Original Article

# Evaluation of skeletal changes in mandibular ramus height, corpus length, and mandibular angle changes following twin block appliance therapy using cone-beam computed tomography: A clinical prospective study


## ABSTRACT

**Aim and Objectives:** This study aims to evaluate the skeletal changes in mandibular ramus height, corpus length, and mandibular angles changes following twin block (TB) functional appliance therapy using cone-beam computed tomography (CBCT).

**Methodology:** Fifteen patients with skeletal Class II, growing of 9–14 years of age with mandibular retrognathism, were treated with TB functional appliance treatment. Pretreatment CBCT and posttreatment CBCT were taken (T0) before treatment and (T1) at the end of the 12 months following TB therapy. The data obtained are analyzed and compared for the skeletal changes in ramus height, corpus length, and mandibular angle changes following therapy. Student's paired *t*-test was used compare the pre- and post-treatment periods.

**Results:** The test results demonstrate that the Ramus height (mm) in posttreatment period was significantly increased as compared to pretreatment period. The mean increase of 1.23 mm in the ramus height between pre- and post-treatment period was statistically significant at $P < 0.001$, and that the corpus length (mm) in posttreatment period was significantly increased as compared to pretreatment period. The mean increase of 3.35 mm in the corpus length between pre- and post-treatment period was statistically significant at $P < 0.001$, and demonstrate that the mean gonial angle (degrees) in posttreatment period was significantly increased as compared to pretreatment period. This mean increase of 3.18 in the gonial angle between pre- and post-treatment period was statistically significant at $P < 0.001$.

**Conclusion:** TB appliance therapy increases the ramus height, and corpus length stimulating the growth of condyle in backward and upward direction and increases the gonial angle by backward rotation of mandible.


**Keywords:** Cone-beam computed tomography, mandibular retrognathism, Skeletal class II malocclusion, twin block appliance

## INTRODUCTION

Malocclusions of class II can manifest in various skeletal and dental configurations. Most Class II patients have a deficiency in the anteroposterior position of the jaw Class II malocclusion, which comprises a group of specific skeletal, dental, and facial features, is one of the most common orthodontic problems, and it occurs in about one-third of the population. Class II malocclusion is more common in whom mandibular retrognathism is a consistent finding.[1]

Subjects with Class II, Division 1 malocclusion typically present with an increased overjet, lower lip trapped behind maxillary incisors and an unfavorable facial profile, which may predispose children towards a negative feeling of self-image

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and self-esteem. The goal of orthodontic treatment for these patients is to achieve a harmonious relationship of dentoskeletal subunits along with an esthetically pleasing facial profile.[2,3]

Functional appliance therapy has become an increasingly popular method of correcting Class II malocclusion. Several varieties of functional appliances, removable appliances (activator, bionator, twin-block , frankel regulator) or fixed appliances (herbst appliance, mandibular advancement repositioning splint, mandibular protraction appliance, eureka spring, jasper jumper, churro jumper, mandibular anterior repositioning appliance), have been used for many years in the treatment of Class II Division 1 malocclusions to improve skeletal imbalances.[4-6]

TBs are simple removable bite blocks with occlusal inclined planes which act as a functional appliance, designed for full-time wear. It was invented by Dr. William J. Clark in 1977, and since then, it has been a very popular functional appliance in the correction of malocclusion in growing patients.

In comparison to other functional appliances, TB has some advantages which made it popular among the clinicians. Its mechanism of function is very similar to the natural dentition. Vertical eruption of posterior teeth can be easily controlled, less obstructive during speech, lateral movements of the jaw and other oral functions.

Furthermore, the appliance design is simple over one-piece appliance. Free mandibular movement and less bulk bring better patient compliance. In addition, after the insertion of the appliance the appearance is noticeably improved. There have been several studies evaluating the soft tissue changes, dentoskeletal changes, temporomandibular joint (TMJ) changes, and treatment effects produced by the TB.

The placement of the functional appliance results in a displacement of the condyle in the glenoid fossa and stimulates the growth at the condylar cartilage. In orthodontic literature, TMJ adaptations following functional therapy have been visualized by various techniques such as cephalograms, panoramic radiographs, computed tomography, and magnetic resonance imaging. However, there are many limitations to image acquisition of the craniofacial regions using conventional techniques.[7]

Improvements in technology have led to cone-beam computed tomography (CBCT). This technique produces accurate images with high resolution and minimal distortion and allows the creation of three dimensional (3D) images in sagittal, coronal, and axial planes. It is possible to make more precise measurements of craniofacial structures since there are no projections or overlapping of bilateral structures.[8]

Some studies have focused on the comparison of effect with other functional appliances. If the results of all these studies can be combined as a whole, it would be beneficial for both the clinicians and the researchers to understand the function, efficacy, and implement of TB appliance in details.[9]

Currently, CBCT has been frequently used in the precise measurement of dental and maxillofacial pathologies, orthodontic diagnosis and treatment plan, craniofacial morphology, and airway assessment. In literature, there are also studies which reflect the use of CBCT for estimation of mandibular condylar volume.

In recent studies, they have compared the measurements from 2D cephalograms and 3D CBCT. Lee *et al*.[10] concluded that for the assessment of surgical outcomes, image fusion is a reliable method which is not affected by spatial or surgical changes. In the literature, it was determined that CBCT has been used to assess the condylar growth after a functional appliance.[11]

There are several studies assessing the mandible changes using the lateral cephalograms where the changes in effective maxillary length ($C_0$-A) and mandibular length ($C_0$-$P_0$g); however, no CBCT study where the mandibular component length (ramus height, corpus length) and angle comparing pre- and post-treatment CBCT following TB functional appliance.

### Source of data

Fifteen subjects willing for TB functional appliance treatment of age between 9 and 14 years with mandibular retrognathism based on inclusion criteria, reporting to the outpatient department (OPD) of the Department of Orthodontics and Dentofacial Orthopedics, were the part of the study. Thirty CBCT images ($T_0$ and $T_1$) records were taken before and after TB treatment.

### Method of collection of data

Records, namely pretreatment CBCT and posttreatment CBCT head scans, will be collected of 15 patients from the department of oral medicine and radiology. CBCT head scans are obtained from NewTom cone beam imaging machine. The exposure parameter included tube voltage of 110 kvp, tube current of 5 mA. The data will be obtained as digital imaging and communication in medicine (DICOM) format files. The DICOM files are measured for skeletal changes in mandibular ramus height, corpus length, angular changes with NNT viewer software (NEWTOM | CEFLA S.C.UNITED KINGDOM).

### Inclusion criteria

- Class II div 1 malocclusion with normal maxilla and retrognathic mandible (ANB >4°)
- Age: 9–14 years (mixed dentition to early permanent dentition period)
- Horizontal or average growth pattern
- Unilateral or bilateral Class II molar and canine relation
- Increased overjet (≥4 mm)
- Minimum or no crowding in the dental arches.

### Exclusion criteria

- Angle's Class III malocclusion
- Skeletal Class III cases
- Patient with a history of trauma and cleft and palate
- Patient with gross facial asymmetry and temporomandibular disorders
- Congenital abnormalities and birth defect.

### Ethical clearance

The study protocol was reviewed, and ethical clearance no AJEC/REV/209/2017 was provided by the "Institutional Ethical Committee."

## METHODOLOGY

Fifteen subjects with skeletal Class II with mandibular retrognathia based on inclusion criteria are selected and willing for TB functional appliance treatment of age between 9 and 14 years, reporting to the OPD of The Department of Orthodontics and Dentofacial Orthopedics were the part of the study.

For all the 15 patients, consent was taken regarding 2 CBCT scans done ($T_0$ and $T_{1)}$, the measurements done using DICOM viewer.

All the 15 patients were treated with TB functional appliance. Class I molar and canine relationship was obtained, and increased overjet was eliminated at the end of functional therapy. The average time for functional treatment was 12 months.

Skeletal changes to the TB functional therapy were evaluated on CBCT images that had been taken before treatment (T0) and after functional therapy (T1). A full skull CBCT scan was taken before the insertion of the TB and at the end of functional therapy to check for ramus height, corpus length, and gonial angle changes. Pretreatment and posttreatment images were taken while the patients were standing in an upright position with the Frankfort horizontal plane parallel to the ground. They were instructed to breathe normally through the nose and to avoid swallowing during the scanning process.

The raw images were exported into DICOM. All landmark identifications and measurements were made using NNT viewer software. To carry out the measurements on CBCT scan, conventional oblique slicing was used.

In this study, the CBCT views taken for evaluating the angular and linear measurements are: the sagittal (lateral) view was used [Tables 1 and 2]:

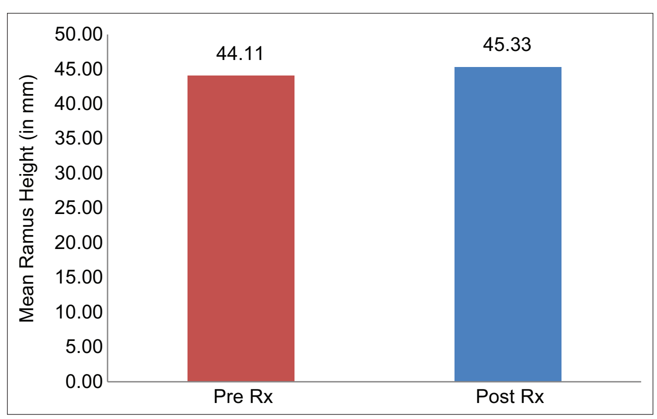
1. Ramus height: Ar-Go (According to Rakosi's analysis)
2. Corpus length: Go-Me (According to Rakosi's analysis)
3. Gonial angle: Ar-Go-Me (According to Rakosi's analysis).

## RESULTS

The study was aimed at evaluating the skeletal changes in ramus height, corpus length, and mandibular angle changes following TB functional appliance therapy using CBCT [Tables 1 and 2].

Table 3 shows the comparison of the mean Ramus height (mm) between pre- and post-treatment periods using Student's paired *t*-test. The test results demonstrate that the mean Ramus height (mm) in posttreatment period (45.33 ± 2.69) was significantly increased as compared between pre and post treatment period was statistically significant at $P < 0.001$ [Graph 1].

Table 4 shows the comparison of the mean corpus length (mm) between pre- and post-treatment periods using Student's paired *t*-test. The test results demonstrate that the mean corpus length (mm) in posttreatment period (71.61 ± 3.36) was significantly increased as compared to pretreatment




**Graph 1: Mean Ramus height (mm) between pre and post treatment periods**

period (68.27 ± 3.48). This mean difference of 3.35 mm in the corpus length between pre- and post-treatment period was statistically significant at $P < 0.001$ [Graph 2].

Table 5 shows the comparison of the mean gonial angle (degrees) between pre and post treatment periods using Student's paired *t*-test. The test results demonstrate that the mean Gonial Angle (in degrees) in posttreatment period (122.22 ± 2.09) was significantly increased as compared to pretreatment period (119.05 ± 2.01). This mean difference of 3.18° in the gonial angle between pre- and post-treatment period was statistically significant at $P < 0.001$ [Graph 3].

**Table 1: Definitions of skeletal three dimensional landmarks in the study**

| Landmark | Definition |
|---|---|
| Ar | The point of intersection of the posterior margin of the ascending ramus and outer margin of the cranial base |
| Go | The right and the left midpoint on the angles of the mandible, halfway between the corpus and ramus |
| Me | The most inferior midpoint of the chin on the outline of the mandibular symphysis |

**Table 2: Definitions of skeletal measurements in the study**

| Measurements | Definition |
|---|---|
| Ar-Go-Me | The expression for form of the mandible, with reference to relation between body and ramus. Gonial angle (degrees) |
| Go-Me | The linear distance between point Go and Me, measuring the corpus length (mm) |
| Ar-Go | The linear distance between points Ar and Go, measuring the ramus length (mm) |

**Table 3: Comparison of mean ramus height (mm) between pre- and post-treatment periods using Student's paired *t*-test**

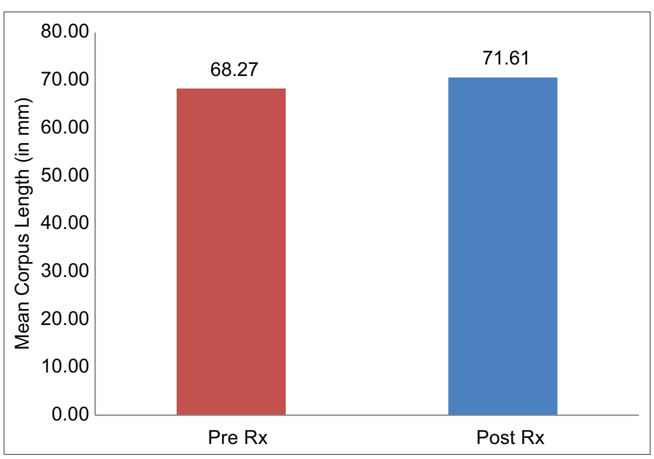
| Time | *n* | Mean | SD | Mean difference | *t* | *P* |
|---|---|---|---|---|---|---|
| Pre-Rx | 15 | 44.11 | 2.69 | -1.23 | -15.535 | <0.001* |
| Post-Rx | 15 | 45.33 | 2.69 | | | |

*Statistically significant. SD: Standard deviation

**Table 4: Comparison of mean corpus length (mm) between pre- and post-treatment periods using Student's paired *t*-test**

| Time | *n* | Mean | SD | Mean difference | *t* | *P* |
|---|---|---|---|---|---|---|
| Pre-Rx | 15 | 68.27 | 3.48 | -3.35 | -20.479 | <0.001* |
| Post-Rx | 15 | 71.61 | 3.36 | | | |

*Statistically significant. SD: Standard deviation



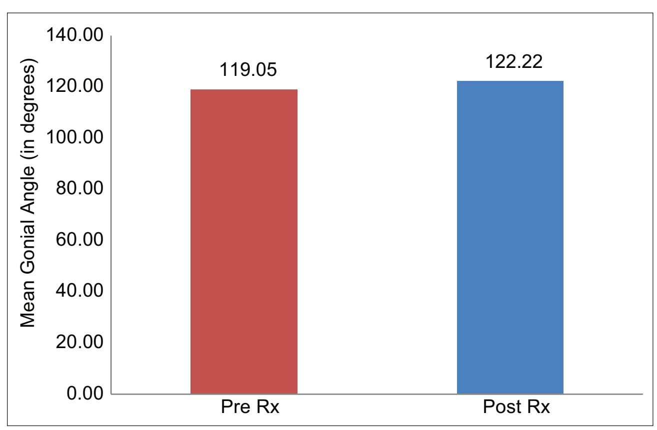

**Graph 2: Mean corpus length (mm) between pre and post treatment periods**

## DISCUSSION

The importance of beauty and attractiveness in today's society has been well established. Patients with Class II malocclusions are referred mainly for esthetic enhancement as the increased overjet, and unpleasant profile may lead to negative self-image in these patients.[12] This study intended to study the skeletal changes in mandibular ramus height, corpus length, and mandibular angle changes following TB functional therapy.

According to McNamara, 60% of the Class II patients having mandibular deficiency need forward positioning or stimulation of favorable growth of the mandible. With more number of mandibular deficiencies in the Class II patient population, an effective means of enhancing the forward growth and development of the mandible is desirable.[9,13] To bring about some changes in the posture, size, and shape of the mandible, functional jaw orthopedics can be applied during the treatment of Class II malocclusion with mandibular deficiency.[14] TB appliances are among the most popular functional appliances.[15-17]

Regarding the craniofacial changes, the present study showed that the TB appliance produced an orthopedic effect in both anteroposterior and vertical directions. This presented by improvement in the facial profile by reduction in both




**Graph 3: Mean gonial angle (degrees) between pre and post treatment periods**

**Table 5: Comparison of mean gonial angle (degrees) between pre- and post-treatment periods using Student's paired *t*-test**

| Time | *n* | Mean | SD | Mean difference | *t* | *P* |
|---|---|---|---|---|---|---|
| Pre Rx | 15 | 119.05 | 2.01 | -3.18 | -22.827 | <0.001* |
| Post Rx | 15 | 122.22 | 2.09 | | | |

*Statistically significant. SD: Standard deviation

anteroposterior linear and angular measurements.[18-21] This was emphasized by the cephalometric studies of Mills and McCulloch,[22] Trenouth[23] and Lund and Sandler,[24] and the 3D study of Yildirim *et al*.[9]

Recent improvements in technology have led to 3D CBCT. In the assessment of craniofacial structures, CBCT is more adequate than conventional helical computed tomography because of lower radiation exposure.[25,26] While it is possible to scan the complete head in a few seconds with an effective dose of 50 mSv with CBCT, conventional computed tomography uses 2000 mSv. Other advantages of CBCT are lower costs, increased accessibility to orthodontic practices, flexibility in the field of view, and submillimeter spatial resolution.[9]

The 3D image is reconstructed from raw data by means of a mathematical algorithm that has the ability to calculate and eliminate the magnification factor, so in CBCT there is no magnification and measurements are reported to be reliable and anatomically accurate.[9] Other advantages of CBCT are lower costs, increased accessibility to orthodontic practitioners, flexibility in the field of view, and submillimeter spatial resolution. Gribel *et al*.[7] concluded that CBCT craniometric measurements are accurate to subvoxel size and can be used as orthodontic diagnostic tool potentially. Park *et al*.[27] concluded that 3D measurements are better than 2D lateral cephalogram wherein superimposition led to different angular and linear measurements.

Inclines serve like natural dentition, vertical eruption of posterior teeth can be easily controlled, less obstructive during speech, lateral movements of the jaw, and other oral functions. Furthermore, the appliance design is simple over one-piece appliance.[9,11]

Many controversies exist regarding the effects produced by the functional appliances. Many studies showed that both skeletal and dentoalveolar changes results from functional appliances.[28] With the recent advances in technology, it is now possible to evaluate skeletal and dental changes quantitatively with the help of CBCT. In the present study, skeletal changes were evaluated, which include ramus height, corpus length, and gonial angle, as shown in Tables 3-5 (angular measurements and linear measurements). CBCT of full skull was taken before and after TB therapy, and the results are discussed below.

The condyle is the growth site of the mandible and plays an important role in the growth and development of the mandible. Gonial angle is formed between the tangents to the posterior border of the mandibular ramus (Ar-Go) and inferior border of the body of the mandible (Go-Me). Gonial angle indicates the rotation of the mandible. CBCT showed increased gonial angle which indicates the downward growth of the mandible. In this present study, the mean difference increase of 3.18° in the gonial angle between pre- and post-treatment period was statistically significant as shown in Table 5. The reported increase in the current study was greater than the increase produced by TB appliance as reported in randomized clinical trials and controlled clinical trials included in a recent systematic review. Mills and McCulloch[22] found that the mandibular plane angle and the anterior facial height were significantly increased in the TB group more than in the control group.

Ramus height is formed by the tangents to the posterior of mandibular ramus (Ar-Go). CBCT shows comparison of the mean ramus height (mm) between pre- and post-treatment periods [Table 3]. In the study, the mean difference increase of 1.23 mm in the ramus height between pre- and post-treatment periods was statistically significant. Elfeky *et al*. showed in his study that there was a net result of an increase in both ramal (3.47 mm) and body length (2.96 mm). The overall mandibular skeletal changes could be attributed to the increase in mandibular length by 3.19 mm.

Corpus length is formed by the tangents to lower border of the mandible (Go-Me). CBCT showed the comparison of the mean corpus length (mm) between Pre and Post TREATMENT periods [Table 4]. In this study, the mean difference increase of 3.35 mm in the corpus length between pre and post treatment period was statistically significant.

## CONCLUSION

The following conclusions were drawn from this study, which evaluates the skeletal changes following the TB appliance therapy:

- TB Appliance therapy increases the ramus height stimulating growth of condyle in backward and upward direction
- TB appliance therapy increases the corpus length by stimulating growth of condyle in backward and upward direction

- TB appliance therapy increases the gonial angle by backward rotation of mandible.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Nil.

### Conflicts of interest

There are no conflicts of interest.


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