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Original Research Article

Radiographic assessment of skeletal and soft tissue parameters in class II malocclusion cases with Frankel appliance (FR II), Twin block (TB), and Forsus FRD: A comparative study

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Abstract

Introduction - For the successful correction of Class II malocclusion, the use of functional appliances such as FR II, TB, and Forsus FRD can be highly effective initially followed by a fixed appliance treatment later. This study has been done to analyze the impact of FR II, TB, and FRD on a class II malocclusion patient on skeletal, dentoalveolar, and soft tissue.

Materials and Methods: The study included 60 patients aged between 12±0.85 and 14±0.91 years, divided into 3 groups of 20 patients. Group A, Group B, and Group C were treated with FR II, TB, and Forsus FRD respectively. All patients had class II malocclusion, cusp-to-cusp molar relationship, minimal or no crowding in mandible, overjet not less than 5mm, no history of previous orthodontic treatment etc. The patients were followed up regularly and their skeletal, dentoalveolar, and soft tissue changes were recorded, evaluated, and compared to determine which appliance resulted in these changes.

Result: FR II shows forward mandibular growth and positive soft tissue profile. TB shows mandibular growth in sagittal and vertical dimensions, correcting the overjet and reducing facial convexity. The group with Forsus FRD shows mandibular growth through continuous, low-force stimulation, aiding in the coordination of dental arches**.**

Conclusion: FR II shows marked changes in the dentoalveolar relationship with a direct impact on soft tissue changes, TB shows significant skeletal and dentoalveolar changes with a positive effect on soft tissues, Forsus FRD group shows both skeletal and dentoalveolar changes but indirect and very minimal soft tissue changes.

Keywords: Class II malocclusion, Fixed functional appliance, Forsus FRD, Frankel appliance II, Removable functional Appliance, Twin block.

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1. Introduction

For the treatment of Class II malocclusion, the use of a functional appliance can be highly effective in the initial phase. However, it is commonly necessary to follow this with the next phase of treatment using fixed appliances to achieve comprehensive results.[1]

Repositioning the mandible forward is a proven and effective method for correcting Class II malocclusion caused by a retruded mandible.[2] The treatment of these cases depends on several factors, including cost, patient cooperation, and patient acceptance. These factors often determine the best treatment option, which can range from removable functional appliances like Frankel appliances, Twin block (TB), Activator, and Bionator to fixed functional appliances such as Forsus Fatigue Resistant Device (FRD). The Frankel Functional Regulator (FR) is an incredibly intriguing functional appliance. Designed to target the oral vestibule, its buccal shields and lip pads effectively keep the buccal and labial musculature away from teeth and investing tissues, thus removing any potential restrictive influence from the functional matrix.[3] The Frankel Regulator II (FRII) appliance is the exclusive functional appliance supported by soft

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tissue. The duration required to achieve a Class I incisor relationship is a crucial factor to be taken into consideration.[4] The Twin-block (TB) is widely utilized appliance for correcting Class II malocclusion. This appliance works by applying continuous forces to guide the growth and development of the jaws, ultimately improving the alignment of the teeth and bite. Twin Block (TB) works by repositioning the condyle in the glenoid fossa, promoting condylar cartilage growth, and stimulating mandibular elongation.[5] Advancements in fixed mandibular devices have revolutionized the field by obviating the necessity for patient cooperation and allowing their use in combination with fixed appliances, thereby overcoming the principal limitations of removable functional appliances. This innovation allows for combining functional appliance use with multibracket therapy, ultimately shortening treatment duration. In addition, fixed mandibular advancement devices offer continuous guidance for the mandible's growth, while also effectively correcting dental malocclusions. This integration of treatment modalities can lead to more efficient and comprehensive orthodontic care for patients.[6] Research demonstrates that the FRD effectively treats this type of malocclusion by targeting skeletal aspects, like restricting maxillary growth, as well as dentoalveolar changes, primarily involving the mesial movement of the mandibular incisors and first molars. Additionally, the FRD has shown promising results in reducing the severity of skeletal discrepancies, leading to more stable and long-lasting outcomes. Therefore, the objective of this study is to assess and contrast the impact of the Frankel Appliance (FR II), Twin Block (TB), and Forsus FRD on correcting class II malocclusion by analyzing the effects on skeletal, dentoalveolar, and soft tissue.[7]

2. Materials and Methods

This study is of retrospective design and it was approved by the Ethics in Research Committee of the Institute of Dental Sciences, Bhubaneswar under Siksha 'O' Anusandhan University, Bhubaneswar.

The study included a sample size of 60 patients, who were treated previously with either Frankel II appliances, Twin Block appliances, or Forsus FRD appliances. The patients were between the ages of 12 ± 0.85 years and 14 ± 0.91 years and were divided into three groups. All patients were selected from the files of the Department of Orthodontics and Dentofacial Orthopaedics at the Institute of Dental Sciences, Siksha 'O' Anusandhan University, located in Bhubaneswar, Odisha, India. The inclusion criteria were as follows: Class II dental malocclusion having a cusp-to-cusp molar relationship and class II canine relationship, minimal or no crowding in the mandibular arch, overjet not less than 5 mm, retrognathic mandible, presence of all teeth up to the first permanent molar in all four quadrants, horizontal to average growth pattern, Cervical Vertebrae Maturity (CVM) index 5 or 6 as determined by cephalometric radiographs and no previous orthodontic treatment. All patients were treated at least 2 years ago and maintain their regular follow-up visits. In group A, 20 patients were treated with Frankel II appliances, consisting of 12 males and 8 females. In group B, 20 patients were treated with Twin Block appliances, with 11 males and 9 females. In group C, 20 patients were treated with Forsus FRD appliances, including 8 males and 12 females. The lead researcher thoroughly described the details of the study to both the patients and their parents, ensuring that they fully understood the nature of the research. Following this, written consent was obtained from all participants, cementing their willingness to take part in the study.

Group A, consisted of 20 patients, with 12 males and 8 females, who were treated with Frankel II appliance. The FR-II appliance was utilized progressively for a duration of 2 to 2.5 years. Initially, it was worn full-time, with the wearing time gradually increasing over this period. Subsequently, a retention phase of 1.5 to 2 years followed, during this time FR-II was worn twice in the afternoon and at night. Finally, a second retention phase of 1.5 years was implemented, during which the FR-II was exclusively worn during nighttime. The patients who were included in the study design were given exclusive treatment with the FR-II appliance. No fixed orthodontic treatment was done in any of the patients. These patients presented with excessive overjet and a complete Class II molar relationship.

Figure 1: Patient given Twin block appliance for Class II correction.

Group B consisted of 20 patients, divided into 9 females and 11 males. All patients in this group received treatment with the TB appliance.(**Figure 1**) The average treatment time for this group was 1.25 ± 0.34 years. The models of the patients were articulated when the mandible was kept in a protrusive position to achieve the desired results. The initial activation was done to reduce the overjet by 5 to 6 mm. This treatment plan involved a single activation for all patients in this group. To correct midline displacement caused by functional occlusal interference or guidance, a bite registration was performed for optimal patient outcome. To

correct midline displacement caused by functional occlusal interference or guidance, a bite registration was performed for optimal patient outcome. The orthopedic phase of the treatment was considered complete when patients achieved a minimum of 2 mm of Class I molar overcorrection. Throughout the treatment process, regular adjustments were made to the appliance, typically once a month. Also acrylic from the occlusal surfaces of the maxillary bite-blocks were trimmed to create space so that it encourages the eruption of lower molars and helps to reduce the value of the curve of Spee. After the orthopedic phase, patients were advised to continue the use of the appliance as it will function as an active retainer for an average of 10-11 months. A comprehensive approach and meticulous attention to detail in each stage of treatment allowed us to achieve remarkable results for our patients in Group B.

Figure 2: Patient given Forsus FRD for Class II correction.

In Group C, the maxillary and mandibular arches were bonded using 0.022 x 0.028-in MBT-prescribed appliances. The process began with leveling and aligning stages using nickel-titanium (Ni-Ti) wires of different sizes. Once the teeth were properly aligned, the Forsus FRD appliance was attached to stainless steel (SS) archwires on both the upper and lower arches.(**Figure 2**) During the appliance insertion stage, a transpalatal arch was placed in the maxillary arch and a Stainless Steel archwire in the mandibular arch. The lower parts of the Forsus FRD were placed in such a way that they were located beyond the mandibular canine teeth. This positioning was important for the effectiveness of the device in treating Class II malocclusions. To evaluate the effects of the Forsus appliance, records were taken before its insertion, just after its removal, and at a 6-month interval. Once the patient achieved a class I or super class I molar relationship and canine relationship the Forsus FRD appliance was removed. After this stage the anterior teeth were nearly achieving their proper position. To evaluate the effect of the treatment on soft tissues, lateral cephalometric radiography and CBCT were performed at three specific intervals. Skeletal and dental changes were assessed through lateral cephalograms. All radiographs were taken using the Orthopantomograph OP300, with a 10-second exposure time of 2.3 seconds and optimized patient dose. The lateral cephalograms were carefully analyzed to evaluate any skeletal and dental alterations. The use of the Orthopantomograph OP300, with its optimized patient dose and short exposure time, ensured the acquisition of high-quality radiographs. Lateral cephalograms were taken once before the start of the treatment and once after completion of the treatment. The soft copies of these radiographs were stored in the computer, the cephalometric landmarks were marked, all the values were analyzed using Dolphin Imaging 11.5 software.

3. Results

Effects on the Skeletal Structure: The FR II appliance is specifically engineered to stimulate forward mandibular growth by positioning the mandible in a more advanced manner, resulting in increased mandibular length, and improved sagittal jaw relationship. Studies have demonstrated its ability to induce favorable skeletal changes, effectively addressing Class II malocclusion. The Twin Block appliance facilitates mandibular growth and repositions the mandible forward,[8] leading to positive effects on the sagittal and vertical dimensions of the mandible. This contributes to a more harmonious skeletal relationship, harnessing the patient's muscular forces to stimulate mandibular advancement and ultimately enhancing facial aesthetics. The Forsus FRD is a fixed functional appliance designed to encourage mandibular growth through continuous, low-force stimulation. It has been seen that it can promote favorable skeletal changes, including mandibular advancement and correction of Class II discrepancy. Additionally, it diminishes the reliance on patient compliance when compared to removable appliances.[9-10] The changes in value of SNA post-treatment in Group A is -1.32±2.99°, in Group B is -0.95±3.73° while in Group C is -0.76 ±2.19°. Whereas the changes of value in SNB in Group A, Group B, and Group C are 0.57±2.53°,0.063±3.21°and 0.78±3.84° (**Table 2**) respectively showing significant dentoalveolar changes have been associated with Group A where the patients were given FR II.

Table 1: Pre-treatment cephalometric values in different functional appliances

Variables	Group A (FR II)	Group B (TB)	GroupC (FRD)	P values
Skeletal Relationship				
SNA	80.12±2.73°	80±2.18°	81.12±2.42°	0.244
SNB	78.35±3.88°	77.10±4.02°	79.10±3.38°	0.312
ANB	5.65±1.60°	5.80±1.80°	5.87±1.14°	0.875
Wits Appraisal	3.71±2.80mm	3.40±3.20mm	4.55±2.77°	0.629
SN to MP (Steiners)	29.60±3.15°	32.80±2.75°	30.80±5.29°	0.013
Effective Max. Length	76.87±4.79mm	73.60±4.55mm	80±2.18mm	0.024
Effective Mand. Length	95.91±7.88mm	97.80±8.26mm	96.63±6.20mm	0.643
LAFH	53.22± 6.96mm	55.30± 8.42mm	52.73±7.18mm	0.215
Dentoalveolar Relationship				
U1 to N-A	4.80± 2.22mm	5.30± 1.65mm	6.54± 1.87mm	0.723
U1 to N-A (angle)	25.16±8.20°	25.16±8.20°	23.10±7.39°	0.225
L1 to N-B	4.82±1.76mm	5.50±2.30mm	5.77±2.44mm	0.020
L1 to N-B (angle)	30.86±5.19°	32.10±5.25°	30.68±3.95°	0.013
Interincisal angle				
IMPA (Tweed)	95.11±2.64°	97.82±3.86°	95.41±4.12°	0.324
Overjet	6.86±2.23mm	6.32±1.73mm	5.87±1.34mm	0.191
Overbite	3.81±2.70mm	3.1±1.11mm	2.78±1.76mm	0.207
Soft Tissue Relationship				
Upper lip to E Plane	0.38±4.83mm	0.24±3.11mm	0.45±2.98mm	0.912
Lower lip to E Plane	1.97±2.32mm	1.42±1.68mm	1.65±1.22mm	0.745
Nasolabial angle	120.38±7.20°	123.22±8.97°	121.31±6.50°	0.004

*Statistically significany atP <0.05

Table 2: Post-treatment comparison of how much cephalometric values change in different types of functional appliances (Changes in values = Pre-treatment values- posttreatment values):

Variables	Group A (FR II)	Group B (TB)	Group C (FRD)	P values
Skeletal Relationship				
SNA	-1.32±2.99°	-0.95±3.73°	-0.76 ±2.19°	0.012
SNB	0.57±2.53°	0.63±3.21°	0.78±3.84°	<0.001
ANB	-2.71±1.70°	-1.87±2.56°	-2.20±3.15°	0.002
Wits Appraisal	-3.09±2.23mm	-2.30±1.97mm	-1.89±1.08mm	0.260
SN to MP (Steiners)	0.61±2.15°	0.43±3.10°	0.76±2.95°	0.012
Effective Max. Length	3.97±6.38mm	4.14±8.30mm	4.35±7.21mm	0.020
Effective Mand. Length	8.90±7.24mm	9.10±6.73mm	8.87±7.14mm	0.001
LAFH	5.81±3.86mm	5.30±3.29mm	6.27±3.24mm	<0.001
Dentoalveolar Relationship				
U1 to N-A	-0.11±2.17mm	-0.51±3.70mm	-0.25±0.12mm	0.021
U1 to N-A (angle)	-2.18±2.73°	-2.30±3.12°	-1.86±3.81°	<0.001
L1 to N-B	0.90±0.70mm	0.75±1.12mm	0.83±1.41mm	0.312
L1 to N-B (angle)	0.75±2.11°	0.43±2.78°	0.61±2.65°	0.417
IMPA (Tweed)	-0.82±2.35°	-0.61±2.76°	-0.43±3.10°	<0.001
Overjet	-3.88±2.58mm	-3.11±1.37mm	-2.94.±1.59mm	0.002
Overbite	-0.71±2.44mm	-0.61±1.34mm	-0.75±1.77mm	<0.001
Soft Tissue Relationship				
Upper lip to E Plane	-3.09±0.19mm	-2.11±0.78mm	-1.87±0.20mm	0.230
Lower lip to E Plane	1.77±5.81mm	1.32±4.97mm	0.80±.50mm	<0.001
Nasolabial angle	0.63±7.97°	0.57±9.81°	0.31±2.35°	<0.001

*Statistically significany atP <0.05

Effects on the Dentaloalveolar Components: The FR II appliance, commonly used in orthodontic treatment, is designed to impact the alignment and positioning of teeth within both the maxillary and mandibular arches encouraging the forward movement of lower incisors and the backward movement of upper incisors is a highly effective strategy for addressing the dental components of Class II malocclusion. The Twin Block appliance primarily influences the dentoalveolar structures by guiding the eruption of posterior teeth and correcting the overjet, leading to the overall

correction of the Class II dental relationship through lower incisor proclination and upper incisor retroclination. The Forsus FRD contributes to dentoalveolar changes by applying continuous forces to correct malocclusion, aiding in the coordination of dental arches, and aligning teeth within the oral cavity to address Class II malocclusion.[11] In Group B where TB appliances were given it has been seen that post-treatment the values has markedly changed. U1 to N-A (angle) is changed by -2.30±3.12° and L1 to N-B (angle) ischanged by 0.43±2.78° (**Table 2**), suggesting a marked dentoalveolar changes occur with TB appliances. Effects on Soft Tissues: All three appliances impact soft tissues to varying degrees: Frankel Appliance (FR II): The forward positioning of the mandible by the FR II appliance may positively influence the soft tissue profile,[12] enhancing chin projection and improving facial aesthetics.[13] Twin Block (TB): The ability of the Twin Block to encourage mandibular growth can positively impact the soft tissue profile, promoting a balanced facial appearance and reducing facial convexity associated with Class II malocclusion. Forsus FRD: By aiding in the correction of the skeletal and dental components, the Forsus FRD indirectly contributes to improved soft tissue harmony[14] and facial aesthetics.

4. Discussion

Several studies have previously been conducted on the effects of the Frankel appliance, Twin Block, and Forsus FRD individually. However, there has to be a comprehensive study that examines the use of these appliances on different patients and compares their effects on skeletal and dentoalveolar changes. It is crucial to conduct such a study to gather comparative data and evaluate the effectiveness of these appliances in various scenarios. The study comprised a substantial sample of 60 patients, who had undergone treatment using either Frankel II appliances, Twin Block appliances, or Forsus FRD appliances. These patients, aged between 12 ± 0.85 years and 14 ± 0.91 years, were divided into three distinct groups. A careful selection was made from the meticulously maintained files of the esteemed Department of Orthodontics and Dentofacial Orthopaedics at the renowned Institute of Dental Sciences, Siksha 'O' Anusandhan University, situated in Bhubaneswar, Odisha, India.

The current study is a retrospective study, which may introduce some bias. However, to minimize this bias, a specific age group of patients with similar clinical features was selected. This greatly reduced the chances of bias.

In this study, it was found that functional appliances such as the Frankel appliance and the Twin Block appliance resulted in noticeable changes in the teeth and surrounding bone.[15-16] In contrast, a fixed functional appliance like the Forsus FRD not only produced significant changes in the skeletal structure but also in the teeth and surrounding bone.

Patients treated with the FR II showed a considerable increase in chin prominence during soft tissue analysis. On the other hand, the group treated with the Twin Block achieved a more balanced facial appearance by reducing facial convexity.

While there is no direct correlation between the use of Forsus FRD and changes in soft tissue, indirect changes in facial soft tissue were observed. These changes contributed to improved facial harmony and aesthetics.

To thoroughly evaluate even the smallest changes at the skel et al, dentoalveolar, and soft tissue level, both pre-treatment and post-treatment lateral cephalometric variables were recorded for all three groups.[17-18]

5. Limitation

There are no gender-related changes in skeletal, dentoalveolar, and soft tissues have been studied in any of the groups. Further studies related to differences in skeletal, dentoalveolar, and soft tissue changes with FR II, TB, and Forsus FRD need to be done.

6. Conclusions

The comparative evaluation of post-treatment cephalometric changes among the three functional appliances—FR II (Group A), Twin Block (Group B), and Fixed Functional Appliance (FRD, Group C)—reveals statistically significant skeletal, dental, and soft tissue adaptations. All groups demonstrated an improvement in skeletal Class II correction, as indicated by reductions in ANB and Wits appraisal values, with Group A (FR II) showing the greatest decrease in ANB angle. Mandibular advancement, as reflected by increases in SNB and effective mandibular length, was most pronounced in Group C, though all groups exhibited similar mandibular growth.

Dentoalveolar changes showed minimal upper incisor retraction across groups, while lower incisor proclination was modest and statistically insignificant. Significant improvements were also observed in overjet reduction, particularly in Group A, though overbite changes were minimal in all groups. Soft tissue parameters, such as lower lip position relative to the E-plane and nasolabial angle, exhibited statistically significant differences, especially in Group C, suggesting favorable esthetic changes.

Overall, while all three appliances were effective in achieving Class II correction, FR II produced the most pronounced skeletal changes, particularly in ANB and overjet reduction, whereas the Twin Block and FRD showed comparable outcomes in mandibular advancement and soft tissue improvement.

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None.

8. Conflict of interest

None.

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