changes than dentoalveolar changes.

The pre and post treatment changes with N perp to pt A were not significant in all the three groups (Table 9). As stated in various studies[12] no significant changes were observed with the N perp to pt A values as the functional appliance didn't directly act on the pt A or maxilla in general. As little reduction in N perp to A value was observed with the Twin block appliance which was due to the "Headgear effect"[8] but the difference was not statistically significant.

The changes with N perp to Pog were significant due to anterior repositioning of the mandible shifting the hard tissue Pogonion point anteriorly (Table 9). Moreover, withing the groups the changes were higher in the Twin block group (4.78 ± 1.38) suggesting of better correction of the lower jaw position in Class II correction as stated in one of the similar study[15]. Sidlauskas A et al conducted a study[13] where 34 patients with Class II Division 1 malocclusion treated with the Twin block appliance were cephalometrically analysed for pre and post treatment. They stated that there was evident growth of the mandibular base with the Twin block appliance advancing the Pogonion point anteriorly resulting in increased chin prominence in patients with retruded mandible.

The changes with lower anterior facial height (LAFH) were also extremely significant with pre-treatment and post treatment values (Table 9). The Bionator group exhibited higher change in LAFH (4.54 ± 1.52) among the three groups due to increase in gonial and articular angle.

The Maxillary unit (Co-pt A) changes were statistically not significant in all the groups. However, it was observed that statistically significant changes were observed with Mandibular unit (Co- Gn) and higher changes were seen with the Bionator and the Twin block group. (Table 9)

The soft tissue changes calculated were the Upper lip to E line and Lower lip to E line. Upper lip to E line changes were statistically not significant in all the three groups. Overall, in all the groups the Upper lip to E line was maintained in the Dynamax group due to the anterior torqueing spring but the change was statistically insignificant. The Lower lip to E line changes were statistically significant due to mandible repositioning post treatment with the functional appliances. Lower lip to E line changes were noticed higher in the Twin block group (2.88 ± 1.77) due to more skeletal as well as dental changes within the mandibular jaw[16]. The lower lip changes were due to advancement of the mandible leading to change in the soft tissue profile of the patient. (Table 9)

In summary, these statistical comparison of the skeletal/ dental effects of all the three appliances together has concluded that the Twin block appliance is more superior in the final achievement of the skeletal, dental and soft tissue appraisal of the Class II disharmony in a decided period of treatment time (8 months) over the Bionator and the Dynamax appliance going in the accordance with the popularity of the usage of the Twin block appliance.

However, when the vertical control was the main objective in the form of bite correction and jaw rotation, the Bionator appliance has worked well as compared to the Twin Block appliance and the Dynamax appliance. The Bionator appliance can become an appliance of choice with convergent jaw rotation with skeletal deep bite besides the Twin Block and the Dynamax.

The control over the maxillary horizontal growth component was more superior in the Twin Block group suggestive of its headgear effect hence it may be an appliance of choice in combination of maxillary and mandibular defect with minor to moderate discrepancy. The preference of the Twin Block appliance should be preferred over the Bionator or the Dynamax appliance when bi-jaw correction is demanded.

The Dynamax appliance was superior for the control of the maxillary and mandibular incisors inclinations because of its configuration which included upper toquing spring and the lower lingual arch. This design helps in maintaining the torque of incisors. Hence, it can be an appliance of first perffernce where maximum horizontal correction on skeletal bases are demanded.

Limitation of the study

1. Controlled group could not be assigned as one of the study group as this was a prospective longitudinal study. Collection of records for Class II division 1 patients who have not undergone any treatment was not possible and would lead to an ethical issue if treatment is not provided to the patient even after diagnosis of Class II malocclusion with retrognathic mandible.
2. The treatment duration with an individual appliance was 8 months which may be insufficient for the pterygoid response and changes in the condylar region.

Conclusion:

1. Patients who received treatment with the Twin block appliance exhibited more significant changes in molar relation, canine relation and greater reduction in overjet. This was due to combination of skeletal and dento-alveolar effects i.e. the mandible advancement also caused proclination of lower incisors reducing the overjet.
2. In patients with Dynamax appliance showed more skeletal changes with less dento-alveolar changes as compared to the Twin block and the Bionator group. Due to less dental changes with the Dynamax appliance, there was more scope of bringing the mandible in the anterior position.
3. In vertical plane more changes were seen with the Bionator appliance due to remodelling of the condyle in the vertical plane than the Twin block and the Dynamax appliance.
4. Dynamax appliance did not cause any significant lower incisor proclination due to presence of a fixed lingual arch when compared with the other two appliances.

5. Dynamax appliance had many advantages over the other two appliances. i.e. no acrylic component in lower arch, lingual arch also acted as a space maintainer, easy method of activation of the appliance and the lower arch can be simultaneously treated with the fixed appliance.
6. Bionator and Twin block were more fracture resistant and rigid due to more acrylic covering than the Dynamax appliance.

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