“EFFECTS OF FIXED TWIN-BLOCK AND FORSUS FATIGUE RESISTANCE DEVICE ON MANDIBULAR THIRD MOLAR ANGULATION- A COMPARATIVE STUDY”

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Under the Guidance Of

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My Family

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LIST OF ABBREVIATIONS

FTB	:	Fixed Twin Block
FRD	:	Forsus Fatigue Resistant Device
OPG	:	Orthopantomogram
mm	:	millimetre
°	:	degree

ABSTRACT

Introduction: Fixed Functional Appliances such as Fixed Twin Block and Forsus Fatigue Resistant Device improve Class II skeletal relationships by increasing the length of the mandible, which subsequently lead to an increase in the retromolar space. This would bring about a positional and angular change in the mandibular third molar. These appliances also produce forward movement of the mandibular buccal segments, which has also been cited as an important factor providing space and therefore improving the angulation and eruption potential of the third molars.

Objective: To evaluate and compare the effects of Fixed Twin Block and Forsus Fatigue Resistant Device treatment on mandibular third molar angulation

Materials and Methods: Pre-treatment and post treatment lateral cephalograms and orthopantomograms of 25 patients with Class II division 1 malocclusion treated with Fixed Twin Block (FTB) were compared with those of 25 patients treated with Forsus Fatigue Resistant Device (FRD). Sagittal and vertical skeletal relationships and mandibular length were assessed on lateral cephalogram, whereas linear parameters such as retromolar space, space width ratio, distance of Xi point from distal surface of lower second molar, and angular parameters such as α, β, ϒ and gonial angles were measured on the orthopantomograms. Intra group comparison was done using Paired t-test, while Unpaired t-test was done for inter group comparison of the observed changes.

Results: Mandibular length increased significantly in the FTB group, whereas mesialization of the mandibular dentition was significantly more in the FRD group. Both groups showed a significant increase in retromolar space, space width ratio, Xi point to 7 distance, α angle and a decrease in β angle. These changes were significantly more pronounced in the FTB group.

Conclusion: There was a significant improvement in the third molar angulation following treatment with Fixed Functional Appliances, which was comparatively more in the FTB group than in FRD, owing to an increase in mandibular length.

Key words: Third molar angulation, Fixed Functional Appliances. Fixed Twin Block, Forsus Fatigue Resistant Device

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INTRODUCTION

One of the most unpredictable events in the course development of thehuman dentition is the eruption of the mandibular third molar and its subsequent oc clusal location in the dental arch. As mandibular third molars are the last teeth to develop, they are particularly prone to impaction.Hard tissue formation of these teeth begins between the ages of 8 and 10, with enamel formation completed by the ages of 12 to 16 years. They erupt at 17-21 years, while root completion occurs at roughly 18-25 years of age.[1]

Successful eruption of the mandibular third molar occurs by means of the tooth continuing to upright with respect to the mandibular plane and moving occlusally into sufficient space.[1] Authors such as Richardson (1978)[2], have reported that uprighting occurs by differential mesial root growth[1].

For a long time, insufficient development of retromolar space has been considered to be the most important factor contributing to the high impaction rate of lower third molars.[4]Chances of eruption increase with an increase in available retromolar space. Bjork, Jensen and Palling[3] have suggested that sufficient space is produced by mandibular growth and a forward movement of the dentition as it erupts.[1] Considerable jaw growth is required to allow sufficient room for these teeth. This growth occurs by bone resorption of the anterior-facing surface of the ramus and deposition on the posterior-facing surface[1], resulting in the lengthening of the mandibular corpus. A lack of eruptive space in the mandibular corpus will produce errant eruptive paths and consequent third molar impaction.[1]

Many studies found greater chances of lower third molar impaction in subjects with decreased mandibular length, as is seen in Class II skeletal malocclusions with shorter, narrower mandibles.[4]

Janson et al.[5]showed that the available retromolar space could differ between Class II and Class I skeletal malocclusions, indicating that sagittal skeletal relationships might also have an impact on the fate of these teeth. Furthermore, they also reported less space for mandibular third molars on the sides of skeletal Class II malocclusion compared with the sides of skeletal Class I malocclusion, which was supported by authors such as Jakovljevic[4].

These linear and angular indicators aside, patient age is another factor that cannot be overlooked. Authors such as Kruger[6] have noted changes in position of third molar teeth after the age of 18, which have promoted their better eruption. These findings may be attributed to further skeletal growth occurring after the onset of adulthood which might be a contributor to the increase in retromolar space. [4]

Class II functional appliances bring about the correction of mandibular deficiencies by holding the mandible forward and/or downward, thus allowing mandibular postural changes [7,8] These appliances cause the muscles and soft tissues to stretch and the pressure generated is transmitted to the skeletal and dental structures which causes skeletal growth modification and tooth movement.[7,8]

Both fixed and removable Class II functional appliances are used to improve skeletal Class II malocclusions. Since the success with removable appliances largely depends on patient’s compliance, using a fixed appliance can increase the chances of a favourable outcome as it negates the compliance of the patient from the treatment.

These appliances can also be used concurrently with fixed orthodontic therapy, as they can be cemented or attached directly to the main archwire, thus saving the time of secondary post functional mechanotherapy.

The Fixed Twin Block and Forsus Fatigue Resistant Device are two commonly used fixed functional appliances employed in the correction of skeletal Class II malocclusions.

The Twin Block appliance, developed by William Clark[9], consists of maxillary and mandibular acrylic plates with inclined planes at an angle of 70°, which encourages the forward and downward displacement of the mandible. A Fixed Twin Block appliance that can be fixed with dental cement in the patient’s mouth, would produce more favourable treatment outcomes, since reliance on compliance in these patients is eliminated completely.

The Forsus Fatigue Resistant Device (FRD) is a fixed Class II appliance developed by William Vogt[10], which essentially is “a three-piece, hybrid telescoping system incorporating a superelastic nickel-titanium coil spring.” The apparatus consists of a telescoping cylinder into which the distal end of the push rod is inserted and a hook on the mesial end which is crimped directly onto the archwirenear the canine or premolar bracket.

While the Fixed Twin Block is used during the growth phase and has been known to bring about definite skeletal changes rather than dental, the Forsus Fatigue Resistant Device which is used towards the end of the growth phase, has shown to bring about a greater degree of dental changes than skeletal[11,12].

These appliances improve Class II skeletal relationships by increasing the length of the mandible. Hence, as the length of the mandible increases, subsequently the retromolar spacealso increases, which would bring about a positional and angular change in the mandibular third molar. They also produce forward movement of the mandibular buccal segments, which has also been cited as an important factor providing space and therefore improving the eruption potential of the third molars.[1]

Therefore, the purpose of this study was to evaluate and compare the changes in the retromolar space and mandibular third molar angulation, in skeletal Class II division 1 patients treated with Fixed Twin Block (FTB) versus Forsus Fatigue Resistant Device(FRD).

AIM OF THE STUDY:

To evaluate and compare the effects of Fixed Twin Block and Forsus Fatigue Resistant Device treatment on mandibular third molar angulation.

OBJECTIVES:

- To evaluate the changes in retromolar space and mandibular third molarangulation in cases treated with Fixed Twin Block appliance.
- To evaluate the changes in retromolar space and mandibular third molarangulation in cases treated with Forsus Fatigue Resistant Device.
- To compare the changes in retromolar space and mandibular third molar angulation in cases treated with Fixed Twin Block appliance versus Forsus Fatigue Resistant Device.

REVIEW OF LITERATURE

THIRD MOLAR ANGULATION

While studying the effect of premolar extractions on third molars, **Staggers JA et al[13] (1992)** noted improvements from pre to post treatment in maxillary and mandibular third molar angulation in relation to the occlusal plane. They, however, found no statistically significant differences in patients treated with first premolar extraction and those treated without extractions, which suggest that third molar angulation might be influenced by various factors apart from available space.

Richardson ME[14] (1992) foundage to be an important factor that should be weighed in while evaluating changes in third molar angulation. They asserted that despite lack of space and advanced root formation, some lower third molars undergo considerable positional changes in both mesiodistal and buccolingual directions after the age of 18 years.

C Dolce et al[1] (2000) found favourable effects onthird molar angulationfollowing functional treatment with Bionator appliance. They also found that teeth in front of the anterior border of the ramus have a smaller mesiodistal angulation than the teeth behind the anterior border of the ramus, while those in front of the anterior body of the ramus and above the cementoenamel junction of the second molar exhibit the smallest mesiodistal angulation.

Artunet al[15] (2005) found that maxillary third molar angulation improves in patients treated with premolar extractions, whereas no appreciable changes were observed inmandibular third molar angulation. They also found “more than 30°

distal angulation as well as an amount mesial angulation of the upper 3rd molars post treatment, and a better frequency of greater than 40-degree mesial angulation of the mandibular third molars post treatment in patients with impaction than in those with eruption", indicating that these angulations may be potential risk factors for third molar impaction.

Behbehaniet al[16] (2006) conducted a study in 134 subjects to identify the risk factors for mandibular third molar impaction in adolescent orthodontic patients. Radiographs taken before (T1) and after (T2) treatment and at 10 years post-retention (T3) were evaluated. Their findings suggested that increased retromolar space and mesial molar movement during active treatment reduce the risk of mandibular third molar impaction in adolescent orthodontic patients, whereas increased mesial angulation of the third molar buds and signs of pronounced forward mandibular growth rotation increase the possibility of impaction.

Jain et al.[17] (2009) studied the effect of premolar extractions on mandibular third molar angulationusing ahorizontal reference plane. They found that mandibular third molars uprighted significantly more in the extraction group than the non-extraction group on both the right and left sides.

Tarazona et al.[18] (2010) carried out a retrospective study to analyze the changes in the angulation and position of the 3rd molar in cases treated either with extraction or without extraction of the 1st or 2nd premolars as well as to assess the variation in the gonial angle and the degree of inclusion of the 3rd molars. Their aim was also to establish a predictive impaction model for 3rd molar eruption. The initial and final OPGs of 88 patients (28 patients treated with extractions of 1st premolars, 30 with 2nd premolars and 30 without extraction) were analyzed and the angulation of the

3rdmolars were measured. To evaluate the degree of third molar inclusion within the mandibular ramus, a new variable was being created. The results show that the 3rd molar angulation improves with time, no matter which treatment, and presents a greater disimpaction in cases treated with extractions. The conclusions suggest that other factors may influence the angulation and position of 3rd molars and that it's impossible to determine a predictive impaction model for the same.

Gohilotet al[19] (2012) evaluated changes in third molar angulation in relation to a horizontal reference plane, in patients treated with and without premolar extractions. They found improvements in maxillary third molar angulation in the extraction group, thus concluding that while non-extraction therapy did not seem to have any adverse effects, premolar extractions certainly had a positive influence on the developing maxillary 3rd molar angulations on both sides.

Turkoz et al[20] (2012) found that mandibular third molar impaction showed a strong correlation to third molar angulation and the angle formed by the long axes of the second and third molars. Although there was a significant increase in retromolar spacein the group treated with extractions, this did not seem to prevent third molar impaction. The findings from this study indicate that even with enough retromolar space, third molars may still remain impacted if the angulations are unfavourable.

Jakovljevic A et al[14] (2015) evaluated linear and angular radiographic predictors for lower 3rd molar eruption in patients with varying anteroposterior skeletal relations. These radiographic predictors showed the most improvement in Class III and least improvement in Class IIcases. Based on the findings of their study, they stated that β angle and Go-Gn measurements and the amount of retromolar space are important determinants of third molar eruption.

Patel et al[21] (2015) evaluated lateral cephalograms and OPGs of thirty patients to compare changes in space, angulation and eruption potential of third molars in patients treated with extraction and those without. They found that third molars in the extraction cases showed more favourable improvements in the available space, angulation and overall chances of eruption.

Durgesh et al[22] (2016) found that premolar extractions did not seem to have a significant effect on the improvement in third molar angulation and agreed with previous studies that the angulation and eruption potential of third molars may be influenced by factors other than premolar extraction.

Mendoza-Garcíaet al[23] (2017) in their retrospective study, found thatretromolar space increased significantly in both male and female patients following orthodontic treatment with extraction of premolar teeth. They however found a discrepancy in the improvement in third molar angulation, with α and β angles improving only the left side in females and only the α angle improving on the right side in males.

FIXED TWIN BLOCK

William Clark[9] (1982) in his first published paper described the technique of Twin blocks, which consist of upper and lower bite blocks that interlock at an angle of 45° causing functional mandibular displacement. The concorde face bow uses horizontal inter maxillary elastic from the lower appliance to the facebow thus combining extra-oral traction with inter-maxillary traction. It was observed that the response to treatment varied according to growth pattern. All the early cases showed a combination of skeletal and dentoalveolar changes. The individual response apparently depended on growth pattern and timing of treatment.

William Clark[24] (1988) found that patients treated with Twin Blockshowed highly significant growth changes especially during the active phase of treatment. He also found improved ANB values, increase in effective mandibular length, increase in length of the facial axis and increase in facial height.

Trenouth[25] (1989) described Class II correction using a modification of the Twin Block functional appliance. He reported a reduction of SNA angle by 3° and an increase in SNB by 2°, the greatest change was decrease in upper incisor to maxillary plane, and an increase of 2° in lower incisor to mandibular.

David Ian Lund[26] (1998) investigated the net effects of the Twin Blockfunctional appliance considering the effects of normal growth in an untreated control group. The treatment group consisted of 36 subjects treated with Twin Block appliance while the control group consisted of 27 subjects. These patients were observed for a mean time of 1.2 years with radiographs. In the treatment group, a reduction in ANB of 2° was observed largely because of an increase in SNB of 1.9°. Maxillary growth showed no statistically significant restraint. Treatment resulted in a An increase in Ar-Pog of 5.1 mm was observed in the treatment group, compared with the control group increase in Ar-Pog of 2.7 mm, leading to a net gain of 2.4 mm. Combination of a net maxillary incisor retroclination of 10.8° and net mandibular incisor proclination of 7.9° as well as forward movement of the mandible contributed to a reduction in overjet. Lower molar eruption, restraint within the eruption of the upper molars and forward growth or repositioning of the mandible led to correction of buccal segment relationships.

Christine Mills et al[27] 1998 investigated the effects of Twin Block appliancein 28 Class II patients treated with Twin Block appliance records of these patients were evaluated and compared with an age and sex matched sample of untreated Class II control subjects. Within the treatment group, an average of 4.2 mm more mandibular growth was observed than within the control group over the 14-month treatment period. Additionally, some dentoalveolar effects in both arches contributed to the overjet correction. The incisor overjet reduced 5.6 mm on average in the treatment group. Of this reduction in overjet, nearly two thirds could be accounted for by the forward growth of the mandible.

Illing, Morris and Lee[28] (1998) compared treatment effects of Bionator, Twin Block and Bass appliance. A statistically significant increase in the length of the mandible was noted in the Bionator and Twin Block groups as compared to the control group, with an anterior or forward movement of pogonion & point B seen more in the Twin Block group. Flaring of the lower incisors occurred more in the Bionator group.

Tumer and Gultan[29] (1999) evaluated the differences between mono block appliance and Twin Block appliance. They found that the stimulation of mandibular growth and the correction of the Angle Class II relationship were achieved, particularly in the Twin Block group. Within both treatment groups, facial convexity and over-jet decreased, a distal movement of the upper molars and therefore the mesialization of the lower molars was observed.Upper incisors retroclined more in the mono block whereas lower incisors proclined more in the TB group.

Toth and McNamara, Jr[30] (1999) in their retrospective study, evaluated effects produced in 40 treated patients with the Twin Block appliance; FR-2 appliance and untreated Class II controls. Significant reduction in overbite & overjet were observed at the end of treatment in the Twin Block and Frankel groups. Increase in mandibular length were observed in both the treated groups compared to the untreated subjects. Twin Block group showed an additional 3.0 mm of mandibular length, whereas the

Frankel group showed increase of 1.9 mm more than the controls. No significant restriction of mid facial growth was observed in either functional group relative to controls. An increase in lower anterior facial height was evident in both treatment groups. Vertical increase in the Twin Block group was significantly greater than in the FR-2 group. The tooth-borne Twin Block appliance showed more dentoalveolar adaptation than with the tissue-borne FR-2 appliance. Significant retroclination and extrusion (eruption) of the maxillary incisors was observed in both groups. The Twin Block exhibited distal movement of the upper molars. In both treatment groups slight lower incisor proclination was noted, while lower molar extrusion was found to be significantly greater within the dual block group compared with the other 2 samples. Correction of Class II with FR-2 appliance seems to have primarily a skeletal effect, however, the Twin Block appliance produces both skeletal and dentoalveolar adaptations.

Christine Mills, and McCulloch[31] (2000) found an average increase in mandibular length of 6.5 mm over a mean of 14 months (annual rate of change of 5.6 mm per year) in patients treated with Twin Block appliance. In comparison to the Twin Block group, the control group showed a 2.3 mm increase in mandibular unit length during the observation period of 13 months (annual rate of 2.1 mm per year). In the post-treatment phase, the change in mandibular unit length for the Twin Block group was 6.0 mm over a 36-month period (annualized rate of change of 2 .0 mm per year). A mean increase in mandibular unit length of 6.7 mm over the post treatment assessment period that was 34 months in duration (annualized rate of change of 2.4 mm per year) was seen in the control group. They also observed these changes over a period of 3 years and found that although much of the increase in mandibular length that was achieved with Twin Block was maintained after 3 years, there was still a reduction mandibular growth rate.

Trenouth MJ[32] (2002) found that Twin Block produced a combination of mandibular skeletal and maxillary dentoalveolar responses. The correction of class II relationship was achieved by bodily movement of the mandible anteriorly along with elongation in the region of the condyle and ramus and posterior tipping of the upper incisors.

Jena AK et al[33] (2010) compared treatment effects of Twin Block and MPA- IV against those of a control group and found that increase in mandibular length and sagittal skeletal correction were greater in the TB group than MPA, indicating that skeletal changes contributing to Class II correction were more pronounced in the TB group as compared to MPA.

FORSUS FATIGUE RESISTANT DEVICE

William Vogt[10] in 2006, described the clinical application of Forsus Fatigue Resistant Device and reported that it can be used instead of Class II elastics in mild cases and instead of Herbst appliance in severe cases. Interarch appliance has a tendency to cause slight slowing of maxillary growth, slight acceleration of mandibular growth, & flaring of the mandibular incisor. The Forsus can intrude the maxillary 1st molar and thus correct without opening the bite.

Karacay, Akin[34] in 2006, evaluated the effects of ForsusNitinol Flat spring and Jasper Jumper. Cephalometric analysis revealed that mandibular growth simulation, increase in the anterior face height because of the lower face, and elongation in the posterior face height because of the growth at temporomandibular joint occurred with both the appliances. Maxillary central incisor was extruded, retruded, and distally tipped. In contrast, intrusion, protrusion, & labial tipping were seen in lower central incisors. Distal movement & intrusion of upper first molar & mesial movement & extrusion of the lower first molars were the other dental alterations. Overjet and overbite were reduced, & a Class I molar relationship & improvement in the profile was achieved in both treatment groups. ForsusNitinol Flat spring & Jasper Jumper were both effective in the class II malocclusion treatment and presented nearly the same changes in skeletal, dental, & soft tissue parameters.

Jones, Buschang[35] in 2008, compared treatment effects of Forsus FRD with those of intermaxillary elastics. They found that both modalities primarily bring about correction of overjet and molar relation through pronounced dentoalveolar effects causing mesialization of the mandibular molars and flaring of the mandibular incisors, with no statistically significant difference between the two group. They concluded that Forsus FRD is an acceptable substitute for Class II elastics in non-compliant patients.

While comparing ForsusNitinol Spring and Jasper Jumper,**Darda, Goel[36] in 2010**, found both appliances to be effective protocols in the management of Class II malocclusion.They observed that the two appliances stimulate mandibular growth but have a very minimum restraining effect on the maxilla and their overall treatment effects are mainly at the dentoaloveolar level than any true skeletal change.

Franchi, Alvetro[37] (2011) reported that correction of class II malocclusion along with a combination of skeletal, mainly maxillary & dentoalveolar, mainly mandibular modification is effectively mediated by the FRD protocol.

They found significant restriction of the maxillary growth, significantly increased length of the mandibular corpus, and an appreciable improvement in the maxillomandibular sagittal skeletal relationshipin patients treated with FRD. Flaring of the lower incisors and forward movement of the mandibular buccal segments was also noted.

Esen Ali Gunay, Tulin Arun[38] (2011) found that while Forsus FRD can be used as a more comfortable substitute to intermaxillary elastics, they mainly correct Class II malocclusions by dentoalveolar changes and very little or no sagittal and vertical skeletal changes.

Oztoprak and Nalbantgil[39] (2012) compared treatment effects of the Sabbagh universal spring and Forsus FRD appliance, and noted that both appliances brought about Class II correction predominantly by dentoalveolar changes, with no significant skeletal changes. Comparatively, the lower incisors proclined more in the FRD group.

Bowman and Saltaji[40] (2013) carried out a survey to note the problems experienced by patients treated with Forsus FRDand to assess patient comfort and overall patient acceptance of the appliance. They found that in general, FFRD was more comfortable and well accepted by patients, especially those who had been treated earlier with intermaxillary elastics. Although there were a few limitations like discomfort due to cheek irritation, these diminished gradually over time.

Giorgio Cacciatore, Lisa Alvetro, EfisioDefraia, Luis Tomas HuaneGhislanzoni, and Lorenzo Franchi[41](2014) found that Class II correction by Forsus FRD was predominantly brought about by dentoalveolar changes rather than skeletal. The overjet and overbite decreased significantly, and molar relationship improved. The changes were associated with significant retroclination of upper incisors, proclination, &retrusion of the lower incisors and mesialization of mandibular molars.

Giorgio Cacciatore et al[42] (2014) evaluated radiographs of 36 growing patients with Class II malocclusion taken before and after treatment with Forsus FRD. These findings were compared with those of an untreated control group. They noted a significant restriction of the maxillary growth in sagittal plane as well as significant correction in overjet, overbite and molar relationship.

TWIN BLOCK VERSUS FORSUS

Mahamad et al[11] (2012) conducted a comparative study for skeletal, dental and soft tissue parameters on 25 patients treated with Twin Block and compared with 25 patients treated withForsus FRD and compared these with those of a control group. They observed that patients undergoing treatment with Twin block showed high statistically significance with increase in mandibular length (6.02 mm), whereas, patients undergoing treatment with Forsus appliance showed significant ($p < 0.05$) increase in length of the mandibular (1.6 mm) when compared with control group (0.3 mm).Other dental and soft tissue parameters were also appreciably improved in both FTB and FRD groups.

Veronica Giuntiniet al[12] (2015) compared the dentoskeletal changes produced by the Twin Block appliance and Forsus FRD against a control group with untreated Class II malocclusion. They found that the TB group produced greater amounts of skeletal changes in terms of mandibular growth with a significant increase in the length of the mandibular body. A significant restriction of maxillary growth was noted in the FRD group compared to the other two groups. Lower incisors also proclined more in the FRD group than TB and control groups.

MATERIALS AND METHOD

STUDY DESIGN: Comparative study

SOURCE OF DATA: Patients who have undergone treatment and agreed to report to the Department of Orthodontics and Dentofacial Orthopaedics (for post-retention records)

KLE'S Academy of Higher Education and Research, KLE VK Institute of Dental Sciences, Belagavi-590010

INCLUSION CRITERIA:

- Patients with skeletal Class II Division 1 malocclusion, with ANB ≥ 4 degrees.
- Patients treated with Fixed Twin Block and Forsus FRD appliance.
- Patients with full complement of permanent teeth with radiographically confirmed lower third molars
- No permanent teeth extracted.
- Age between 16-25 years at the time of post-treatment radiographs.
- Both male and female patients.

EXCLUSION CRITERIA:

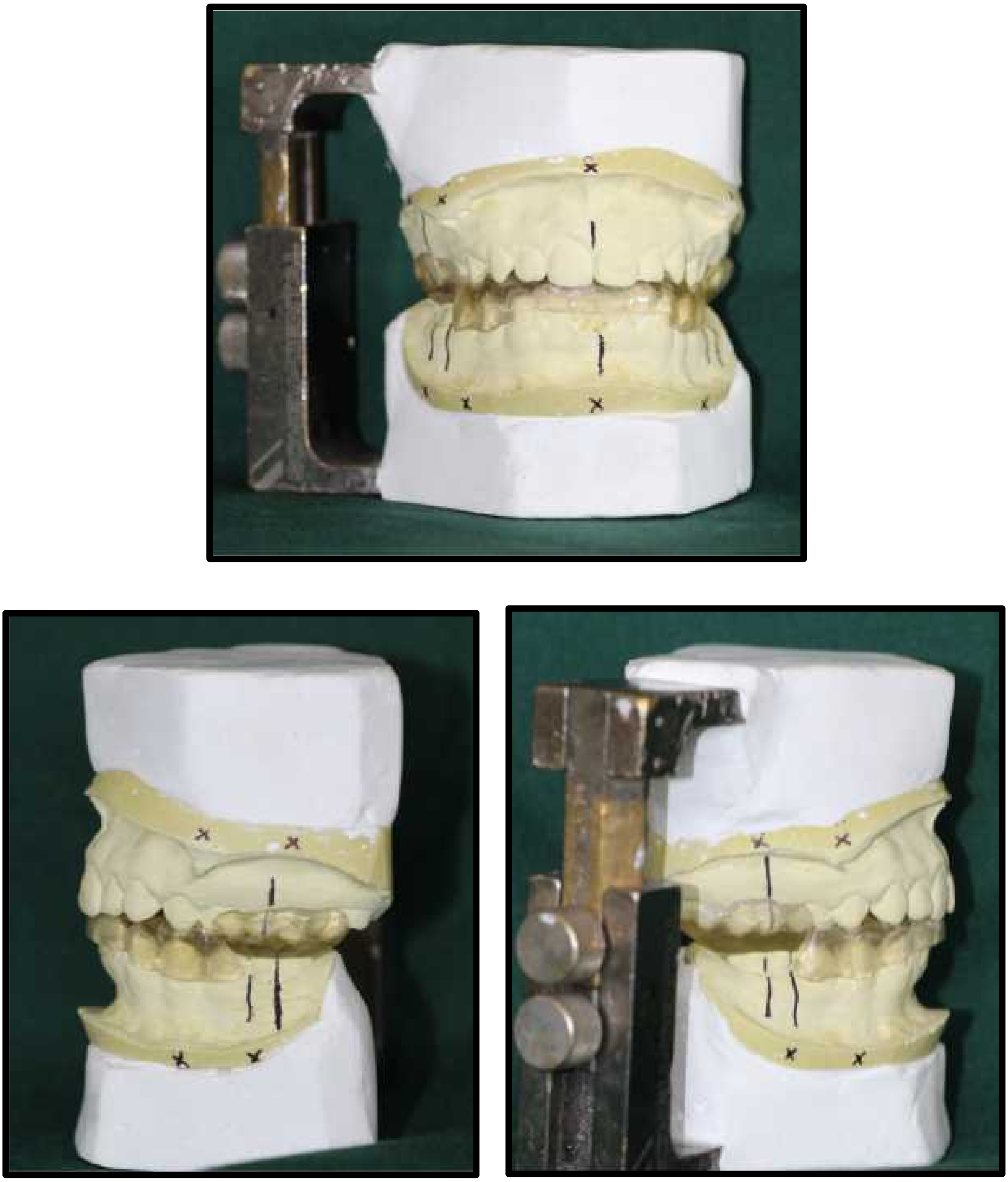
- History of orthognathic surgical treatment.
- History of extracted or missing permanent teeth.
- Congenitally missing mandibular third molars.

- Presence of any developmental anomalies, dentofacial deformities, or severe facial asymmetries.
- Patients with skeletal Class I and Class III malocclusions.

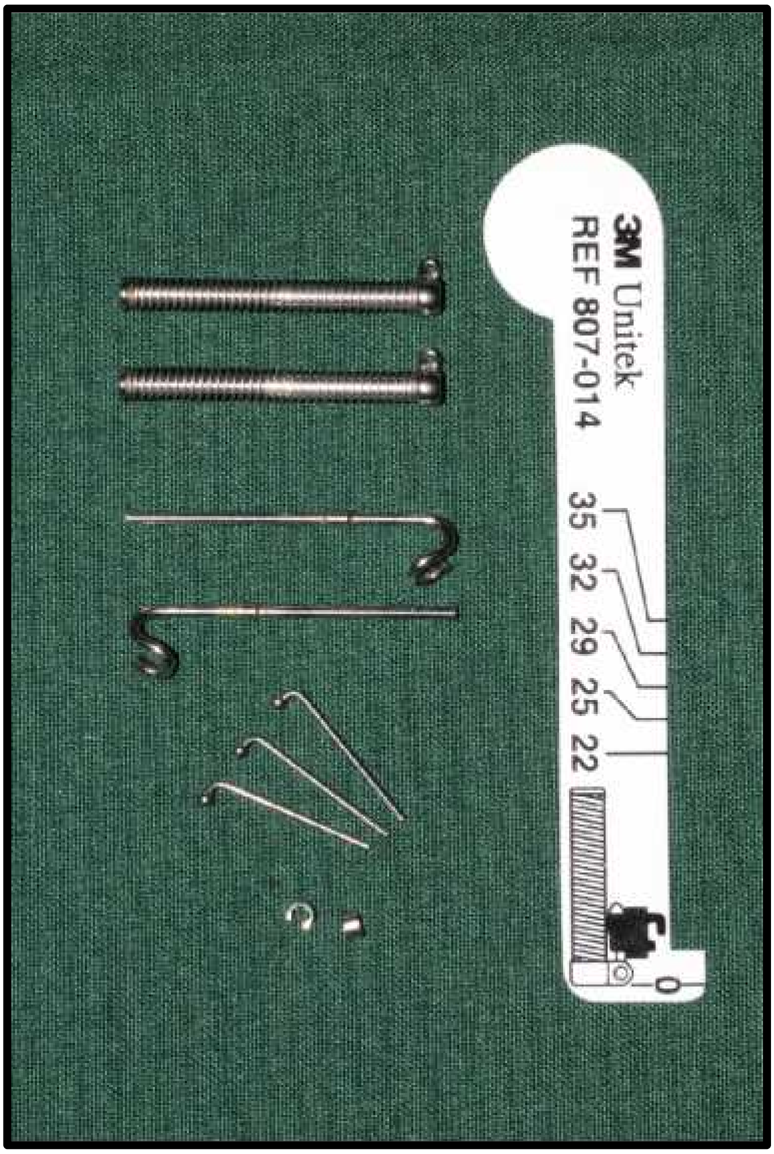
Patients were divided into two equal groups

- Group A: 25 patients treated with Fixed Twin Block appliance
- Group B: 25 patients treated with Forsus FRD appliance

(manufactured by 3M Unitek 4 Corp Orthodontic products)



PHOTOGRAPH 1: PHOTOGRAPH OF FIXED TWIN BLOCK ON AN ARTICULATOR



PHOTOGRAPH 2: PHOTOGRAPH OF COMPONENTS OF FORSUS FATIGUE RESISTANT DEVICE

PHOTOGRAPH 3: INTRAORAL PHOTOGRAPH OF FIXED TWIN BLOCK

PHOTOGRAPH 4: INTRAORAL PHOTOGRAPH OF FORSUS FATIGUE RESISTANT DEVICE

Pre-treatment lateral cephalograms and orthopantomograms of the patients were collected.

Patients were recalled for the purpose of taking post-retention lateral cephalograms and orthopantomograms 3-4 years after completion of their treatment i.e., in the age group of 16-25 years, to evaluate the retromolar space and late mandibular growth.

For the purpose of evaluating the skeletal parameters, acetate matte sheets were placed over the lateral cephalograms and the cephalometric landmarks were traced.

Similarly, for the purpose of evaluating the retromolar space and the mandibular third molar angulation, the orthopantomograms were traced and the outlines of the mandibular body and ramus, mandibular second and third molar teeth and their long axes were drawn on the tracing sheet.

As there was a significant time gap between some pre-treatment and post retention records, some radiographs had to be digitally standardized. Standardization was done by scanning the radiographs and uploading them on Adobe Photoshop CS5, on which they were digitized, and a standard scale was set.

The following measurements were made

1. **On lateral cephalogram:**

   a. **Linear measurements:**

      - Growth of the mandible was assessed by the following parameters**(Figure 1)**

      - **Go-Gn (mm)–**"Length of body of the mandible"- Distance between gonion and gnathion
      - **Co-Go (mm)–**"Effective length of ramus"- Distance between condylion and gonion
      - **Co-Gn (mm) –** "Effective length of the mandible"- Distance between condylion and gnathion

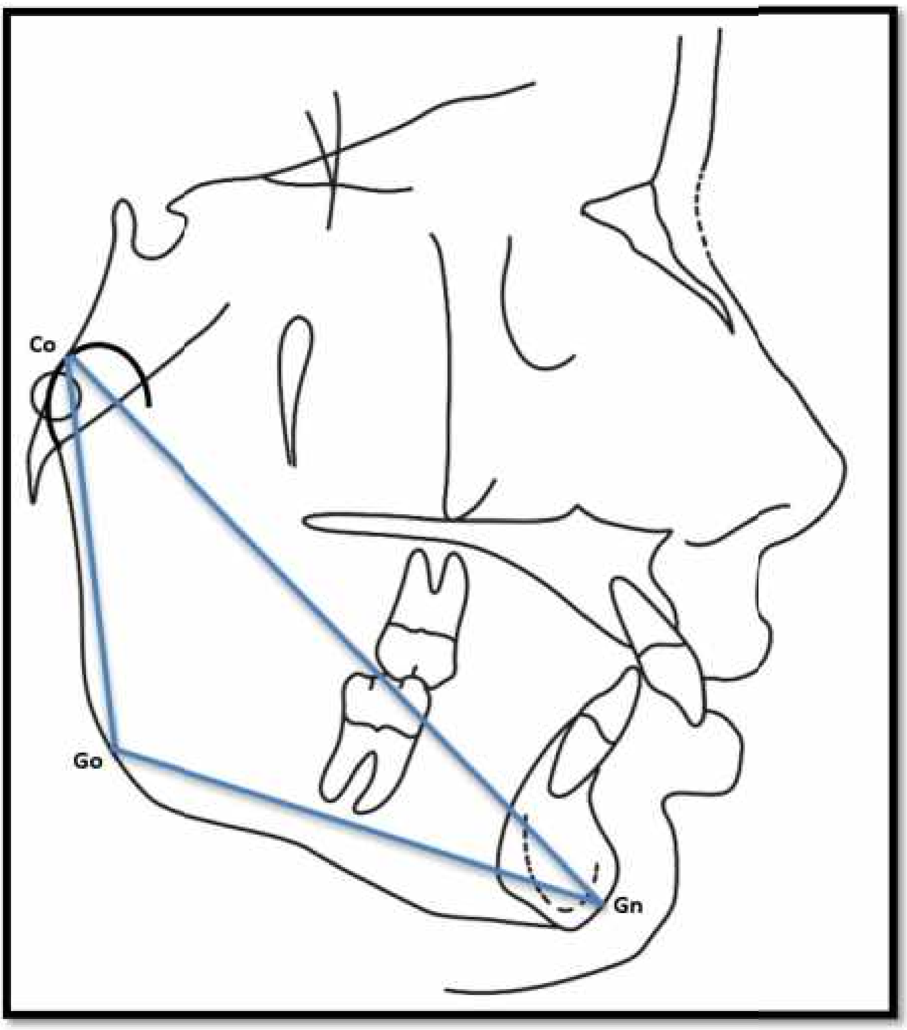


FIGURE 1: DIAGRAMMATIC REPRESNTATION OF CEPHALOMETRIC SKELETAL LINEAR MEASUREMENTS

Pancherz analysis[43]**(Figure 2)**was done to assess sagittal mandibular molar and incisor movements with respect to a vertical reference line (OLp) drawn from the sella (S) perpendicular to the occlusal plane (OL).

This suggested the amount of dentoalveolar changes in terms of mesialization of the mandibular molars and incisors that take place while bringing about Class II correction with Fixed Functional appliances.

- **Ii (incision inferius)-** "The incisal tip of the most prominent mandibular central incisor, with respect to OLp"
- **Mi (molar inferius)-** "The mesial contact point of the mandibular permanent first molar, determined by the tangent perpendicular to OL; with respect to OLp"

where OL (occlusal line)- "a line through is (incision superius) and the distobuccal cusp of the maxillary permanent first molar";

OLp (occlusal line perpendicular)- "a line perpendicular to OL through S (sella)"

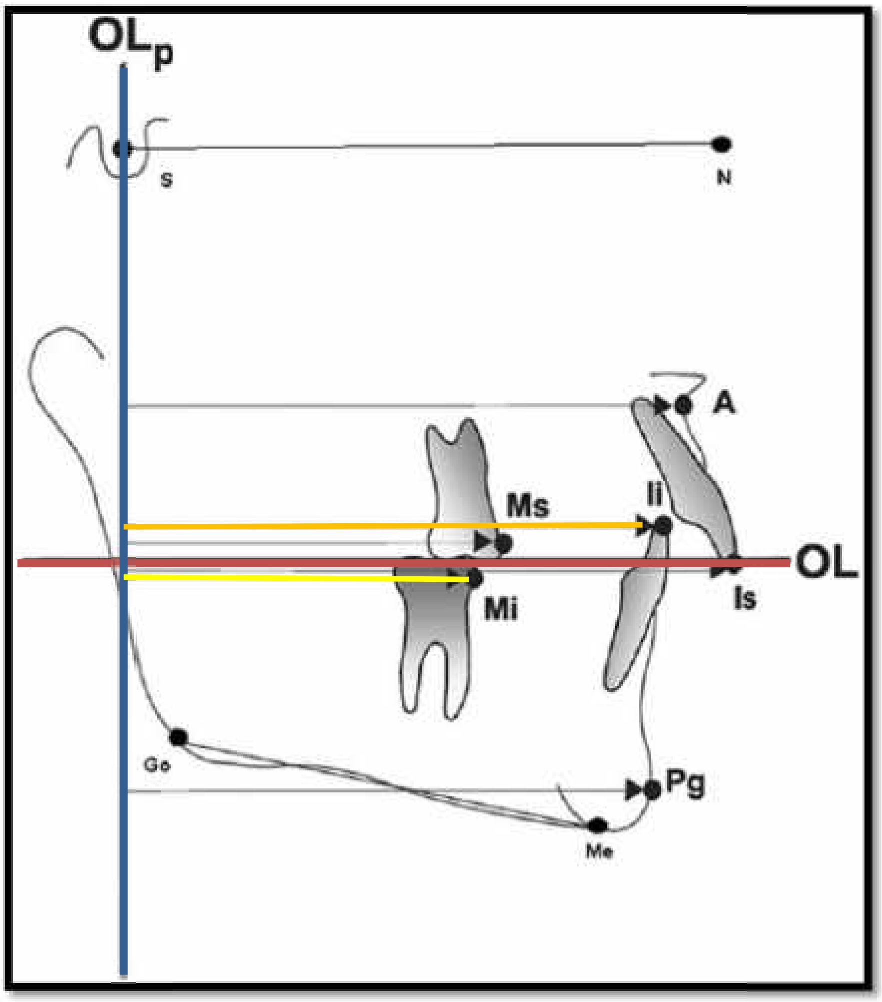


FIGURE 2: DIAGRAMMATIC REPRESNTATION OF CEPHALOMETRIC DENTAL LINEAR MEASUREMENTS PANCHERZ ANALYSIS

- The following parameters were used to evaluate sagittal and vertical skeletal relationships**(Figure 3)**

- **SNA angle- "**Angle between cranial base to subspinale" (A-point)

- **SNB angle- "**Angle between cranial base to supramentale" (B-point)

- **ANB angle**- "Difference between SNA and SNB"

- **SN/MP angle**- "Mandibular plane to cranial base angle"

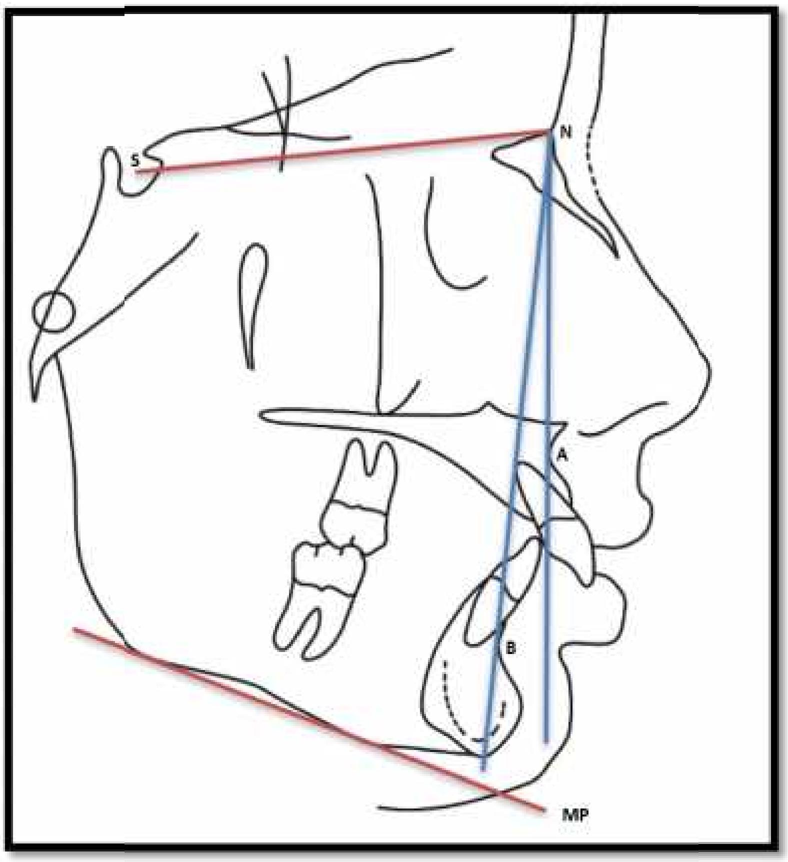


FIGURE 3: DIAGRAMMATIC REPRESNTATION OF CEPHALOMETRIC SKELETAL ANGULAR MEASUREMENTS

2. On panoramic radiograph:

a. Linear measurements:(Figure 4)

- **RMS (mm)-**Retromolar space: "length of the line drawn along the occlusal plane from the point it bisects TL to the point it bisects the anterior edge of the ramus"

- **MDW (mm)-** Mesiodistal width: "the greatest distance between the mesial and distal surface of the lower third molar crown"

- **SWR-** Space width ratio- "Retromolar space/Mesiodistal width ratio: calculated by dividing the RMS and MDW"

  where ≥1 indicates greater possibility, and <1 indicates less possibility of eruption.

  - Proposed by Henry and Morant[44] as an "Index of Molar Space" to predict the impaction of third molar on lateral cephalogram.
  - Eruption chances are good if the mesiodistal width value is same or less than the available space, whereas when the mesiodistal width value is greater, there are greater chances of impaction.

- **Xi-7 (mm)-** "Distance between Xi point (geometric center of the mandibular ramus) and the distal surface of the second mandibular molar"

  - By definition, Xi point is the geometric center of the ramus of the mandibleand is considered a physiologic center of occlusion which can be accurately determined. Moreover, it is a stable point during mandibular growth[45]. There is also active resorption of the anterior border of the ramus during mandibular growth as a mechanism of retromolar spacedevelopment, due to which many authors have therefore suggested superiority of the Xi point as a landmark for lower eruption space analysis over measurement of retromolar space.

- After reviewing various methods for calculating the available space and molar location shifts, Turley[46] and Schulhof[47] concluded that the distance from Xi point to the distal surface of the lower second molar is the most useful parameter to evaluate space available for a third molar.

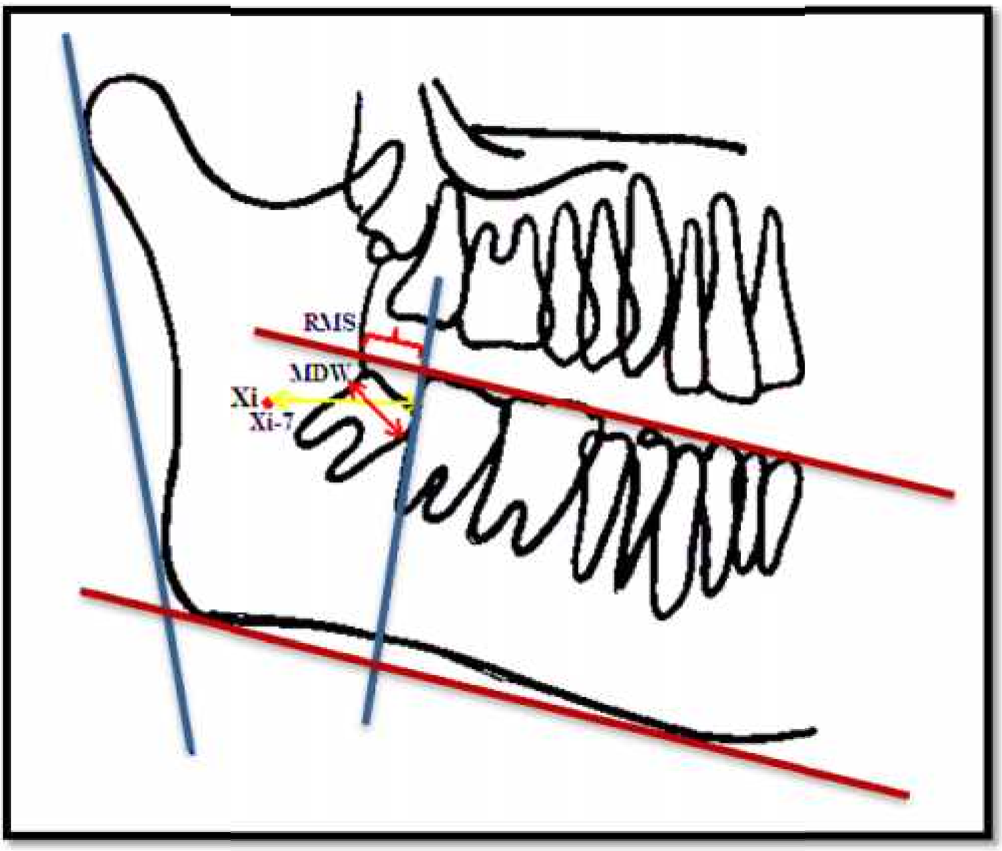


FIGURE 4: DIAGRAMMATIC REPRESNTATION OF LINEAR MEASUREMENTS DONE ON PANORAMIC RADIOGRAPH

b. Angular measurements: (Figure 5)

- **α angle**- Alpha angle: “angulation of lower third molar to mandibular line”
  - Studies have shown that during tooth development, if the α angle is decreased, the chances of impaction increase. Chances of eruption increase with an increase in the α angle, which indicates uprighting of the lower third molar.[48,49]
- **β angle**- Beta angle: “inclination between lower third and second molars”
  - For successful eruption of the lower third molar, Haavikko et al.[50] stated that “the initial angulation of β angle shows a tendency to become smaller and to change to parallel and distal angulation.” Decrease in the β angle would therefore be favourable to the eruption of these teeth.
- **γ angle-** Gamma angle: “angulation of lower second molar to mandibular line”
  - an increase in this angle indicates uprighting of the lower second molar
- **Go angle**- Gonial angle: “formed between tangent line to the posterior border of the mandibular ramus and the tangent line to the lower border of mandibular corpus”

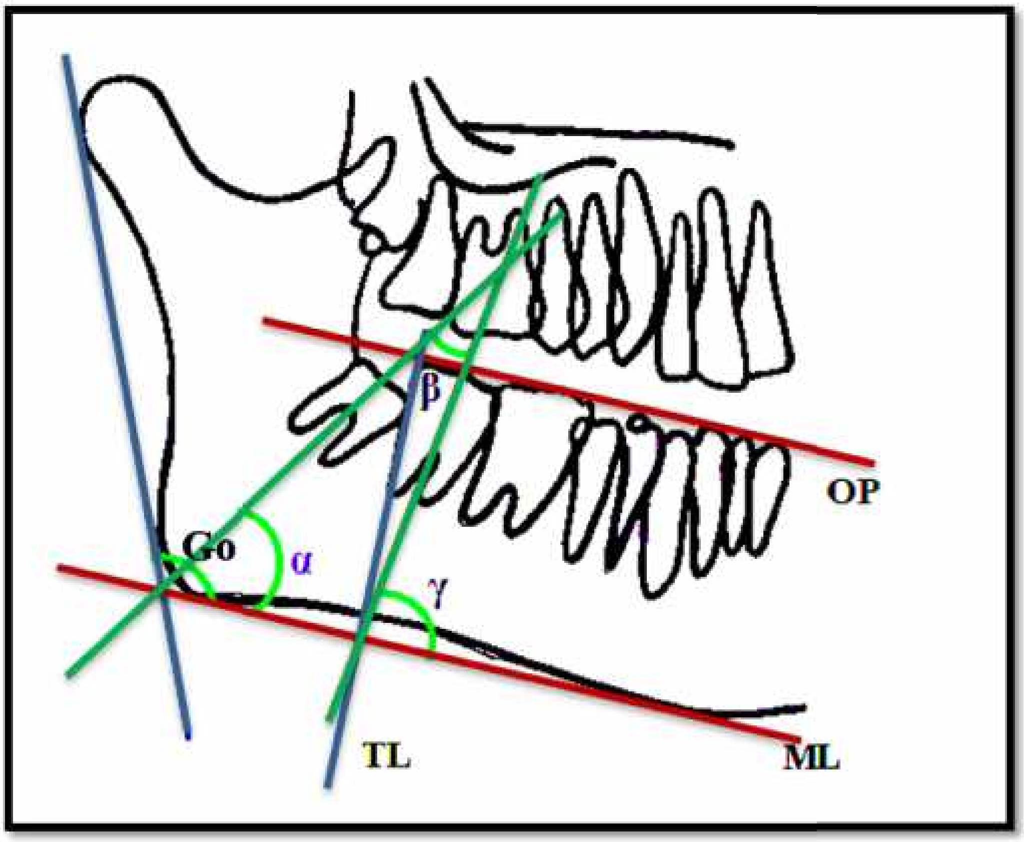


FIGURE 5: DIAGRAMMATIC REPRESNTATION OF ANGULAR MEASUREMENTS DONE ON PANORAMIC RADIOGRAPH

ARMAMENTARIUM:

- Pre-treatment and post-treatment lateral cephalograms
- Pre-treatment and post-treatment pantographs
- Acetate matte sheets
- Lead pencil (0.35 mm)
- Scale
- Set squares
- Protractor
- View box

SELECTION OF SUBJECTS

- Patients were selected from among those who have undergone treatment and reported to the Department of Orthodontics and Dentofacial Orthopaedics(for post-retention records)
  KLE'S Academy of Higher Education and Research, KLE VK Institute of Dental Sciences, Belagavi-59001

SAMPLE SIZE ESTIMATION

Sample size for the study was calculated as 25 subjects in each group (Fixed TwinBlock functional appliance and Forsus functional appliance) with a total of 50 subjects, based on the formula

$$N = \frac{2 (S)^2 (Z_{1-\alpha/2} + Z_{1-\beta})^2}{d^2}$$

Where standard deviation

S=2.66

d=detectable mean difference= 5.80

Z_α=1.96 at 5% α error

Z_β=0.84 80% power

So, the estimated sample size is **25** per group, which makes the sample size **50** in total

STATISTICAL TESTS:

1. Paired t-test
2. Unpaired t-test

RESULTS

Table 1 – Descriptive statistics of Linear parameters at pre and post-intervention in Fixed Twin Blockgroup

Parameters		Mean	Std. Deviation
GoGn	Pre	66.65	5.13
	Post	72.36	4.67
CoGo	Pre	51.24	4.27
	Post	54.74	4.69
CoGn	Pre	99.75	4.97
	Post	104.04	5.34
Ii	Pre	70.00	4.82
	Post	72.86	4.64
Mi	Pre	45.57	4.58
	Post	48.52	4.47
RMS right side	Pre	7.16	3.31
	Post	10.12	3.00
RMS left side	Pre	7.89	3.39
	Post	9.89	3.15
MDW right side	Pre	11.75	1.10
	Post	11.44	1.22
MDW left side	Pre	11.81	1.19
	Post	11.32	1.24
SRW right side	Pre	.62	.30
	Post	.90	.30
SRW left side	Pre	.67	.29
	Post	.87	.27
Xi-7 right side	Pre	21.72	2.66
	Post	24.59	3.57
Xi-7 left side	Pre	21.69	3.07
	Post	23.97	3.88

Table 2 – Descriptive statistics of Angular parameters at pre and post-intervention in Fixed Twin Block group

Parameters		Mean	Std. Deviation
α angle right side	Pre	62.60	12.85
	Post	72.20	15.97
α angle left side	Pre	59.56	12.17
	Post	73.00	13.11
β angle right side	Pre	23.32	11.73
	Post	19.44	14.35
β angle left side	Pre	25.00	11.16
	Post	19.76	13.68
ϒ angle right side	Pre	86.00	5.62
	Post	90.52	6.65
ϒ angle left side	Pre	84.84	6.25
	Post	92.08	10.10
Go angle right side	Pre	124.36	6.70
	Post	121.36	6.60
Go angle left side	Pre	124.28	6.57
	Post	121.36	6.51

Table 3 – Descriptive statistics of Linear parameters at pre and post-intervention in Forsus Fatigue Resistant Device group

Parameters		Mean	Std. Deviation
GoGn	Pre	69.26	6.69
	Post	71.01	6.78
CoGo	Pre	50.99	4.41
	Post	52.20	4.60
CoGn	Pre	99.60	4.41
	Post	101.54	4.27
Ii	Pre	74.41	8.34
	Post	81.65	7.81
Mi	Pre	51.35	5.49
	Post	58.13	5.30
RMS right side	Pre	10.93	3.79
	Post	11.80	3.37
RMS left side	Pre	9.97	3.93
	Post	12.34	5.13
MDW right side	Pre	12.10	1.42
	Post	11.89	2.93
MDW left side	Pre	11.94	2.61
	Post	11.76	3.52
SRW right side	Pre	.92	.30
	Post	.99	.28
SRW left side	Pre	.83	.32
	Post	1.04	.40
Xi-7 right side	Pre	23.07	4.12
	Post	24.82	3.89
Xi-7 left side	Pre	21.20	3.95
	Post	24.45	4.36

Table 4 – Descriptive statistics of Angular parameters at pre and post-intervention in Forsus Fatigue Resistant Devicegroup

Parameters		Mean	Std. Deviation
α angle right side	Pre	69.68	18.68
	Post	73.12	26.26
α angle left side	Pre	69.89	17.06
	Post	73.97	21.60
β angle right side	Pre	20.60	11.01
	Post	19.74	15.36
β angle left side	Pre	22.36	18.25
	Post	22.76	18.48
ϒ angle right side	Pre	83.64	6.86
	Post	90.80	8.89
ϒ angle left side	Pre	83.52	7.90
	Post	93.04	8.88
Go angle right side	Pre	125.32	6.04
	Post	122.56	5.93
Go angle left side	Pre	125.40	6.13
	Post	122.56	6.04

Table 5 - Intra group comparison of different linear parameters pre and post-intervention in Fixed Twin Blockgroup using paired t-test

Parameters	Mean Paired Differences	t value	Paired t-test p value
GoGn Pre - GoGn Post	-5.71000	-16.144	**.000***
CoGo Pre - CoGo Post	-3.50400	-15.290	**.000***
CoGn Pre - CoGn Post	-4.28880	-14.764	**.000***
Ii Pre – Ii Post	-2.86000	-13.467	**.000***
Mi Pre - Mi Post	-2.95200	-11.047	**.000***
RMS right side Pre - RMS right side Post	-2.95720	-6.796	**.000***
RMS left side Pre - RMS left side Post	-1.99920	-5.219	**.000***
MDW right side Pre - MDW right side Post	.31080	2.151	**.042***
MDW left side Pre - MDW left side Post	.49000	2.506	**.019***
SRW right side Pre - SRW right side Post	-.27863	-7.647	**.000***
SRW left side Pre - SRW left side Post	-.20191	-7.450	**.000***
Xi-7 right side Pre - Xi-7 right side Post	-2.87400	-4.573	**.000***
Xi-7 left side Pre - Xi-7 left side Post	-2.28320	-3.127	**.005***

p value <0.05* statistically significant

Table 6 - Intra group comparison of different angular parameters pre and post-intervention in Fixed Twin Blockgroup using paired t-test

Parameters	Mean Paired Differences	t value	Paired t-test p value
α angle right side Pre - α angle right side Post	-9.60000	-3.347	**.003***
α angle left side Pre - α angle left side Post	-13.44000	-5.825	**.000***
β angle right side Pre - β angle right side Post	3.88000	1.487	.150
β angle left side Pre - β angle left side Post	5.24000	2.444	**.022***
ϒ angle right side Pre - ϒ angle right side Post	-4.52000	-3.749	**.001***
ϒ angle left side Pre - ϒ angle left side Post	-7.24000	-4.083	**.000***
Go angle right side Pre - Go angle right side Post	3.00000	8.542	**.000***
Go angle left side Pre – Go angle left side Post	2.92000	9.095	**.000***

p value <0.05* statistically significant

Table 7 - Intra group comparison of different linear parameters pre and post-intervention in Forsus Fatigue Resistant Devicegroup using paired t-test

Parameters	Mean Paired Differences	t value	Paired t-test p value
GoGn Pre - GoGn Post	-1.60000	-8.211	**.000***
CoGo Pre - CoGo Post	-1.21200	-11.936	**.000***
CoGn Pre - CoGn Post	-1.94800	-10.969	**.000***
Ii Pre - Ii Post	-7.24000	-7.418	**.000***
Mi Pre - Mi Post	-6.78000	-8.873	**.000***
RMS right side Pre - RMS right side Post	-.86760	-2.450	**.022***
RMS left side Pre - RMS left side Post	-2.36840	-3.617	**.001***
MDW right side Pre - MDW right side Post	.21400	.621	.541
MDW left side Pre - MDW left side Post	.18320	.890	.382
SRW right side Pre - SRW right side Post	-.06452	-1.831	.080
SRW left side Pre - SRW left side Post	-.20966	-4.258	**.000***
Xi-7 right side Pre - Xi-7 right side Post	-1.7560	-1.232	.230
Xi-7 left side Pre - Xi-7 left side Post	-3.25480	-2.954	**.007***

p value <0.05* statistically significant

Table 8 - Intra group comparison of different angular parameters pre and post-intervention in Forsus Fatigue Resistant Device group using paired t-test

Parameters	Mean Paired Differences	t value	Paired t-test p value
α angle right side Pre - α angle right side Post	-3.44000	-1.300	.206
α angle left side Pre - α angle left side Post	-4.08000	-1.171	.253
β angle right side Pre - β angle right side Post	.66000	.391	.700
β angle left side Pre - β angle left side Post	-.40000	-.182	.857
ϒ angle right side Pre - ϒ angle right side Post	-7.16000	-4.456	**.000***
ϒ angle left side Pre - ϒ angle left side Post	-9.52000	-5.043	**.000***
Go angle right side Pre - Go angle right side Post	2.76000	14.910	**.000***
Go angle left side Pre – Go angle left side Post	2.84000	17.750	**.000***

p value <0.05* statistically significant

Table 9- Intergroup comparison of linear parameters between Fixed Twin Block group and Forsus Fatigue Resistant Device group using unpaired t-test

Linear parameters	Groups	Mean Difference	t value	Unpaired t test p value
GoGn	FTB group	1.35	-.485	**.030***
	FRD group			
CoGo	FTB group	2.54	1.933	**.059***
	FRD group			
CoGn	FTB group	2.49	1.824	**.045***
	FRD group			
L1	FTB group	-8.79	-4.835	**.000***
	FRD group			
L6	FTB group	-9.60	-6.924	**.000***
	FRD group			
RMS right side	FTB group	-1.67	-1.857	**.049***
	FRD group			
RMS left side	FTB group	-2.45	-2.036	**.047***
	FRD group			
MDW right side	FTB group	.04	.070	.944
	FRD group			
MDW left side	FTB group	.42	.565	.575
	FRD group			
SRW right side	FTB group	-.05	-.565	**.057***
	FRD group			
SRW left side	FTB group	-.16	-1.655	**.049***
	FRD group			
Xi-7 right side	FTB group	.67	.641	.525
	FRD group			
Xi-7 left side	FTB group	.51	.444	.659
	FRD group			

*p value <0.05 statistically significant

Table 10- Intergroup comparison of angular parameters between Fixed Twin Block group and Forsus Fatigue Resistant Device group using unpaired t-test

Angular parameters	Groups	Mean Difference	t value	Unpaired t test p value
α angle right side	FTB group	6.76	1.337	**.018***
	FRD group			
α angle left side	FTB group	2.48	.403	**.059***
	FRD group			
β angle right side	FTB group	3.80	.904	**.031***
	FRD group			
β angle left side	FTB group	-3.00	-.652	**.051***
	FRD group			
ϒ angle right side	FTB group	-.280	-.126	.900
	FRD group			
ϒ angle left side	FTB group	-.96	-.357	.723
	FRD group			
Go angle right side	FTB group	-1.20	-.675	.503
	FRD group			
Go angle left side	FTB group	-1.20	-.675	.503
	FRD group			

*p value <0.05 statistically significant

The purpose of this study was a statistical comparison of treatment changes in 50 patients with Class II Division 1 malocclusion, of which 25 patients were treated with FTB and 25 patients were treated with FRD.

Linear and angular measurements were carried out on pre and post treatment/ post retention lateral cephalograms and orthopantomograms to record skeletal and dental changes following treatment with FTB and FRD appliances. The findings of the study were statistically analyzed using Paired t-test for intra group comparison and Unpaired t-test for the inter group comparison between the groups for assessment of statistical significance.

For the purpose of ease of interpretation, the results were categorized according to the p value:

- Statistically significant * indicates p value < 0.05
- Statistically not significant p value >0.05

STATISTICAL INTERPRETATION OF RESULTS

- **Tables 1, 2, 3 and 4 depict descriptive statistics of intra group pre and post intervention for FTB and FRD group respectively**
- **TABLE 5 SHOWING INTRA GROUP COMPARISON OF DIFFERENT LINEAR PARAMETERS AT PRE AND POST INTERVENTION IN FTB GROUP USING PAIRED T-TEST**
    - **The following intra group parameters were statistically significant**

  i.e. * indicating p value <0.05

1. **Gonion to Gnathion (Go-Gn)-** an increase in the length of the body of the mandible by 5.71 mm (p value 0.000)
2. **Condylion to Gonion (Co-Go)-** an increase in the ramus height of the mandible by 3.50 mm (p value 0.000)
3. **Effective mandibular length Condyle to Gnathion (Co-Gn)**- an increase in the effective length of the mandible by 4.28 mm (p value 0.000)
4. **Ii-** an increase in the distance between the incisal tip of the most prominent mandibular central incisor from OLp, along OL, by 2.86 mm (p value 0.000)
5. **Mi-** an increase in the distance between the mesial contact point of the mandibular permanent first molar from OLp, along OL, by 2.95 mm (p value 0.000)
6. **Retromolar space (RMS) r-** an increase in the retromolar space on the right side by 2.95 mm (p value 0.000)
7. **Retromolar space (RMS) l-** an increase in the retromolar space on the left side by 1.99 mm (p value 0.000)
8. **Mesiodistal width of lower third molar (MDW) r-** decrease in the mesiodistal width of the lower third molar on the right side by 0.31 mm (p value 0.042)
9. **Mesiodistal width of lower third molar (MDW) l-** decrease in the mesiodistal width of the lower third molar on the left side by 0.49 mm (p value 0.019)
10. **Space width ratio (SWR) r-** an increase in the right space width ratio i.e. ratio between retromolar space and mesiodistal width of the lower right third molar by 0.27 mm (p value 0.000)

11. **Space width ratio (SWR) l-** an increase in the left space width ratio i.e. ratio between retromolar space and mesiodistal width of the lower left third molar by 0.20 mm (p value 0.000)
12. **Xi point to distal surface of lower second molar (Xi-7) r-** an increasein the distance of the right Xi point to the distal surface of the lower right second molar by 2.87 mm (p value 0.000)
13. **Xi point to distal surface of lower second molar (Xi-7) l-** an increasein the distance of the left Xi point to the distal surface of the lower left second molar by 2.28 mm (p value 0.005)

- **TABLE 6 SHOWING INTRA GROUP COMPARISON OF DIFFERENT ANGULAR PARAMETERS AT PRE AND POST INTERVENTION IN FTB GROUP USING PAIRED T-TEST**
  - **The following intra group parameters were statistically significant**

  i.e. * indicating p value <0.05

1. **α angle r-** an increase in α angle on the right side indicating uprighting of lower right third molar by 9.6° (p value 0.003)
2. **α angle l-** an increase in α angle on the left side indicating uprighting of lower left third molar by 13.44° (p value 0.000)
3. **β angle l-** a decrease in β angle on the left side indicating uprighting of the lower left third molar in relation to the long axis of the second molar by 5.24° (p value 0.022)

4. **ϒ angle r-** an increase in the ϒ angle on the right side indicating uprighting of lower right second molar, by 4.52° (p value 0.001)
5. **ϒ angle l-** an increase in the ϒ angle on the left side indicating uprighting of lower left second molar, by 7.24° (p value 0.000)
6. **Go angle r-** a decrease in the right gonial angle by 3° (p value 0.000)
7. **Go angle l-** a decrease in the left gonial angle by 2.92° (p value 0.000)

- **The following parameters were not statistically significant**

  1. **β angle r**

❖ **TABLE 7 SHOWING INTRA GROUP COMPARISON OF DIFFERENT LINEAR PARAMETERS AT PRE AND POST INTERVENTION IN FRD GROUP USING PAIRED T-TEST**

- **The following intra group parameters were statistically significant**

i.e. * indicating p value <0.05

1. **Gonion to Gnathion (Go-Gn)-** an increase in the length of the body of the mandible by 1.6 mm (p value 0.000)
2. **Condylion to Gonion (Co-Go)-** an increase in the ramus height of the mandible by 1.21 mm (p value 0.000)
3. **Effective mandibular length Condyle to Gnathion (Co-Gn)-** an increase in the effective length of the mandible by 1.94 mm (p value 0.000)
4. **Ii-** an increase in the distance between the incisal tip of the most prominent mandibular central incisor from OLp, along OL, by 7.24 mm (p value 0.000)

5. **Mi-** an increase in the distance between the mesial contact point of the mandibular permanent first molar from OLp, along OL, by 6.78 mm (p value 0.000)
6. **Retromolar space (RMS) r-** an increase in the retromolar space on the right side by 0.86 mm (p value 0.022)
7. **Retromolar space (RMS) l-** an increase in the retromolar space on the left side by 2.3 mm (p value 0.001)
8. **Space width ratio (SWR) l -** an increase in the left space width ratio i.e. ratio between retromolar space and mesiodistal width of the lower left third molar by 0.20 mm (p value 0.000)
9. **Xi point to distal surface of lower second molar (Xi-7) l-** an increasein the distance of the left Xi point to the distal surface of the lower left second molar by 2.28 mm (p value 0.007)

- **The following parameters were not statistically significant**
    1. **Mesiodistal width of lower third molar (MDW) r**
    2. **Mesiodistal width of lower third molar (MDW) l**
    3. **Space width ratio (SWR) r**
    4. **Xi point to distal surface of lower second molar (Xi-7) r**

❖ **TABLE 8 SHOWING INTRA GROUP COMPARISON OF DIFFERENT ANGULAR PARAMETERS AT PRE AND POST INTERVENTION IN FRD GROUP USING PAIRED T-TEST**

- **The following intra group parameters were statistically significant**

i.e. * indicating p value <0.05

1. **ϒ angle r-** an increase in the ϒ angle on the right side indicating uprighting of lower right second molar, by 7.16° (p value 0.000)
2. **ϒ angle l-** an increase in the ϒ angle on the left side indicating uprighting of lower left second molar, by 9.52° (p value 0.000)
3. **Go angle r-** a decrease in the right gonial angle by 2.76° (p value 0.000)
4. **Go angle l-** a decrease in the left gonial angle by 2.84° (p value 0.000)

- **The following parameters were not statistically significant**
    1. **α angle r**
    2. **α angle l**
    3. **β angle r**
    4. **β angle l**

❖ **TABLE 9 SHOWING INTERGROUP COMPARISON OF DIFFERENT LINEAR PARAMETERS BETWEEN FTB AND FRD GROUP USING UNPAIRED T TEST**

- **The following inter group parameters were statistically significant**

i.e. * indicating p value <0.05

1. **Gonion to Gnathion (Go-Gn)-** an increase in the length of the body of the mandible, as seen more in the FTB group i.e. 5.71 mm than the FRD group i.e. 1.60 mm (p value 0.030)**(Graph 1)**
2. **Condylion to Gonion (Co-Go)-** an increase in the ramus height of the mandible, as seen more in the FTB group i.e. 3.50 mm than in the FRD group i.e.1.21 mm (p value 0.059)**(Graph 2)**

3. **Effective mandibular length Condyle to Gnathion (Co-Gn)-** an increase in the effective length of the mandible, as seen more in the FTB group i.e. 4.28 mm than in the FRD group i.e.1.94 mm (p value 0.045)**(Graph 3)**
4. **Ii-** an increase in the distance between the incisal tip of the most prominent mandibular central incisor from OLp, along OL, as seen more in the FRD group i.e. 7.24 mm than in the FTB group i.e. 2.86 mm (p value 0.000)**(Graph 4)**
5. **Mi-** an increase in the distance between the mesial contact point of the mandibular permanent first molar from OLp, along OL, as seen more in the FRD group i.e. 6.78 mm than in the FTB group i.e. 2.95 mm (p value 0.000)**(Graph 5)**
6. **Retromolar space (RMS) r-** an increase in the retromolar space on the right side, as seen more in the FTB group i.e. 2.95 mm than in the FRD group i.e. 0.86 mm (p value 0.049)**(Graph 6)**
7. **Retromolar space (RMS) l-** an increase in the retromolar space on the left side, as seen more in the FRD group i.e. 1.99 mm than in the FTB group i.e. 2.36 mm (p value 0.047)**(Graph 7)**

FTB group showed a greater overall increase in the retromolar space as compared to FRD group

8. **Space width ratio (SWR) r**- an increase in the right space width ratio i.e. ratio between retromolar space and mesiodistal width of the lower right third molar, as seen more in the FTB group i.e. 0.27 mm than in the FRD group i.e. 0.06 mm (p value 0.057) **(Graph 8)**

9. **Space width ratio (SWR) l-** an increase in the left space width ratio i.e. ratio between retromolar space and mesiodistal width of the lower left third molar by 0.20 mm in both FTB and FRD groups (p value 0.049) **(Graph 9)**

FTB group showed a greater overall increase in the space width ratio as compared to FRD

- **The following parameters were not statistically significant**
  1. **Mesiodistal width of lower third molar (MDW) r**
  2. **Mesiodistal width of lower third molar (MDW) l**
  3. **Xi point to distal surface of lower second molar (Xi-7) r**
  4. **Xi point to distal surface of lower second molar (Xi-7) l**

❖ **TABLE 10 SHOWING INTERGROUP COMPARISON OF DIFFERENT ANGULAR PARAMETERS BETWEEN FTB AND FRD GROUP USING UNPAIRED T TEST**

- **The following inter group parameters were statistically significant**

i.e. * indicating p value <0.05

1. **α angle r-** an increase in α angle on the right side indicating uprighting of lower right third molar, as seen more in the FTB group i.e. 9.6° than the FRD group i.e. 3.44° (p value 0.018)**(Graph 10)**
2. **α angle l-** an increase in α angle on the left side indicating uprighting of lower left third molar as seen more in the FTB group i.e. 13.44° than the FRD group i.e. 4.08° (p value 0.059)**(Graph 11)**

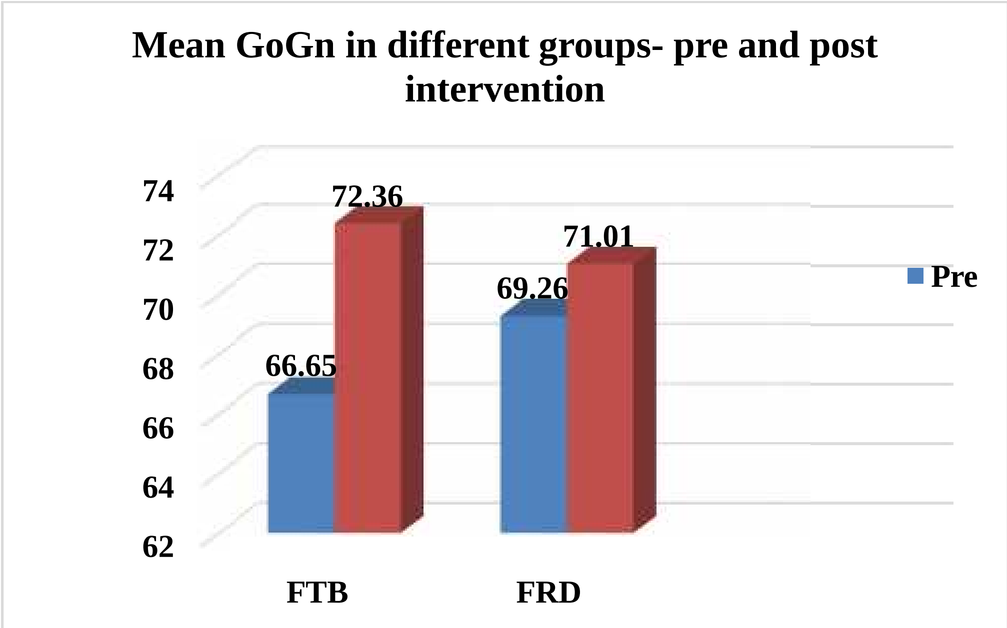
FTB group showed a greater overall increase in the α angle as compared to FRD group

3. **β angle r-** a decrease in β angle on the right side indicating uprighting of the lower right third molar in relation to the long axis of the second molar, as seen more in the FTB group i.e. 3.88° than in the FRD group i.e. 0.66° (p value 0.031)**(Graph 12)**
4. **β angle l-** a decrease in β angle on the left side indicating uprighting of the lower left third molar in relation to the long axis of the second molar, as seen in the FTB group i.e. 5.24° and an increase in β angle by 0.4° in the FRD group indicating worsening of the angle between the lower left second and third molars (p value 0.051)**(Graph 13)**

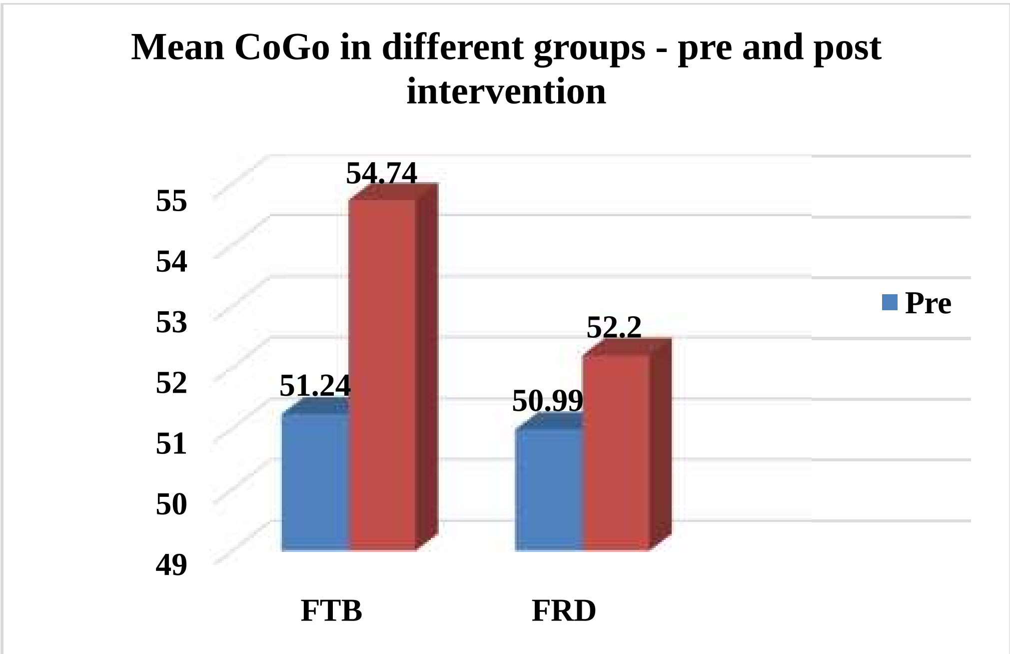
FTB group showed a greater overall decrease in the β angle as compared to FRD group

- **The following parameters were not statistically significant**
  1. **ϒ angle r**
  2. **ϒ angle l**
  3. **Go angle r**
  4. **Go angle l**

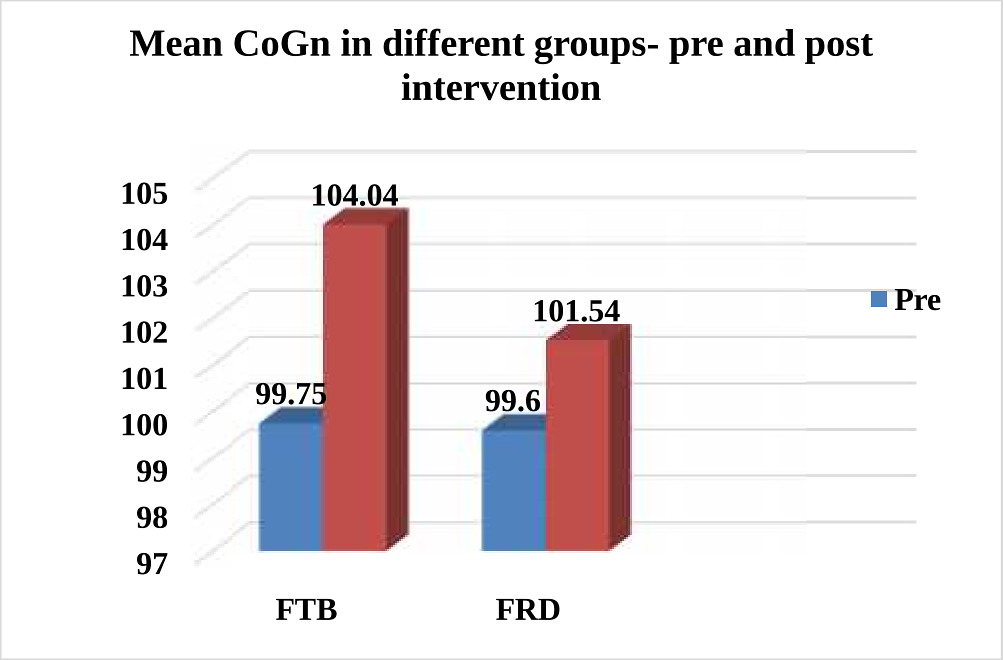
GRAPH 1: Comparison of Pre and Post Intervention changes in Go-Gn values in FTB and FRD



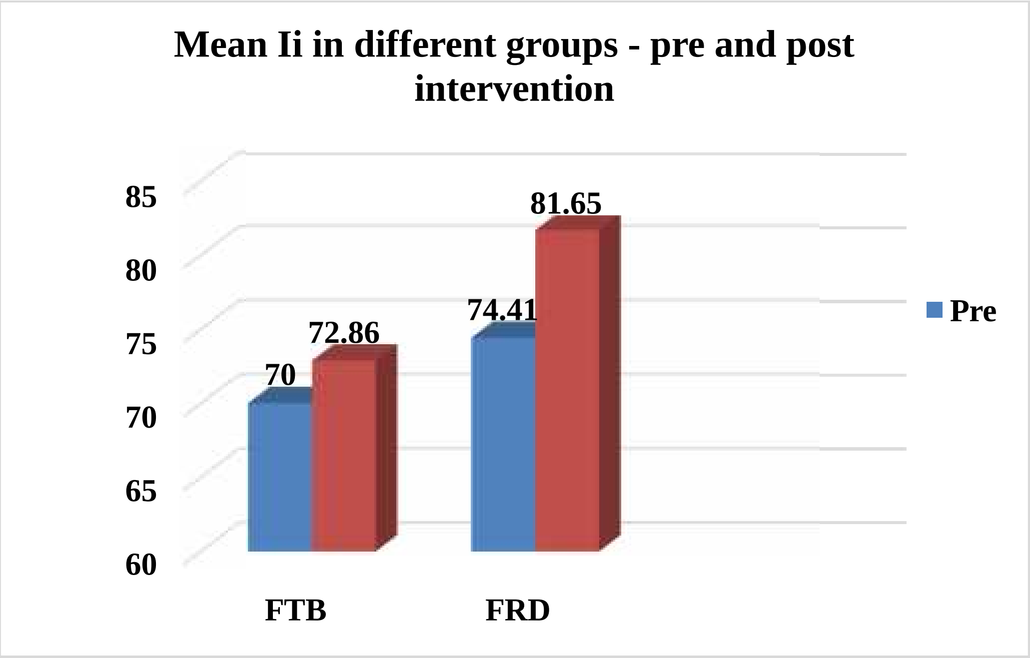
GRAPH 2: Comparison of Pre and Post Intervention changes in Co-Go values in FTB and FRD



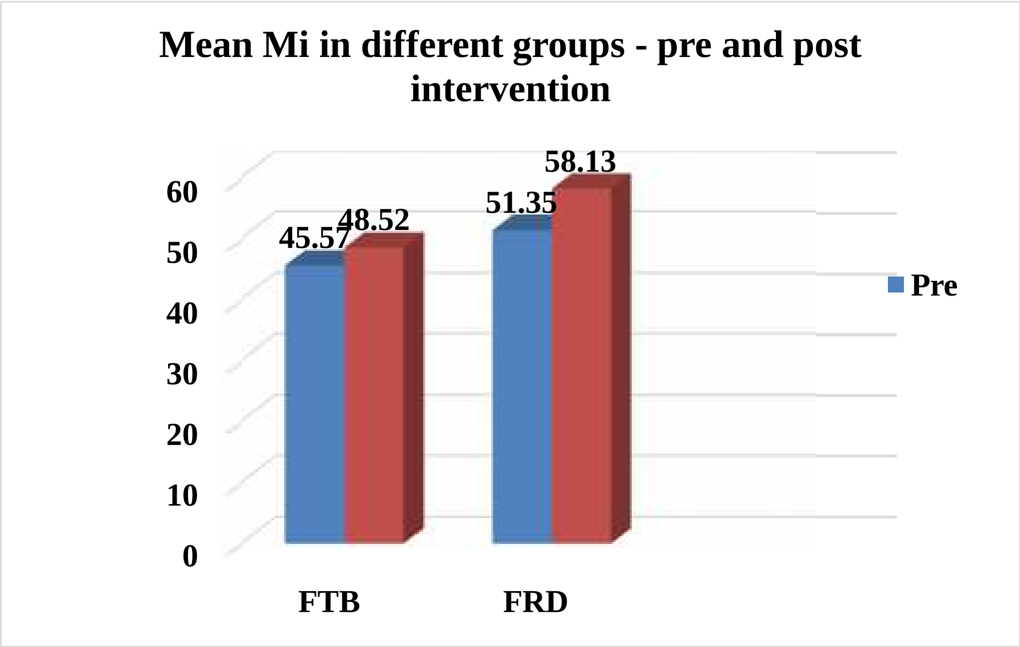
GRAPH 3: Comparison of Pre and Post Intervention changes in Co-Gn values in FTB and FRD



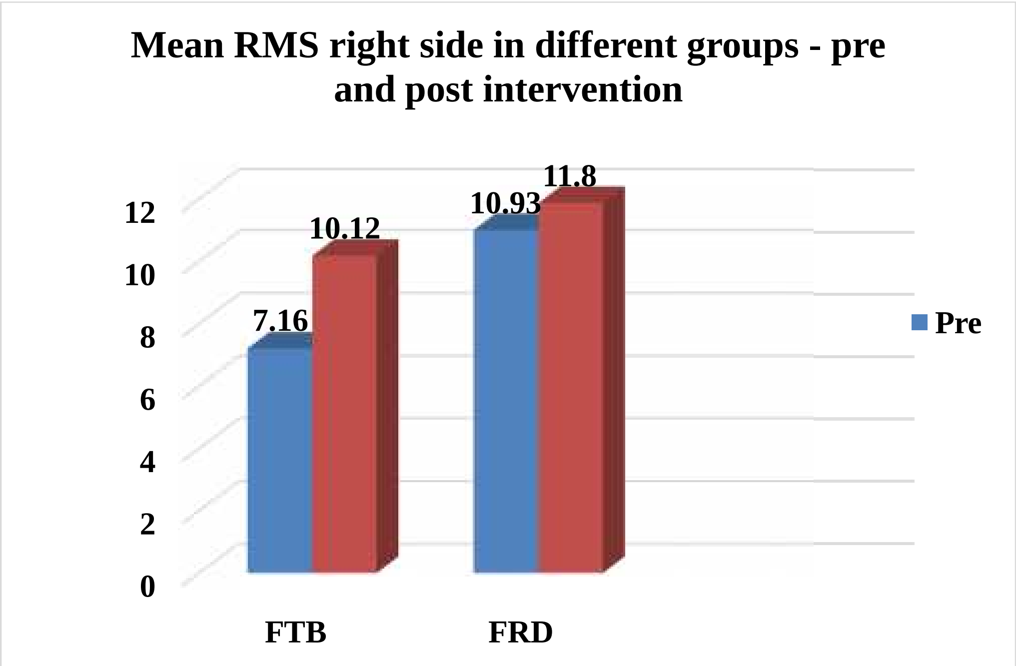
GRAPH 4: Comparison of Pre and Post Intervention changes in Ii values in FTB and FRD



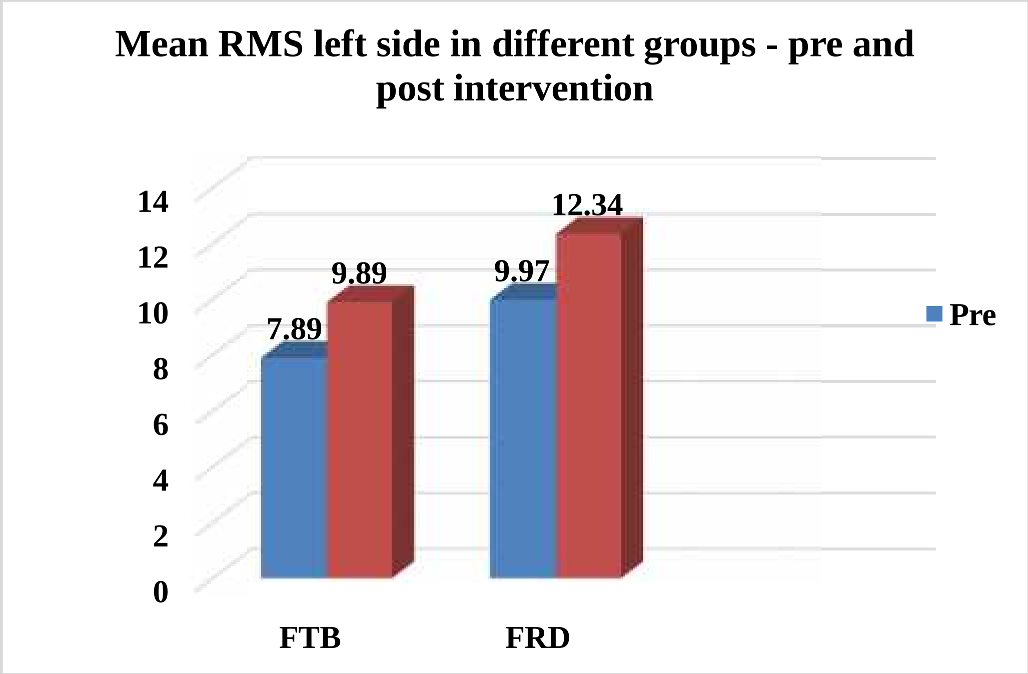
GRAPH 5: Comparison of Pre and Post Intervention changes in Mi values in FTB and FRD



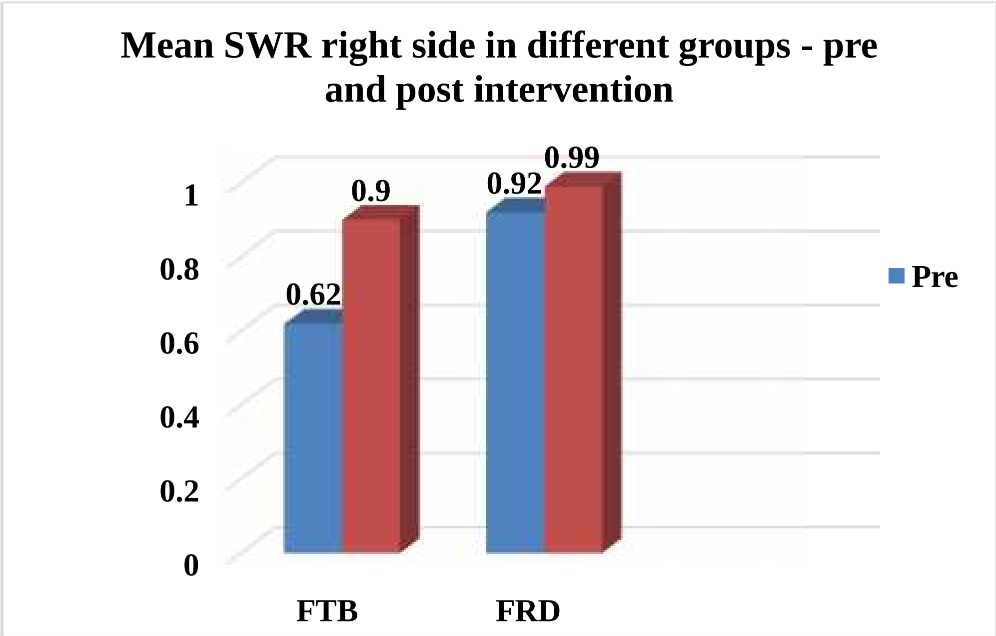
GRAPH 6: Comparison of Pre and Post Intervention changes in RMS (right side) values in FTB and FRD



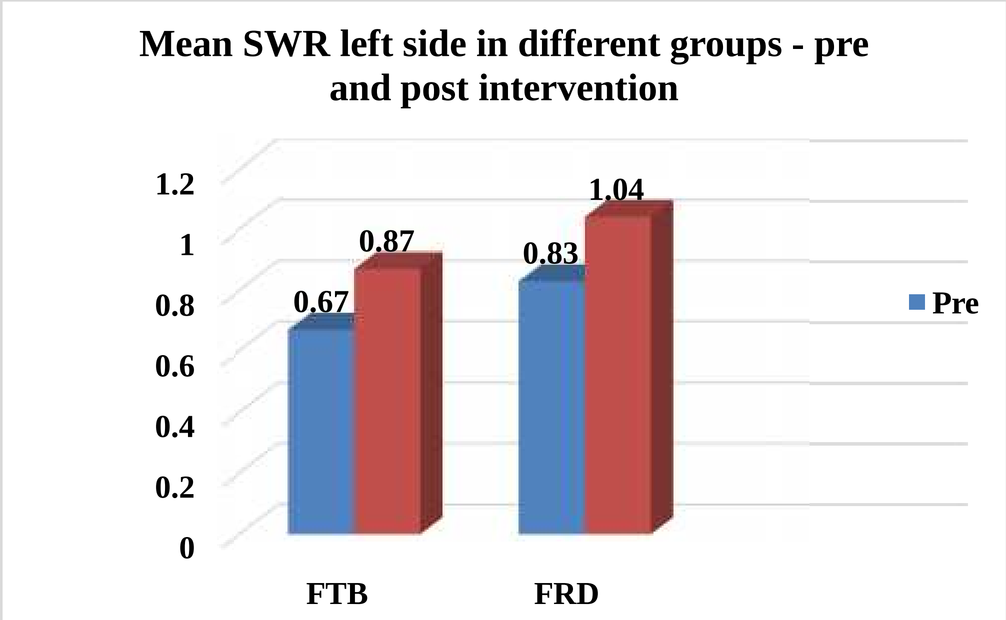
GRAPH 7: Comparison of Pre and Post Intervention changes in RMS (left side) values in FTB and FRD



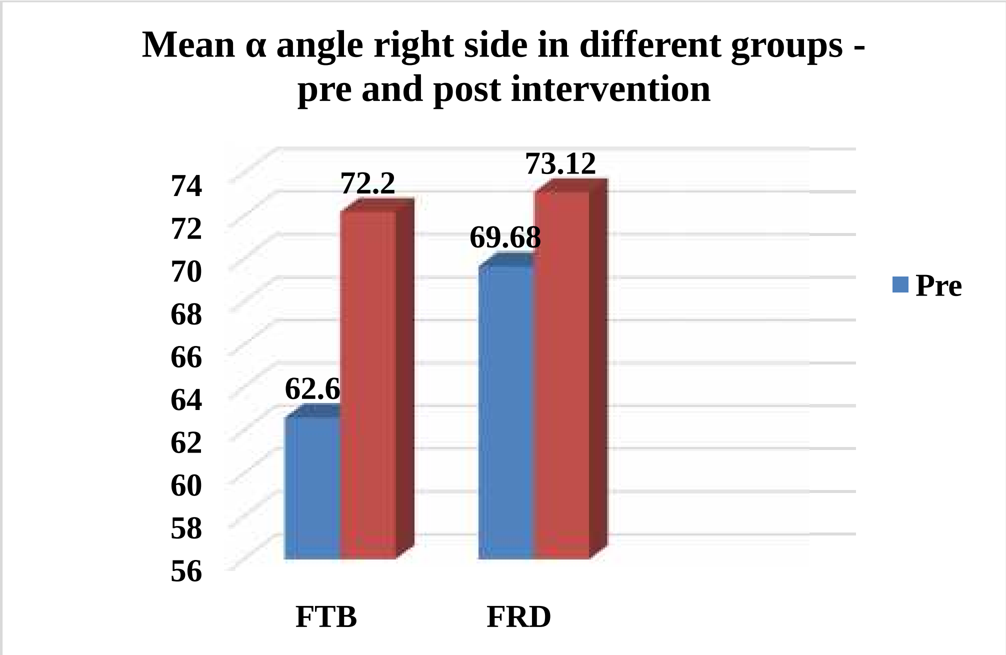
GRAPH 8: Comparison of Pre and Post Intervention changes in SWR (right side) values in FTB and FRD



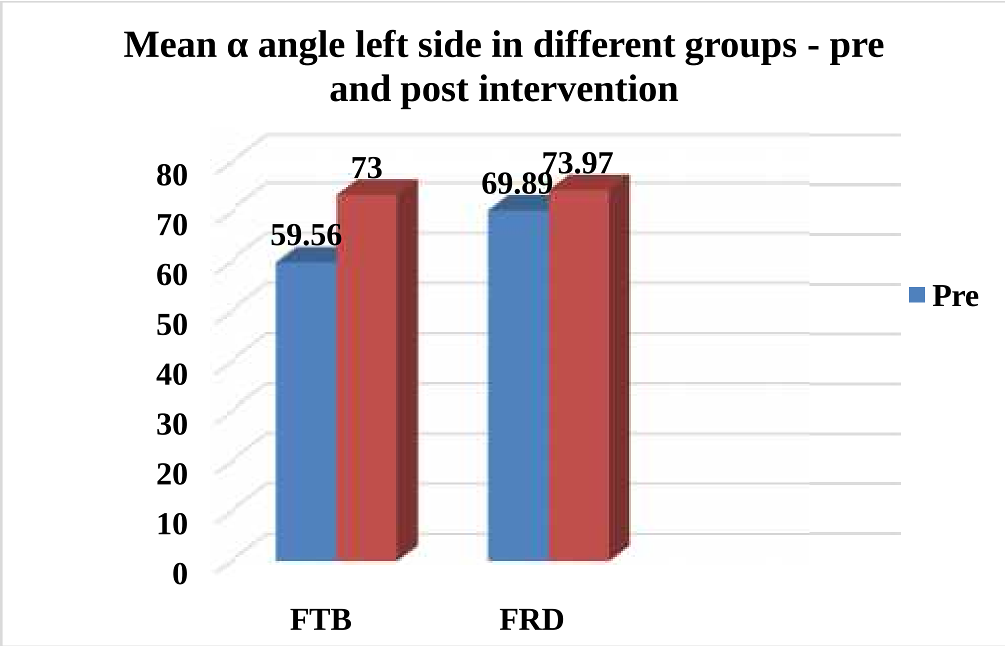
GRAPH 9: Comparison of Pre and Post Intervention changes in SWR (right side) values in FTB and FRD



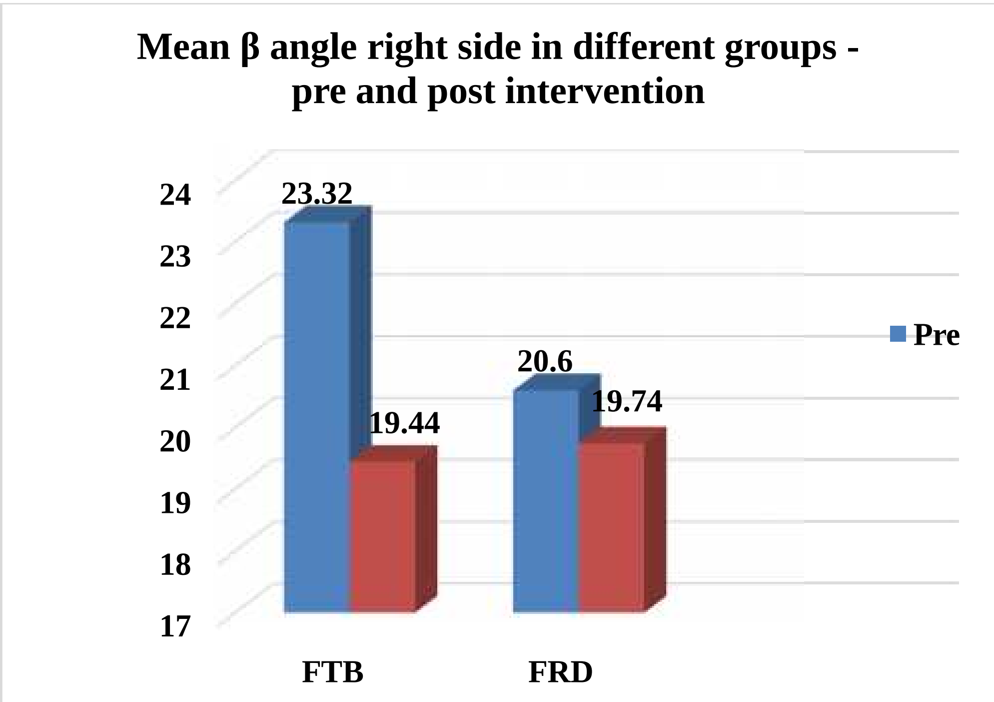
GRAPH 10: Comparison of Pre and Post Intervention changes in α angle (right side) values in FTB and FRD



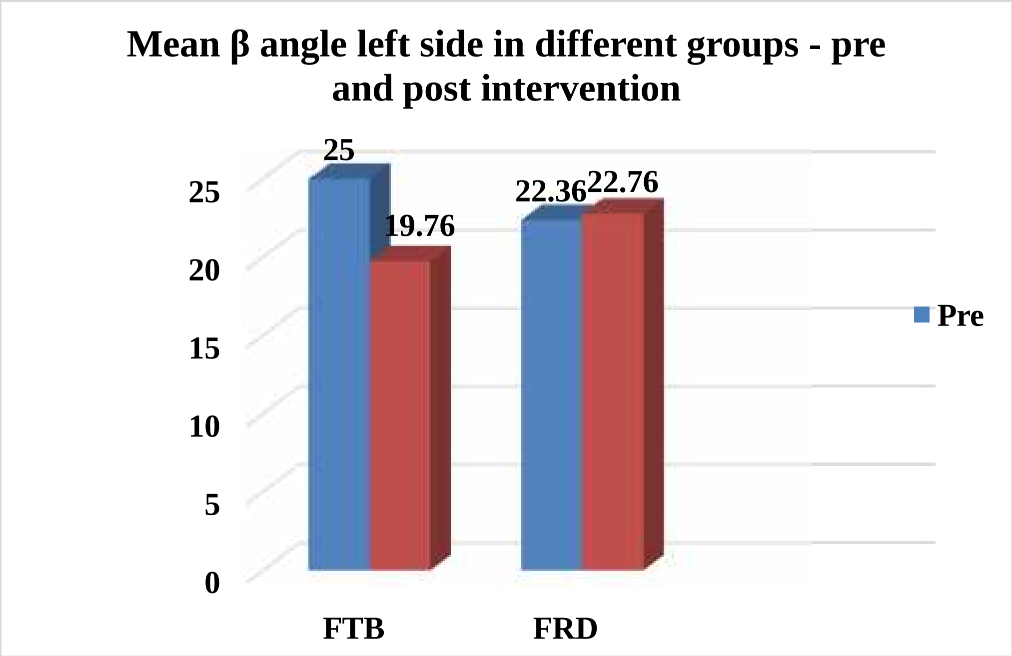
GRAPH 11: Comparison of Pre and Post Intervention changes in α angle (right side) values in FTB and FRD



GRAPH 12: Comparison of Pre and Post Intervention changes in β angle (right side) values in FTB and FRD



GRAPH 13: Comparison of Pre and Post Intervention changes in β angle (right side) values in FTB and FRD



DISCUSSION

The mandibular third molar is by far the most frequently impacted tooth, followed by the maxillary third molar[51], with a prevalence rate ranging from 9.5% to 39%.[52] The great amount of variability in size, shape, position, root formation, time of calcification, and path of eruption of these teeth make their emergence one of the most unpredictable events in the course of development of the human dentition.[51]

The mandibular third molar continually changes its angular position in relation to the mandibular plane and the adjacent teeth and undergoes pre-eruptive rotational changes while uprighting itself into the dental arch, which occur as soon as the developing bud comes in contact with the distal aspect of the second molar. These pre-eruptive changes are of utmost importance to the emergence of these teeth in the dental arch, the absence of which increases the chances for impaction, which occurs when the space available is deficient.[53]

Lack of space posterior to the mandibular second molars has been cited as one of the most common reasons of mandibular third molar impaction. Over the years, several authors have suggested various factors that might be responsible for contribution of developmental space for the mandibular third molar. Brash suggested resorption of the anterior border of the ramus of the mandible[54] and the backward slope of the anterior border of the ramus in relation to the alveolar bone[55] might play an important role in creation of space posterior to the mandibular second molars, while in 1953, Brash[56] and Scott[57]suggested that forward movement of the dentition might be an important contributor. According to Bjork, growth in the length of the mandible, sagittal direction of mandibular growth and sagittal direction of eruption of the dentition were also important factors leading to this increase in developmental space.[3]

Besides retromolar space, several studies have also researched the correlation between the growth in the length of the mandible as suggested by Bjork[3], with the risk of impaction. Richardson[58] found that the proportion of impacted mandibular third molars was more in Class IIskeletal cases with shorter, narrower, more acute angled mandibles. The author also noted that impacted third molar cases showed reduced amount of mandibular growth. Capelli[59] also found that chances of third molar impaction are greatly increased in cases where the length of the mandible is deficient. Sagittal skeletal relationships might also have a role in the eruption of these teeth, as suggested by Janson et al.[5] They reported a difference in available retromolar space in skeletal Class II and Class I malocclusions. These findings were also corroborated by Jakovljevicet al.[4], who found the greatest available space in Class III subjects and the least amount of retromolar space in Class II subjects.

Orthodontic treatment of Class II malocclusion using removable functional appliances has a long-standing history, with the development of various types of functional appliances since Norman Kingsley introduced the concept of “jumping the bite”. Since then, there has been a steady evolution in the design and concept of these appliances, with patient compliance slowly gaining impetus as an important consideration in appliance selection

This gave rise to the growing popularity of Fixed Functional Appliances. These appliances can not only be used in older patients who have crossed the pubertal growth spurt but can also be used in patients where compliance is an issue.

The Fixed Twin Block[9] and the Forsus Fatigue Resistant Device[10] are two such appliances that are commonly used these days for correction of Class II malocclusions. These appliances are cost effective, comfortable and convenient to use. While the Fixed Twin Block can be cemented onto the patient's teeth, the Forsus FRD assembly can be directly attached to the main archwire, thus negating the need for patient compliance. Also, since these appliances may be combined with fixed orthodontic therapy, the time required for a second phase of fixed mechanotherapy post functional appliance therapy is saved.

Treatment effects of these appliances are a combination of skeletal and dental modifications. Comparative studies between these two appliances[11,12] have shown that while both bring about Class II correction by inducing mandibular growth, the Twin Block appliance produced a larger effect on the growth and position of the mandible than did the FRD or what occurred in controls. These studies noted greater increase in mandibular length in patients treated with Twin Block as compared to FRD, indicating that the former produced greater skeletal effects in terms of mandibular advancement and growth stimulation than the latter. Forsus FRD produced comparatively more dentoalveolar effects, a combination of mesialization of the lower molars along with distalization of the upper molars contributing significantly to the Class II molar correction. Overjet correction was also brought about majorly by lower incisor proclination and upper incisor retroclination.

Therefore, the present study was performed to systematically analyse and compare the effects of the skeletal and dentoalveolar changes brought about by the Class II correction with Fixed Twin Blockand the Forsus FRD appliances on mandibular third molar angulation.

A potential problem of previous studies that have evaluated third molar impactions is the age of the subjects included in the study. Third molars erupt between 17 to 21 years of age, but root formation is not completed till the age of 18 to 25 years.[60] Case studies have suggested that third molars that show apparent signs of development of impaction at an earlier stage might even have the potential for eruption during the final stages of root formation, indicating the risk of overdiagnosis of impaction if the age factor is not considered.[61]

Moreover, although mandibular growth is completed at 18 years of age, there might be some amount of late mandibular growth that occurs during early adulthood, which may have a favourable effect on retromolar space, mandibular third molar position and angulation. Chen et al.[62] reported moderate increase in retromolar space through the ages of 16 to 20 years, while Kruger et al.[6] found positional changes of the third molars after the age of 18 years leading to their eruption. Taking into consideration all these factors, patients who completed their treatment before reaching adulthood were recalled 3-4 years after completion of active treatment i.e. in the age group of 16-25 years of age for post retention records, which were then evaluated and compared with their pre-treatment records.

1. **SKELETAL AND "DENTOALVEOLAR EFFECTS"**

➢ **GROWTH IN MANDIBULAR LENGTH**

a. **Length of the body of the mandible (Go-Gn)**

Intra group comparison in the FTB group showed a statistically significant (p value0.000) increase in the length of the mandibular body, by 5.71 mm. These findings are in accordance with studies by Clark[63], Lund[26], Mills[27], Illing[28], Tumer and Gultan[29], Toth and McNamara[30], Mills and McCulloch[31], Trenouth[32], Ashok Kumar Jena[33], O'Brien[64]et al. which report significant lengthening of the mandibular ramus following functional therapy with FTB.

A statistically significant increase in mandibular length (p value 0.000) of 1.6 mm was also seen after intra group comparison in the FRD group. Studies by Karacay[34], Jones[35], Darda[36], Franchi[37]et al. also found a statistically significant improvement in the length of the mandibular corpus following treatment with FRD.

Inter group comparison between the two groups were also found to be statistically significant (p value 0.030), with greater improvement in mandibular length noted in the FTB group than FRD.

Mahamad et al[11] found a statistically significant increase of 5.55 mm in mandibular length in patients treated with Twin Block, compared to an increase of only 1.24 mm in those treated with FRD, which are similar to the values found in the present study.

b. **Effective length of the mandible (Co-Gn)**

After intra group comparison, the effective mandibular length in the FTB group was increased by 4.28 mm, which was a statistically significant

improvement (p value 0.000) from pre to post treatment. Illing[27] found an increase in effective mandibular length (CoGn) by 3.7 mm while Mills[27] noted an increase of 6.5 mm, both of which were statistically significant when compared to a control group. Clark[63], Lund[26], Tumer and Gultan[29], Toth and McNamara[30], Mills and McCulloch[31], Trenouth[32],Ashok Kumar Jena[33,] O'Brien[64] et al. also found similar improvements in the effective mandibular length in patients treated with FTB.

Intra group comparison in the FRD group as well showed a statistically significant increase (p value 0.000) in effective mandibular length, by 1.94 mm. These findings are in accordance with those of Karacay[34], Jones[35], Darda[36], Franchi[37]et al.

Inter group comparison for this parameter between the FTB and FRD groups were also statistically significant (p value 0.045), with a greater increase in effective mandibular length noted in the FTB group over FRD.

Guintini et al[12] noted an increase in effective mandibular length of 9.4 mm in patients treated with Twin Block, which was significantly greater than that seen in patients treated with Forsus FRD i.e. 7.4 mm. These inter group differences match those in the current study.

- **The above findings indicate greater skeletal changes in terms of improvement in mandibular length, in the FTB group than the FRD group.** These findings match those of Mahamadet al.[11] and Guintini et al.[12], who reported that **skeletal changes contributing to Class II correction are more pronounced in the FTB group than in FRD.**

- **MESIAL MOVEMENT OF MANDIBULAR DENTITION**

In the present study, **the lower molars mesialized by 6.78 mm, while the lower incisors proclined by 7.24 mm in the FRD group**. **These intra group changes from pre to post treatment were statistically significant (p value 0.000).** The findings noted are in accordance with Karacay[34], Jones[35], Darda[36], Franchi[37], Gunay[38], Oztoprak et al.[39] who reported statistically significant mesialization of the mandibular molars and proclination of the mandibular incisors" in patients treated with FRD.

Intra group comparison in the FTB group also showedstatistically significant (p value 0.000)mesialization of lower molars by 2.95 mm and proclination of the lower incisors by 2.86 mm. These findings are similar to studies by Clark[63], Lund and Sandler[26], O'Brien[64], Mills[27], Toth and McNamara[30], Ashok Kumar Jena[33] et al. who also reported statistically significant mesialization of the mandibular molars along with mandibular incisor proclination in patients who have undergone FTB therapy.

Inter group comparison between the two groups were also found to be statistically significant (p value 0.000), with greater amount of mesialization of the mandibular dentition noted in the FRD group than FTB group. These findings are in accordance with those of Mahamadet al.[11] and Guintini et al.[12]

- **The above findings suggest that the dentoalveolar effects contributing to Class IImolar and overjet correction are greater in the FRD group as compared to the FTB group,as indicated by the greater amount of mandibular molar mesialization and lower incisor proclination.** These match those of Mahamadet al.[11] and Guintini et al.[12], who reported that **dentoalveolar changes contributing to Class II correction are more pronounced in the FRD group than in FTB.**

2. **CHANGES IN SPACE AVAILABLE**

- **RETROMOLAR SPACE**

Intra group comparison showed that retromolar space increased by 0.86 mm on the right side and by 2.36 mm on the left side **in the FRD group,both of which were statistically significant (p value 0.022 and p value 0.001 respectively).**

Intra group comparison in the FTB group as well showed a statistically significant increase (p value 0.000) in this space by 2.95 mm on the right side and 1.99 mm on the left side.

Inter group comparison showed a greater overall increase in values for the FTB when compared to the FRD group, which were statistically significant on both the right (p value 0.049) and left (p value 0.047) sides.

- **SPACE WIDTH RATIO (SWR)**

Intra group comparison showed a **statistically significant increase in SWR on both sides in the FTB group, which improved by 0.27 and 0.20 on the right and left sides respectively (p value 0.000).**

It increased by 0.06 and 0.20 on the right and left sides respectively in the FRD group. **These intra group changes were statistically significant on the "left side (p value 0.000) but not on the right."**

Inter group differences between the two groups were statistically significant on both the right (p value 0.057) and left sides (p value 0.049).This shows better improvement in SWR in the FTB as compared to the FRD group, indicating greater improvement in the retromolar space with respect to the mesiodistal width in the FTB group.

- **Xi POINT TO 7**

The distance between Xi point and the distal surface of the second molarwas increased by 2.87 mm and 2.28 mm on the right and left sides respectively in the FTB group. **These intra group changes were statistically significant on both the right (p value 0.000) and left (p value 0.005) sides.**

On the other hand, in the FRD group, this distance increased by 1.75 mm and 3.25 mm on the right and left sides respectively, **with statistically significant intra group changes noted only on the left side (p value 0.007).**

Inter group differences between the two groups were not statistically significant.

FTB group thus showed a greater overall increase in the Xi-7 distance as compared to the FRD group, although these differences were not statistically significant.

- **Changes in the space available for the lower third molar showed an overall increase in values for the FTB group over the FRD group**

3. CHANGES IN ANGULATION

➢ α ANGLE

The α angle increased by 9.6° and 13.44° on the right and left sides respectively in the FTB group. **This intra group improvement in α angulation pre and post intervention was statistically significant on both the right (p value 0.003) and left sides (p value 0.000**

In the FRD group, α angle increased only by 3.44° and 4.08° on the right and left sides respectively. **These intra group changes were not found to be statistically significant.**

Inter group comparison of changes in α angulation were statistically significant on both the right (p value 0.018) and left sides (p value 0.059).

Mandibular third molars thus showed greater uprighting in the FTB group as compared to the FRD group, as demonstrated by greater increase in the α angle.

➢ β ANGLE

β angle decreased by 3.88° on the right side and by 5.24° on the left side in the FTB group. **Intra group changes in β angulation were statistically significant on the left side (p value 0.022)**

On the other hand, β angle decreased by 0.66° on the right side and increased by 0.4° on the left side in the FRD group. **These intra group changes were not statistically significant on both sides.**

Inter group differences between FTB and FRD for changes in β angle were found to be statistically significant on both right (p value 0.031) and left (p value 0.051) sides.

Thus, decrease in the β angle was significantly more in the FTB group than the FRD, which means that third molar eruption is more favourable in the FTB group than FRD.

ϒ angle and the gonial angle did not show statistically significant differences between FTB and FRD groups. Haavikko et al.[50] suggested that “the favorable erupting path of lower third molars cannot be predicted from the size of the gonial angle or the second molar angle (ϒ angle) alone and the most valuable variable was the initial angulation of the third molar (α angle).”

Some authors have suggested that there is a stronger correlation between eruption and α and β angles than that with retromolar space, and that even in the presence of enough retromolar space, the third molars may remain impacted if the α and β angles are inconvenient.[65] The concept of resorption at the anterior border of the ramus contributing to the development of retromolar space has been discussed. Bony trabeculae adapt to the stresses and strains caused by external forces, as a part of the bone remodeling process.[66]Türköz[65] suggested that “third molar teeth with appropriate α and β angles may maintain the necessary external force to remodel the retromolar region by expanding the bone in all three dimensions and forming resorption of the ramal region, thus increasing the retromolar space. This concept was backed by Jakovljevicet al.[4]

Furthermore, Niedzielska et al.[67] reported that "the retro molar space/ crown width ratio and third molar angulations in relation to second molar inclination and to the lower border of the mandible are determinants of the ultimate third molar position in the dental arch," all of which were changed significantly in the FTB as compared to the FRD group in the present study.

Regression models in the study of Jakovljevicet al.[4] showed that along with β angle, length of the mandibular corpus (Go-Gn) had a significant influence on the level of mandibular third molar eruption, which would explain the greater degree of favourable changes in the FTB group.

Measurement of third molar angulation on lateral cephalograms, as seen in previous studies might be subject to errors because of the superimposition of contralateral images of third molars. This problem might be eliminated by using panoramic radiographs of the same magnification. Tronje et al.[68] suggested that rotational panoramic radiography causes inbuilt distortion effect; however, they also stated that panoramic radiographic images can be reliable for geometric measurements in clinical practice, as long as they are recorded on the same machine at different times. Stramotaset al.[69] noted that "linear vertical measurements, ratio calculations, and angular measurements can be accurately made on panoramic radiographs. Larheimet al.[70] and Olive et al.[71] also vouched for the reliability of panoramic radiographs in assessing the third molar position. Therefore, in this study, while the skeletal measurements were de one on lateral cephalograms, important linear and angular measurements evaluating third molar position and angulation were done on panoramic radiographs.

This study recognizes the skeletal and dental modifications brought about by Fixed Functional appliances such as FTB and FRD in the correction of Class II skeletal malocclusions, and the effect these changes have on the position and angulation of mandibular third molar teeth. Mandibular growth and forward movement of the mandibular dentitionwere found to have profound effect on the fate of these teeth. Comparison between these two appliances showed that the third molars show more favourable positional and angulation changes in patients treated with FTB, over those treated with FRD. These findings indicate that true skeletal changes, as seen more after treatment with FTB than FRD, play a greater role than dentaolaveolar changes, in the creation of an environment conducive to third molar eruption.

STRENGTHS OF THE STUDY

In the past, several studies have assessed the various factors affecting third molar position and angulation, for which a number of linear and angular parameters and indices have been devised. The effect of premolar and molar extractions on the angulation and eruptive path of third molars has also been studied by several authors.

The present research is the first study evaluating the effect of Fixed Functional Applianceson mandibular third molar angulation and comparing the effect of two popularly used appliances of this kind-Fixed Twin Block and Forsus Fatigue Resistant Device, both of which have proven to be effective protocols in the management Class II malocclusions with a combination of skeletal and dentoalveolar modifications.

With previous studies, there was the risk of overdiagnosis of impaction as the subjects were not evaluated as adults. This study took into account the factor of late mandibular growth that might contribute to positional and angulation changes in the third molar teeth, for which reason those patients who finished active treatment before the age of 16-17 years were recalled for their post retention records.

Another strength of this study is in the inclusion of panoramic radiographs along with lateral cephalograms, which offers an all-round, reliable and accurate picture of third molar position and angulation without the risk of superimposition of bilateral images.

Furthermore, the present study highlights the effects of Fixed Functional Applianceson the mandible and mandibular dentition, in terms of mandibular growth and forward movement of the mandibular teeth while correctingClass II malocclusions, two mechanisms that have been found to contribute significantly to favourable changes in the space available for erupting lower third molars. It recognizes true mandibular skeletal change as the most important factor affecting the space available, positional and angulation changes and thus the eruptive potential of these teeth.

LIMITATIONS OF THE STUDY

1. Samples were not differentiated as per gender
2. Absence of an age matched control group treated with a non-extraction treatment plan and an untreated control group
3. As there was a significant time gap between some pre-treatment and post retention records, some radiographs had to be digitally standardized
4. Differentiation between individual treatment effects as skeletal and dentolaveolar changes that affect third molars could not be done

FUTURE SCOPE OF THE STUDY

1. A study using a larger sample size can be conducted
2. Differentiation of samples as per gender can be done
3. An age matched control group treated with a non-extraction treatment plan can be included
4. An untreated control group can be added
5. A method to differentiate between the individual treatment effects as skeletal and dentoalveolar can be devised and a more comprehensive study can be done

CONCLUSION

1. Both FTB and FRD are effective in the treatment of Class II malocclusion, and they act through a combination of skeletal and dentoalveolar changes.
2. FTB produced a greater effect on growth and position of the mandible, by inducing lengthening of the mandibular corpus, whereas Class II correction by FRD was mainly a result of mesialization of the mandibular molars and proclination of the mandibular incisors.
3. While both FTB and FRD groups showed an increase in retromolar space, space width ratio and the distance of Xi point from the distal surface of the mandibular second molar, these changes were more pronounced in the FTB group than FRD.
4. Both groups showed improvement in mandibular third molar angulation in terms of an increase in α angle and a decrease in β angle, which was significantly more in the FTB group than the FRD group.

SUMMARY

Eruption of the mandibular third molar and its emergence into the dental arch has been long cited as one of the most unpredictable events in the course of development of the human dentition.

Several authors have suggested that two of the most important events governing the development of space for the erupting third molar are:

1. Lengthening of the body of the mandible
2. Forward movement of the mandibular dentition

Apart from this, the initial angulation of the third molar in relation to the mandibular plane and in relation to the second molar determine the potential for eruption. Improvements in these angulations increase the possibility of eruption.

Fixed Functional Appliances such as Fixed Twin Block (FTB) and Forsus Fatigue Resistant Device (FRD) bring about Class II correction by a combination of skeletal and dentolaveolar effects, which might influence the space available and the third molar angulation.

This study was therefore carried out with the aim of evaluating and comparing the effects of Fixed Twin Block (FTB) and Forsus Fatigue Resistant Device (FRD) treatment on mandibular third molar angulation.

25 patients with Class II division 1 malocclusion treated with FTB were compared with 25 patients treated with FRD. Pre-treatment and post treatment lateral cephalograms and OPGs were traced and evaluated for various linear and angular parameters related to lower third molar eruption. Taking into account the factor of late

mandibular growth, patients who completed their treatment before adulthood were recalled 3-4 years after completion of active treatment i.e. in the age group of 16-25 years of age for post retention records, which were then evaluated and compared with their pre-treatment records.

Sagittal and vertical skeletal relationships and mandibular length were assessed on lateral cephalogram. On the panoramic radiographs, retromolar space, space width ratio, distance of Xi point from distal surface of lower second molar, third molar angulation in relation to the mandibular plane (α angle) and to the inclination of the second molar (β angle), second molar angulation in relation to the mandibular plane (ϒ angle) and gonial angle were measured.

The following findings were noted:

1. FTB and FRD effectively corrected Class II malocclusions, with a combination of skeletal and dentoalveolar changes.
2. Increase in mandibular length was significantly greater in the FTB group than FRD, while mesialization of the mandibular dentition was higher in the FRD group than FTB i.e. skeletal changes were more pronounced in the FTB group while FRD group showed predominantly dentoalveolar changes.
3. There was an appreciable increase in retromolar space, space width ratioand the distance of Xi point from the distal surface of the lower second molar, in both the groups. These changes were significantly higher in the FTB group than FRD.
4. Both the groups also showed a significant increase in third molar angulation in relation to the mandibular plane (α angle) and a significant decrease in relation to the second molar inclination (β angle).

Thus, from this study, we concluded that there was a significant improvement in the third molar angulation following treatment with Fixed Functional Appliances, which was comparatively more in the FTB group than in FRD, owing to an increase in mandibular length.

BIBLIOGRAPHY

1. Dolce C, Wheeler TT, Fusco AD, Johnson PD, Ruskin JD, Oberdofer ML. Third molar position following Bionator treatment. Clinical Orthodontics and Research. 2000 Aug;3(3):106-13.
2. Richardson M. Pre-eruptive movements of the mandibular third molar. The Angle Orthodontist. 1978 Jul;48(3):187-93.
3. Björk A, Jensen E, Palling M. Mandibular growth and third molar impaction. Acta odontologica scandinávica. 1956 Jan 1;14(3):231-72.
4. Jakovljevic A, Lazic E, Soldatovic I, Nedeljkovic N, Andric M. Radiographic assessment of lower third molar eruption in different anteroposterior skeletal patterns and age-related groups. The Angle Orthodontist. 2014 Sep 22;85(4):577-84.
5. Janson G, de Lima KJ, Woodside DG, Metaxas A, de Freitas MR, Henriques JF. Class II subdivision malocclusion types and evaluation of their asymmetries. American journal of orthodontics and dentofacial orthopedics. 2007 Jan 1;131(1):57-66.
6. Kruger E, Thomson WM, Konthasinghe P. Third molar outcomes from age 18 to 26: findings from a population-based New Zealand longitudinal study. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2001 Aug 1;92(2):150-5.
7. Proffit, W.R., Fields, H. and Sarver, D. (2013) Contemporary Orthodontics. Elsevier, St. Louis, MO, 5th edn, p. 490–491.
8. S. Ehsani, B. Nebbe, D. Normando, M. O. Lagravere, and C. Flores-Mir, “Short-term treatment effects produced by the Twin-block appliance: a systematic

review and meta-analysis," *European Journal of Orthodontics*, vol. 37, no. 2, pp. 170–176, 2014.

9. Clark WJ. The twin block traction technique. The European Journal of Orthodontics. 1982 May 1;4(2):129-38.
10. Vogt W. The Forsus Fatigue Resistant Device. Journal of clinical orthodontics: JCO. 2006 Jun;40(6):368.
11. Mahamad IK, Neela PK, Mascarenhas R, Akhter Husain BD. A comparision of Twin-block and Forsus (FRD) functional appliance–a cephalometric study. IJO. 2012;23(3):49-58.
12. Giuntini V, Vangelisti A, Masucci C, Defraia E, McNamara Jr JA, Franchi L. Treatment effects produced by the Twin-block appliance vs the Forsus Fatigue Resistant Device in growing Class II patients. The Angle Orthodontist. 2015 Sep;85(5):784-9.
13. Staggers JA, Germane N, Fortson WM. A comparison of the effects of first premolar extractions on third molar angulation. The Angle Orthodontist. 1992 Jun;62(2):135-8.
14. Richardson M. Changes in lower third molar position in the young adult. American Journal of Orthodontics and Dentofacial Orthopedics. 1992 Oct 1;102(4):320-7.
15. Årtun J, Thalib L, Little RM. Third molar angulation during and after treatment of adolescent orthodontic patients. The European Journal of Orthodontics. 2005 Dec 1;27(6):590-6.
16. Behbehani F, Årtun J, Thalib L. Prediction of mandibular third-molar impaction in adolescent orthodontic patients. American journal of orthodontics and dentofacial orthopedics. 2006 Jul 1;130(1):47-55.

17. Jain S, Valiathan A. Influence of first premolar extraction on mandibular third molar angulation. The Angle Orthodontist. 2009 Nov 1;79(6):1143-
18. Tarazona B, Paredes V, Llamas JM, Cibrián R, Gandia JL. Influence of first and second premolar extraction or non-extraction treatments on mandibular third molar angulation and position. A comparative study. Med Oral Patol Oral Cir Bucal. 2010 Sep 1;15(5):e760-6.
19. Gohilot A, Pradhan T, Keluskar KM. Effects of first premolar extraction on maxillary and mandibular third molar angulation after orthodontic therapy. Journal of oral biology and craniofacial research. 2012 May 1;2(2):97-104.
20. Türköz Ç, Ulusoy Ç. Effect of premolar extraction on mandibular third molar impaction in young adults. The Angle Orthodontist. 2013 Jul;83(4):572-7.
21. Patel AK, Deshmukh SV, Naik CR, Jethe S, Patel KA. Radiographic assessment for predicting the mandibular third molar eruption after orthodontic treatment in first premolar extraction group and non-extraction group: a-retrospective study. International Journal of Dental Health Concerns. 2015;1(1):1-6.
22. Durgesh BH, Gowda KH, AlShahrani OA, Almalki AD, Almalki WD, Balharith MM, Motashesh NY, Alkheraif AA, Hashem MI. Influence of premolar extraction or non-extraction orthodontic therapy on the angular changes of mandibular third molars. Saudi Journal of Biological Sciences. 2016 Nov 1;23(6):736-40.
23. Mendoza-García LV, Vaillard-Jiménez E, García-Rocha A, Bellot-Arcís C, Paredes-Gallardo V. Effect of orthodontic treatment involving first premolar extractions on mandibular third molar angulation and retromolar space. Journal of Clinical and Experimental Dentistry. 2017 Mar;9(3):e333.

24. Clark W, Clark WJ. Twin block functional therapy. JP Medical Ltd; 2014 Sep 30.
25. Trenouth MJ. A functional appliance system for the correction of Class II relationships. British Journal of Orthodontics. 1989 Aug;16(3):169-76.
26. Lund DI, Sandler PJ. The effects of Twin Blocks: a prospective controlled study. American Journal of Orthodontics and Dentofacial Orthopedics. 1998 Jan 1;113(1):104-10.
27. Mills CM, McCulloch KJ. Treatment effects of the twin block appliance: a cephalometric study. American Journal of Orthodontics and Dentofacial Orthopedics. 1998 Jul 1;114(1):15-24.
28. Morris DO, Illing HM, Lee RT. A prospective evaluation of Bass, Bionator and Twin Block appliances. The European Journal of Orthodontics. 1998 Dec 1;20(6):663-84.
29. Tümer N, Gültan AS. Comparison of the effects of monoblock and twin-block appliances on the skeletal and dentoalveolar structures. American Journal of Orthodontics and Dentofacial Orthopedics. 1999 Oct 1;116(4):460-8.
30. Toth LR, McNamara Jr JA. Treatment effects produced by the Twin-block appliance and the FR-2 appliance of Fränkel compared with an untreated Class II sample. American Journal of Orthodontics and Dentofacial Orthopedics. 1999 Dec 1;116(6):597-609.
31. Mills CM, McCulloch KJ. Posttreatment changes after successful correction of Class II malocclusions with the twin block appliance. American Journal of Orthodontics and Dentofacial Orthopedics. 2000 Jul 1;118(1):24-33.

32. Trenouth MJ. Proportional changes in cephalometric distances during Twin Block appliance therapy. The European Journal of Orthodontics. 2002 Oct 1;24(5):485-91.

33. Jena AK, Duggal R. Treatment effects of twin-block and mandibular protraction appliance-IV in the correction of class II malocclusion. The Angle Orthodontist. 2010 May 1;80(3):485-91.

34. Karacay S, Akin E, Olmez H, Gurton AU, Sagdic D. Forsus nitinol flat spring and Jasper jumper corrections of Class II division 1 malocclusions. The Angle Orthodontist. 2006 Jul 1;76(4):666-72.

35. Jones G, Buschang PH, Kim KB, Oliver DR. Class II non-extraction patients treated with the Forsus Fatigue Resistant Device versus intermaxillary elastics. The Angle Orthodontist. 2008 Mar 1;78(2):332-8.

36. Darda M. A cephalometric comparison of the dentoskeletal changes in class II malocclusion by using Jasper Jumper and Forsus-A clinical study. International Journal of Contemporary Dentistry. 2010 Nov 30;1(2).

37. Franchi L, Alvetro L, Giuntini V, Masucci C, Defraia E, Baccetti T. Effectiveness of comprehensive fixed appliance treatment used with the Forsus Fatigue Resistant Device in Class II patients. The Angle Orthodontist. 2011 Jul;81(4):678-83.

38. Gunay EA, Arun T, Nalbantgil D. Evaluation of the immediate dentofacial changes in late adolescent patients treated with the Forsus™ FRD. European journal of dentistry. 2011 Oct;5(4):423.

39. Oztoprak MO, Nalbantgil D, Uyanlar A, Arun T. A cephalometric comparative study of class II correction with Sabbagh Universal Spring (SUS2) and Forsus FRD appliances. European journal of dentistry. 2012 Jul;6(3):302.

40. Bowman AC, Saltaji H, Flores-Mir C, Preston B, Tabbaa S. Patient experiences with the Forsus fatigue resistant device. The Angle Orthodontist. 2013 May;83(3):437-46.
41. Cacciatore G, Alvetro L, Defraia E, Ghislanzoni LT, Franchi L. Active-treatment effects of the Forsus fatigue resistant device during comprehensive Class II correction in growing patients. The Korean Journal of Orthodontics. 2014 May 1;44(3):136-42.
42. Cacciatore G, Ghislanzoni LT, Alvetro L, Giuntini V, Franchi L. Treatment and posttreatment effects induced by the Forsus appliance: a controlled clinical study. The Angle Orthodontist. 2014 Nov;84(6):1010-7.
43. Pancherz H. A cephalometric analysis of skeletal and dental changes contributing to Class II correction in activator treatment. American Journal of Orthodontics. 1984 Feb 1;85(2):125-34.
44. Henry CB, Morant GM. A preliminary study of the eruption of the mandibular third molar tooth in man based on measurements obtained from radiographs, with special reference to the problem of predicting cases of ultimate impaction of the tooth. Biometrika. 1936 Dec 1;28(3/4):378-427.
45. Ricketts RM. Principle of racial growth of the mandible. Angle Orthod 1972;2:368.
46. Turely PK. A computerized method of forecasting third molar space in the mandibular arch. Paper presented at: National Institute for Design Research meeting; 1974.
47. Schulhof RJ. Third molar and orthodontic diagnosis. J Clin Orthod 1976;10:272-81

48. Uthman AT. Retromolar space analysis in relation to selected linear and angular measurements for an Iraqi sample. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;104:e76–e82.
49. Chen LL, Xu TM, Jiang JH, et al. Longitudinal changes in mandibular arch posterior space in adolescents with normal occlusion. Am J Orthod Dentofac Orthop. 2010;137: 187–193.
50. Haavikko K, Altonen M, Mattila K. Predicting angulational development and eruption of the lower third molar. Angle Orthod. 1978;48:39–48.
51. Hattab FN, Ma'amon AR, Fahmy MS. Impaction status of third molars in Jordanian students. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 1995 Jan 1;79(1):24-9.
52. Richardson M. Changes in lower third molar position in the young adult. American Journal of Orthodontics and Dentofacial Orthopedics. 1992 Oct 1;102(4):320-7.
53. Richardson MA. Pre-eruptive movements of the mandibular third molar. The Angle Orthodontist. 1978 Jul;48(3):187.
54. Dental Board of the United Kingdom. Five Lectures on" The Growth of the Jaws, Normal and Abnormal, in Health and Disease.". Dental Board of the United Kingdom; 1924.
55. Brash JC. Some problems in the growth and developmental mechanics of bone. Edinburgh medical journal. 1934 Jun;41(6):363.
56. Brash JC. Comparative anatomy of tooth-movement during growth of the jaws. Dent. Rec.. 1953;73:460-76.
57. Scott JH. The alveolar bulb. Dent. Rec. 1953;73:693-9.

58. Richardson ME. The etiology and prediction of mandibular third molar impaction. The Angle Orthodontist. 1977 Jul;47(3):165.
59. Capelli Jr J. Mandibular growth and third molar impaction in extraction cases. The Angle Orthodontist. 1991 Sep;61(3):223-9.
60. Proffit WR, Fields Jr HW, Sarver DM. Contemporary orthodontics. Elsevier Health Sciences; 2006 Dec 8.
61. Kim TW, Årtun J, Behbehani F, Artese F. Prevalence of third molar impaction in orthodontic patients treated nonextraction and with extraction of 4 premolars. American journal of orthodontics and dentofacial orthopedics. 2003 Feb 1;123(2):138-45.
62. Chen LL, Xu TM, Jiang JH, et al. Longitudinal changes in mandibular arch posterior space in adolescents with normal occlusion. Am J Orthod Dentofac Orthop. 2010;137: 187–193
63. Clark WJ. The twin block technique A functional orthopedic appliance system. American Journal of Orthodontics and Dentofacial Orthopedics. 1988 Jan 1;93(1):1-8.
64. O'Brien K, Wright J, Conboy F, Chadwick S, Connolly I, Cook P, Birnie D, Hammond M, Harradine N, Lewis D, McDade C. Effectiveness of early orthodontic treatment with the Twin-block appliance: a multicenter, randomized, controlled trial. Part 2: Psychosocial effects. American Journal of Orthodontics and Dentofacial Orthopedics. 2003 Nov 1;124(5):488-94.
65. Türköz Ç, Ulusoy Ç. Effect of premolar extraction on mandibular third molar impaction in young adults. The Angle Orthodontist. 2013 Jul;83(4):572-7.
66. Wolff J. The Law of Bone Remodelling. Berlin, Germany: Springer-Verlag; 1986.

67. Niedzielska IA, Drugacz J, Kus N, Kręska J. Panoramic radiographic predictors of mandibular third molar eruption. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2006 Aug 1;102(2):154-8.
68. Tronje G, Welander U, McDavid WD, Morris CR. Image distortion in rotational panoramic radiography. I. General considerations. Acta Radiol Diagn (Stockh). 1981;22: 295–299.
69. Stramotas S, Geenty JP, Darendeliler MA, Byloff F, Berger J, Petocz P. The reliability of crown-root ratio, linear and angular measurements on panoramic radiographs. Clin Orthod Res. 2000;3:182–191.
70. Larheim TA, Svanaes DB. Reproducibility of rotational panoramic radiography: mandibular linear dimensions and angles. Am J Orthod Dentofacial Orthop. 1986;90:45–51.
71. Olive RJ, Basford KE. Transverse dentoskeletal relationships and third molar impaction. Angle Orthod. 1981;51:41– 47.

ANNEXURE – I - ETHICAL CLEARANCE LETTER

Research and Ethics Committee
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Sl. No. : 1232

CERTIFICATE

This is to Certify that the synopsis titled Effects of fixed twin-block and forsus fatigue resistance device on mandibular third molar angulation- A comparative study *Submitted by Dr.* Pooja Milind Tendulkar. *P. G. Student / Staff, Guided by* Dr Tejashri Pradhan *from Department of* Orthodontics & dentofacial orthopedics *has been critically evaluated by committee members and granted ethical clearance to conduct the above mentioned study*

Date : 24/06/2019

Member Secretary
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

Chairman
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

Chairman
Research and Ethical Committee
KLEVK Institute of Dental Sciences

ANNEXURE –II – CONSENT FORM

EFFECTS OF FIXED TWIN-BLOCK AND FORSUS FATIGUE RESISTANCE DEVICE ON MANDIBULAR THIRD MOLAR ANGULATION- A COMPARATIVE STUDY

OPERATOR: DR. POOJA TENDULKAR

I, ____ aged ______________ have been informed about my involvement in the study:

1) I agree to give my personal details like name, age, sex, address and the details required for the study to the best of my knowledge.
2) I understand that I will be exposed to x-ray radiation for the purpose of the study.
   I agree and give my consent to the orthodontist for this procedure.
3) I have been informed about the possible complications following exposure to x-ray radiation.
4) I permit the dentist to utilize the information given by me and results obtained from this study for presentation and publication purpose.
5) I will not claim any returns for my cooperation in the study, even if it is being sponsored by any agency. I am participating with my own will and wish.
   I will follow the instructions given by the doctor.
6) During the study, if I wish to resign from the study, I am free to do so and my treatment will still be completed in the department.
7) In my full consciousness and presence of mind, after understanding all the procedure in my vernacular language, I am willing and give my consent to participate in this study.

Date:

Place:

Subject's Signature Signature of witness

ANNEXURE – III - PATIENT INFORMATION SHEET

K.L.E.V.K.INSTITUTE OF DENTAL SCIENCES, K.A.H.E.R, Belagavi-590010

DEPARTMENT OF ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS

PATIENT INFORMATION SHEET

Study title:

"EFFECTS OF FIXED TWIN-BLOCK AND FORSUS FATIGUE RESISTANCE DEVICE ON MANDIBULAR THIRD MOLAR ANGULATION- A COMPARATIVE STUDY"

Name of investigator/Dentist: Dr. PoojaMilind Tendulkar

- The current study is a comparative cephalometric study and there are **no risks** associated with this study since all that will be recorded are post-retention radiographs with no intervention, no procedure.
- The radiographs that will be taken include: 1. Lateral cephalogram; 2. Orthopantomogram
- Data obtained will be subjected to statistical analysis to assess the changes in mandibular third molar angulation from pre to post retention.

FIXED TWIN BLOCK

SR NO	PT	SNA		SNB		ANB		Sn-MP		GoGn(mm)			CoGo(mm)			CoGn(mm)			L1		L6		RMS(mm)(r)		RMS(mm)(l)		MDW(mm)(r)		MDW(mm)l	
		PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST FX	POST	PRE	POST FX	POST	PRE	POST FX	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST
1	Abhishek	82	82	77	80	7	2	27	26	66.9	69.7	73.2	51.7	52.3	53.6	99.4	110.8	102.4	72.5	75.7	48.7	53	1.6	7.26	5.88	7.26	11.97	12.77	11.29	11.8
2	Sweta Patil	82	82	79	81	3	1	28	26	61.7	64.6	66.8	53.2	54	55.8	101.4	103.1	105.2	70.8	73.7	45.7	48.8	5.39	10.32	11.59	10.54	11.02	10.91	11.28	10.53
3	geetanjali	82	80	73	76	9	4	38	32	74.7	76.1	77.7	51.7	53.1	56.9	97.4	99.2	100.3	70.5	74.5	46.6	52.3	8.91	10.45	8.28	11.01	11.16	11.5	11.01	11.5
4	suma	81	81	79	80	2	1	26	24	66.4	69.8	73.5	47.2	48.8	50.4	95	96.7	99.99	66	70.4	42.8	46.8	4.09	6.3	4.6	6.71	13.06	13.01	13.05	12.68
5	dheeraj	78	79	75	78	3	1	25	20	72.6	73.7	75.2	52.6	54.3	56.7	110.3	111.4	114.4	70.1	73.3	47.2	51.1	4	12	10	12	12	12	12	12
6	madhavi	78	80	75	78	3	2	25	24	70	73.2	76.7	56.6	58.1	60.8	102.5	103.5	108.8	74.5	77.3	48.8	51	2	4.27	1.27	3.82	12.23	10.76	11.91	10.67
7	gouri	76	77	68	72	8	5	38	36	57.3	60.3	62.3	48.2	50.9	52.4	100.6	102.4	105.5	68.4	70.8	46.9	48.5	8.78	10.43	11.54	8.95	9.37	8.63	9.89	8.28
8	amit	81	82	77	79	4	3	30	27	62.4	64.4	66.6	53.5	55.7	57.1	108.4	109.4	111.5	67.9	69.7	42.8	44.7	7.64	10.15	8.49	11.37	13.35	13.51	12.33	12.32
9	neha	84	80	79	80	5	0	26	26	72.3	73.9	75.8	58.6	60	62.2	103.3	106.4	110.7	76.2	78.9	45.4	49.2	7.52	7.73	5.38	9.37	10.52	10.09	9.79	9.77
10	shashank	83	83	76	79	7	4	24	25	64.2	68.8	71.3	60.4	62.8	66.2	101.5	104.6	107.4	78.8	80	50	52.4	13.7	14.51	11.48	14.52	12.3	11.11	12.05	12
11	vidyashri	74	73	68	70	6	3	33	31	70.1	72.3	74.3	48.8	50.3	52.2	101.4	105.5	108.1	69.5	70.5	46.7	47.2	9.01	12	7.89	11.42	11.61	10.79	12.19	10.65
12	geetanjali	82	80	73	76	9	4	38	32	71.5	72.8	75.6	52.5	53.6	55.1	97.8	99.3	100.3	73.5	75.6	44.4	46.8	8.91	10.23	8.28	11.11	11.16	11.36	11.01	11.53
13	suma	81	82	79	81	2	1	30	28	67.6	70.1	73.1	51.7	53.5	56.1	100.8	102.5	105.5	68.9	71	40.1	43.5	4.09	6.3	4.6	6.71	13.06	13.01	13.05	12.68
14	dhavalshree	81	81	80	80	1	1	30	30	58.4	61.3	63.5	52.1	53	54	95.6	97.7	101.9	60	63.9	37.5	41.7	7.07	9.31	4.88	6.21	12.41	12.2	13.37	11.84
15	shravana	80	80	75	76	5	4	28	29	60.8	62.6	65.5	45.7	46.2	48.1	94.9	95.2	98.7	62.6	66.4	43.9	45.6	7.55	11.65	8.6	8.67	11.84	10.17	12.03	9.46
16	vaishnavi	84	84	78	81	6	3	31	29	68.2	72.2	74.4	46	46.8	47.9	92.5	93.3	95.8	68.7	72.7	45	50	6.07	8.68	3.75	6.92	12.31	12	11.79	11.39
17	shreedevi	80	77	75	75	5	2	46	40	67.7	70.1	72.5	49.9	51.2	53.5	95.9	96.2	97.7	65.3	68	38.9	41.8	7.3	10.48	9.46	14.63	10.81	11.23	13.44	12.55
18	samruddhi	78	78	72	76	6	2	32	28	57.5	60.2	64.2	56.8	57.1	58.9	104	104.7	106.2	64.8	68	42	46.6	9.23	12.15	9.34	12.18	10.09	10.18	10.69	10.7
19	sachin	76	77	72	75	4	2	30	30	63.3	65.7	68.1	47.2	49.8	53.1	93.6	94	96.7	81	82.8	55	56.8	13.69	11.91	15.49	12.83	13.71	12.95	14.63	13.69
20	prakash	85	85	77	80	8	5	29	28	71.3	72.5	73.1	45.9	47.7	50	95	97.2	99.3	75.7	80.1	53.8	58	6.65	8.23	5.66	8.45	13.2	13.45	12.4	12.9
21	swapnil	76	75	70	71	6	4	34	34	68	70.2	71.5	46	46.9	48.9	99	102.2	104.3	67.4	68.2	42.7	44.8	11.23	15.43	10.5	14.07	10.36	10.82	10.07	10.98
22	priya	78	80	75	78	3	2	25	24	70	73.1	76.7	56.6	58.1	60.8	102.5	104.4	106.8	70.8	75.4	53.5	54.2	2	4.27	1.27	3.82	12.23	10.76	11.91	10.67
23	prem	78	79	75	78	3	1	25	20	72.6	73.9	75.2	52.6	54.2	56.7	110.3	111.6	114.4	70.1	73.3	48.7	51.1	4	12	10	12	12	12	12	12
24	kalshri	74	73	68	70	6	3	33	31	70.1	71.9	74.3	49.9	52.4	53.2	95.9	97	99.53	69.6	72.1	43.4	45.2	11.23	15.43	10.5	14.07	10.36	10.82	10.07	10.98
25	shreya	82	82	76	80	6	2	28	29	60.8	63.2	65.5	45.7	46.8	48.1	94.9	97.5	99.7	66.4	69.2	38.9	42.1	7.55	11.65	8.6	8.67	11.84	10.17	12.03	9.46

SR NO	PT	SRW r		SWR l		Xi -7(mm)r		Xi -7(mm)l		α angle r		α angle l		β angle r		β angle l		ϒ angle r		ϒ angle l		Go angle r		Go angle l	
		PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST
1	Abhishek	0.133667502	0.568519969	0.52081488	0.615254237	18.6	25.4	19.95	26.47	65	74	67	76	30	21	40	38	95	95	107	114	131	130	130	129
2	Sweta Patil	0.489110708	0.945921173	1.02748227	1.000949668	19.99	24.61	27.49	19.47	29	52	51	60	51	33	26	14	81	85	77	74	120	118	120	118
3	geetanjali	0.798387097	0.908695652	0.752043597	0.957391304	21.26	26.2	21.41	25.4	80	67	71	77	6	25	18	28	86	92	89	105	133	130	133	130
4	suma	0.313169985	0.48424289	0.352490421	0.529179811	22.38	24.04	21.5	22.4	48	49	40	53	36	31	41	35	84	80	81	83	114	110	114	110
5	dheeraj	0.333333333	1	0.833333333	1	22	30	22	29	63	95	56	95	21	0	23	0	84	88	80	88	116	114	116	114
6	madhavi	0.163532298	0.396840149	0.106633081	0.358013121	17.88	15.75	16.77	18.28	58	60	40	70	21	35	37	27	79	90	77	97	126	120	126	120
7	gouri	0.937033084	1.208574739	1.166835187	1.080917874	20.62	20.17	21.73	18.7	60	63	67	64	26	25	20	16	86	88	87	80	132	130	132	130
8	amit	0.572284644	0.751295337	0.688564477	0.92288961	23.27	24.57	22.51	26.07	64	72	66	67	26	18	20	25	90	90	86	92	130	128	130	128
9	neha	0.714828897	0.766105055	0.549540347	0.959058342	21.53	20.63	19.2	20.64	56	57	63	65	24	20	15	14	80	77	78	79	114	113	114	113
10	shashank	1.113821138	1.306030603	0.952697095	1.21	25.52	24.9	22.28	24.48	76	72	81	86	15	17	3	5	91	89	84	91	122	120	123	121
11	vidyashri	0.776055125	1.112140871	0.647251846	1.072300469	18.52	23.8	22.66	22.85	80	82	72	75	10	16	18	20	90	98	90	95	133	130	133	130
12	geetanjali	0.798387097	0.900528169	0.752043597	0.963573287	21.26	27.1	21.41	25.44	80	67	71	77	5	25	18	28	85	92	89	105	130	129	130	129
13	suma	0.313169985	0.48424289	0.352490421	0.529179811	22.38	24.04	21.5	22.4	48	49	40	53	36	31	41	35	84	80	81	88	110	108	110	108
14	dhavalshree	0.569701853	0.763114754	0.36499626	0.524493243	25.09	25.81	21.42	21.38	70	90	65	80	27	12	18	28	97	102	83	108	125	123	125	122
15	shravana	0.637668919	1.145526057	0.714879468	0.916490486	22.77	25.04	23.06	21.25	55	94	57	77	25	1	27	3	80	93	86	80	120	117	120	117
16	vaishnavi	0.493095045	0.723333333	0.318066158	0.607550483	20.07	22.42	17.85	20.34	67	76	60	76	28	20	30	17	95	96	90	93	130	125	130	125
17	shreedevi	0.675300648	0.933214604	0.703869048	1.165737052	20.06	26.35	26.5	31.12	66	81	62	82	16	15	20	20	82	96	82	102	125	122	125	122
18	samruddhi	0.914767096	1.193516699	0.873713751	1.138317757	20.08	25.94	19.33	23.14	69	70	63	73	12	10	23	9	81	80	87	82	125	117	125	118
19	sachin	0.998541211	0.91969112	1.058783322	0.937180424	28.11	26.42	29.24	30.07	62	65	60	59	26	38	24	32	89	103	84	92	127	124	127	124
20	prakash	0.503787879	0.611895911	0.456451613	0.65503876	27.54	29.99	25.1	29.71	40	43	38	42	51	55	52	54	91	98	90	97	122	121	122	121
21	swapnil	1.083976834	1.426062847	1.042701092	1.281420765	20.71	25.44	18.78	26.12	83	90	73	88	12	0	12	8	95	90	85	96	131	127	130	127
22	priya	0.163532298	0.396840149	0.106633081	0.358013121	17.88	15.75	16.77	18.28	58	60	40	70	21	35	37	27	79	90	77	97	126	120	126	120
23	prem	0.333333333	1	0.833333333	1	22	30	22	29	63	95	56	95	21	0	23	0	84	88	80	88	116	114	116	114
24	kalshri	1.083976834	1.426062847	1.042701092	1.281420765	20.71	25.44	18.78	26.12	70	88	73	88	12	2	12	8	82	90	85	96	131	127	130	127
25	shreya	0.637668919	1.145526057	0.714879468	0.916490486	22.77	25.04	23.06	21.25	55	94	57	77	25	1	27	3	80	93	86	80	120	117	120	117

FORSUS FATIGUE RESISTANT DEVICE

SR NO	PT	SNA		SNB		ANB		Sn-MP		GoGn(mm)			CoGo(mm)			CoGn(mm)			L1		L6		RMS(mm)(r)		RMS(mm)(l)		MDW(mm)(r)		MDW(mm)l	
		PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST FX	POST	PRE	POST FX	POST	PRE	POST FX	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST
1	avdumbar	76	76	74	75	2	1	30	29	70.4	70.8	71.1	51.7	51.9	52.3	99.4	99.9	101	72.4	77.2	51	54.1	7.5	8.09	5.58	8.41	11.58	10.74	12.1	12.2
2	ambika	80	80	76	78	4	2	30	28	75	76.4	77.7	53.2	53.8	54.4	101	101.5	101.8	84	85.5	59	60.9	12	9.53	7.18	7.2	12.61	12.36	11.7	11.1
3	kaveri	82	82	77	80	5	2	30	29	71.7	72.1	73	51.7	52.1	53	97.4	97.7	99.1	82.2	84.9	57	59.2	14	15.13	9.57	11.52	12.55	14.37	11.8	13
4	kaushalya	86	80	78	78	8	2	31	29	66.9	67	67.2	47.2	47.7	48.1	95	95.8	97.6	67.7	90.3	47	64.6	17	15.45	17.2	17.88	14.25	13.67	13.6	11.9
5	ashwini	88	88	82	84	6	4	21	21	77.3	77.9	78.9	52.6	53.1	53.5	110	110.8	111.1	72.9	83.6	53	58.7	13	13.7	12.9	14.6	10.08	11.9	10.9	12.8
6	nurian	80	77	74	76	6	2	32	30	85.4	85.9	86.7	56.6	56.9	58.1	103	102.8	104	107	109.2	67	69.5	9.3	10.58	6.49	7.55	12.9	13.8	12.1	12.1
7	sankalp sinna	80	80	75	77	5	3	34	32	74	72.3	78.4	48.2	49	49.6	101	101.5	103.7	81.9	82.4	58	65.3	12	14.6	11.7	16.74	11.75	12.57	11.3	12.4
8	katikya	76	76	74	75	2	1	31	30	76.1	76.8	77.5	53.5	54.1	55	108	108.9	109.1	70.5	80.7	47	57.3	11	11.4	11	10.3	9.32	8.86	-	-
9	priyanka	82	81	79	80	3	1	28	25	76.3	77.5	79.4	58.6	59	60	103	104.3	106.7	70.2	79.9	50	60.7	8.9	12.15	10.5	10.27	9.92	10.94	10.4	10.4
10	balkshrishna	78	77	75	76	3	1	30	29	77.7	78	78.6	60.4	60.8	62.2	102	102.1	103.7	73.1	81.2	46	54.4	9.6	14.48	10.8	14.47	12.53	15.24	12.8	14.8
11	mahek	82	82	78	80	4	2	26	24	75.3	75.9	77	48.8	49.2	49.7	101	101.9	104	75.1	80.2	55	60.1	13	14.23	9.79	12.21	11.46	9.51	12	9.66
12	megha	79	80	73	77	6	3	34	28	76	76.1	76.3	52.5	53.1	54.9	97.8	98.2	100.4	72.9	81.5	48	57.9	10	10.09	11.4	23.75	10.71	12.64	11.5	12.8
13	ashwini N	81	80	76	78	5	2	28	28	78	78.6	80.5	51.7	52.2	52.8	101	101.4	102.3	78.5	96.6	53	67.5	13	13.7	12.9	14.6	10.08	11.9	10.9	12.8
14	megha H	77	75	72	72	5	3	36	35	61.3	61.7	62.4	52.1	52.9	53.4	95.6	95.9	96.5	73.1	77.5	55	59.4	10	10.09	11.4	23.75	10.71	12.64	11.5	12.8
15	rahul	77	76	72	73	5	3	32	30	60	60.5	62.3	45.7	45.7	45.9	94.9	95.7	97.3	76.6	84.2	50	57.1	12	8.56	7.57	10.77	11.51	10.8	11.4	11.9
16	kavita	87	85	80	81	7	4	24	22	65	65.6	66.7	46	46.2	46.5	92.5	92.9	94	70.8	77.9	51	57.2	10	11.32	12.7	13.8	10.05	10	10	10
17	pavan	80	79	75	77	5	2	27	25	63.6	63.9	65	49.9	50.4	51.3	95.9	96.1	97.8	74.3	80.2	54	60.1	8.1	9.23	6.41	7.37	11.48	11.14	10.9	10.5
18	kiran	84	80	77	77	7	3	31	30	67.2	68.1	68.6	56.8	57.1	58	104	104.4	106.7	73.5	78.9	51	58.7	12	13.03	12	12.21	12.53	11.07	13.5	11
19	prateek	71	74	67	72	5	2	35	35	62.8	63.3	64.9	47.2	47.7	48.1	93.6	94.2	97.5	76.2	81.1	54	59.2	0	2.8	0	2.39	11.11	9.55	11.6	11.2
20	shribhakti	82	81	78	80	4	1	33	30	61.3	62.2	63	45.9	46	46.3	95	95.3	97.3	70.7	76.8	52	57.3	8.6	9.42	5.63	7.51	11.61	10.86	11.3	10.5
21	sneha	76	79	72	76	4	3	37	33	67.8	68.2	70.5	46	46.6	47.1	99	99.4	100.5	64.3	76.3	45	53.5	14	13.45	9.97	10.84	14.67	-	13.8	-
22	meenakshi	77	77	75	76	2	1	22	21	77	77.1	77.3	44.4	45.9	46.6	99.9	100.1	100.7	64.5	71.2	42	48.2	8.2	11.19	9.11	11.26	14.15	15.56	13.4	14.4
23	Shruti	77	77	74	75	3	2	33	30	69.7	69.7	70	47.4	48.1	49	99.9	100.3	101.4	68.3	74.3	52	54.5	21	20.59	19.4	19.68	13.61	12.75	13.3	12.8
24	komal	80	79	75	77	5	2	27	25	63.6	64.3	65	49.9	50.3	51.3	95.9	96.4	97.8	69.7	75.2	46	50.6	8.1	9.23	6.41	7.37	11.48	11.14	10.9	10.5
25	sanjana	84	82	75	78	9	4	35	30	67.2	68	68.6	56.8	56.9	58	104	104.4	106.7	70.3	74.6	43	47.4	12	13.03	12	12.21	12.53	11.07	13.5	11

SR NO	PT	SWR r		SWR l		Xi -7(mm)r		Xi -7(mm)l		α angle r		α angle l		β angle r		β angle l		ϒ angle r		ϒ angle l		Go angle r		Go angle l	
		PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST
1	avdumbar	0.649396	0.753259	0.461921	0.691044	20.89	18.35	19.34	21.67	71	80	68	84	9	12	11	8	80	92	79	92	126	124	126	124
2	ambika	0.931007	0.771036	0.613675	0.648649	23.28	24.8	17.74	20.7	73	85	75	95	21	4	21	3	94	89	96	98	124	121	124	121
3	kaveri	1.109163	1.052888	0.812394	0.886154	29.66	30.09	21.49	24.59	56	45	57	68	30	60	23	25	86	105	80	93	130	127	130	127
4	kaushalya	1.207018	1.130212	1.263817	1.503785	32.49	26.08	26.58	26.77	70	84	80	86	18	3	0	5	88	87	80	91	122	120	122	120
5	ashwini	1.315476	1.151261	1.186175	1.141517	23.25	21.25	23.2	24.94	61	79	68	72	16	0	13	8	77	79	81	80	120	117	120	117
6	nurian	0.724031	0.766667	0.537252	0.623967	19.56	24.6	17.56	18.16	60	72	55	69	27	23	30	20	87	95	85	89	129	126	129	126
7	sankalp sinna	0.990638	1.161496	1.033599	1.348912	23.09	28.15	23.13	27.71	80	87	63	70	0	2	17	18	80	89	80	88	130	125	130	125
8	katikya	1.133047	1.286682			20.51	24.81	20.02	21.81	-	-	38	46	-	-	46	44	81	84	84	90	125	121	125	122
9	priyanka	0.895161	1.110603	1.004808	0.983716	19.36	22.44	20.78	20.82	82	78	85	76	1	27	2	21	83	105	87	97	130	128	131	128
10	balkshrishna	0.767757	0.950131	0.844288	0.976383	24.53	29.65	21.97	26.18	73	86	70	73	10	7	15	15	83	93	85	88	125	123	125	123
11	mahek	1.121291	1.49632	0.817195	1.263975	27.79	27.81	25.4	25.9	54	61	66	51	26	15	3	23	80	76	69	74	118	116	118	116
12	megha	0.969188	0.798259	0.988735	1.85113	19.77	25.39	21.03	32.8	54	50	60	62	26	34	32	32	80	84	92	95	132	130	133	130
13	ashwini N	1.315476	1.151261	1.186175	1.141517	23.25	21.25	23.2	24.94	63	79	60	72	12	0	8	8	75	79	68	80	120	117	120	117
14	megha H	0.969188	0.798259	0.988735	1.85113	19.77	25.39	21.03	32.8	60	50	78	62	30	34	16	32	90	84	94	95	133	131	133	130
15	rahul	1.027802	0.792593	0.66696	0.902766	21.06	20.33	14.23	21.62	75	84	71	80	15	7	21	35	90	91	92	115	140	136	140	137
16	kavita	0.995025	1.132	1.267	1.38	20.1	21.67	23.86	25.15	33	54	43	63	31	28	41	29	64	82	84	92	115	113	115	112
17	pavan	0.704704	0.828546	0.585923	0.703244	22.45	23.71	20.65	21.97	68	88	60	85	22	16	22	18	90	104	82	103	120	116	120	116
18	kiran	0.929769	1.177055	0.892273	1.114051	21.84	23.9	23.66	20	70	83	68	80	9	7	17	7	79	90	85	87	120	118	120	118
19	prateek	0	0.293194	0	0.212823	16.18	14.44	11.94	16.71	49	61	38	63	32	19	47	40	81	80	85	103	128	126	128	126
20	shribhakti	0.741602	0.867403	0.49779	0.714558	22.11	21.45	15.78	18.51	48	62	38	51	33	40	26	53	81	102	64	104	132	130	132	130
21	sneha	0.928425		0.724564		27.12	19.98	21.25	18.28	95	-	85	-	0	-	0	-	95	102	85	95	132	128	132	128
22	meenakshi	0.579505	0.719152	0.679851	0.784669	21.05	22.53	20.58	21.7	84	115	10	13	5	27	85	83	92	92	95	100	122	120	122	120
23	Shruti	1.549596	1.614902	1.455772	1.543529	33.44	32.25	31.3	30.7	75	85	65	70	11	9	24	17	86	94	89	87	120	117	120	117
24	komal	0.704704	0.828546	0.585923	0.703244	22.45	23.71	20.65	21.97	68	88	60	85	22	16	22	18	90	104	82	103	120	116	120	116
25	sanjana	0.929769	1.177055	0.892273	1.114051	21.84	23.9	23.66	20	70	87	68	80	9	1	17	7	79	88	85	87	120	118	120	118