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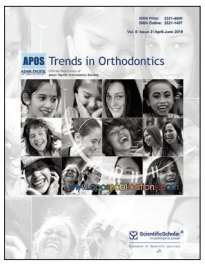

Original Article

Temporomandibular joint and skeletal changes in response to Twin block and Advansync appliance therapy – A three dimensional study

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ABSTRACT

Objectives: This study aimed to analyze and compare the temporomandibular joint (TMJ) and skeletal changes three dimensionally in growing patients with Class II malocclusion treated with the Twin block (TB) and Advansync appliance.

Material and Methods: This prospective study included 20 patients with Class II Division 1 malocclusion of which ten patients comprised the TB group and ten patients the Advansync group. Cone-beam computed tomographs were taken before treatment, and at the end of the functional phase (6–8 months). The condyle, glenoid fossa, and skeletal changes were assessed in all the three planes and the measurements were made using CARESTREAM software.

Results: The TB group demonstrated a significant increase in the condylar dimensions, superior joint space, mandibular length ($P = 0.005$), and decrease in anterior joint space ($P = 0.001$) in response to treatment and the Advansync group showed a significant increase in the condylar dimensions, mandibular length, and a significant restriction in the maxillary length. Comparison between the two groups showed a significant increase in the fossa depth in the TB group and restriction in the maxillary growth in the Advansync group.

Conclusion: TB and Advansync group showed TMJ and skeletal changes. However, the Advansync showed more headgear effect but less glenoid fossa changes compared to the TB group.

Keywords: Orthodontic appliances, Functional, Angle Class II, Twin block, Advansync

INTRODUCTION

Mandibular retrognathism is the most common characteristic of skeletal Class II malocclusions.[1] The treatment of skeletal Class II malocclusion depends on the age,[2] growth potential, severity, and patient compliance.[3] In growing patients, the functional appliance is the treatment of choice.[4] Of the removable functional appliances, Twin block (TB) is the most commonly used appliance because of the design that permits full time wear and the inclined plane that serves as natural dentition.[5,6] The treatment outcome with a removable appliance depends on patient compliance. The previous studies have showed that the non-compliance rate of TB appliance ranged from 15% to 16%.[7,8]

The need for cooperation is reduced with the use of fixed functional appliances (FFAs). FFAs are indicated at or after the end of peak pubertal growth velocity. Treatments with most of

the FFA are carried out in two phases which leads to an increase in treatment duration. Herbst being a prototype of FFA runs between the maxilla and mandible forming an artificial joint.[9]

Advansync appliance (Ormco Co, Glendora, Calif) also known as the "Molar to Molar appliance" was designed to simultaneously advance the mandible and use along with the Fixed appliance.[10] The appliance consists of telescopes that are placed from the maxillary molar to the mandibular molar bands. The appliance consists of spacers of 1 mm and 2 mm in size which are crimped on the telescopes. Advansync appliance can be used earlier than other FFA utilizing the pubertal growth velocity because the telescopes are placed from the maxillary molar to the mandibular molar bands which allows the clinician to use it during the initial archwire stages and also in mixed dentition period. There are a few studies that have evaluated the effects of Advansync using lateral cephalogram and found that the Advansync has a restraining effect on the maxilla,[10,11] increase in mandibular length at the end of post-functional phase[10] and proclination of the lower incisors thereby normalizing the Class II malocclusion.[10,11] Limitations of 2D images are magnification,[12] patient positioning errors,[13] and obstruction of critical landmarks.[14] To overcome these inadequacies of lateral cephalograms, three dimensional imaging is used.

While it is desirable that functional appliances bring about maximum skeletal change, the treatment effects usually are a combination of skeletal and dental changes. The effects of functional appliances includes remodeling of the condyle and glenoid fossa. A few cone beam computed tomography (CBCT) studies have evaluated the dentoskeletal effects of Advansync and found favorable changes in normalizing Class II but have attributed it to predominantly dental changes.[15,16] One study did find changes in condylar volume[17] but no studies have explored the treatment effects of the Advansync appliance on the condylar and glenoid fossa as compared to other functional appliances. Since TB is recommended during the peak growth velocity,[18] this study was designed to evaluate the temporomandibular joint (TMJ) and skeletal changes of Advansync appliance using CBCT and compare these to the TB.

MATERIAL AND METHODS

This prospective study was conducted and ethical approval was obtained from SRIHER Institutional Ethics Committee (Number CSP/18/APR/67/77). The inclusion criteria were patients with Class II skeletal relationship with an ANB >4°, Increased Overjet (≥5 mm), Class II molar relationship of half a cusp (end-to-end) or greater, horizontal to average growth pattern with Go-Gn to SN – 32 ± 2°, cervical vertebral maturation index (CVMI) stage between CS2 and CS4 at the beginning of treatment. Patients with any history of trauma, congenitally missing or extracted permanent tooth, craniofacial anomalies, and TMJ disorders were excluded from the study.

Sample size calculation was done using the mean values in the Point B changes (2.62 ± 1.08 and 1.49 ± 0.79 mm) from the article by LeCornu *et al*.[19] The alpha significance level of 0.05 with a power of 80 and the effect size was 1.1942.

Hence, 20 patients who were to undergo functional appliance therapy were included in the study, after being screened as per the inclusion and exclusion criteria.

The patients were explained about the treatment and informed consent was obtained from the patient and their parents. Patients were assigned to one of the two groups: TB (Group A) and Advansync (Group B). Essential diagnostic records were taken for all 20 patients. The mean age and CVMI stage of patient at the time of appliance insertion are listed in [Table 1]. Patients were matched with regard to age, CVMI, ANB, and growth pattern.

For TB appliance fabrication, construction bite did not exceed more than 70% of the total protrusive path.[20] Standard TB appliance consisting of upper and lower acrylic plates with bite blocks inclined at an angle of about 70° was inserted.

For the Advansync group, maxillary and mandibular arches were bonded from second premolar to second premolar 0.022 × 0.28-inch slot size. Bands were selected for maxillary and mandibular molars from the four available sizes[4-7] and the Advansync appliance was placed. Patients were recalled to check the correction of mandibular advancement once in 6–8 weeks and spacers of 1 or 2 mm were placed for further activation until a Class I molar and canine relationship was achieved.

CBCT scans were taken at2-time intervals, that is, at pre-treatment (T0) and at the completion of functional appliance phase (T1) approximately 6–8 months after appliance placement. CBCT images were taken with Kodak CS 9500 extraoral Imaging system (Carestream health, Rochester, New York, U.S.A) with set as follows: 15 × 18 cm field of view, 90 kV, 10 mA, 20 s exposure, with an axial slice thickness of 0.200 mm. The raw images were exported into Digital Imaging and Communications in Medicine multifiles by using the CS 3 D imaging software.

The CBCT scans were evaluated using CARESTREAM software (Carestream health, Rochester, New York) that incorporates the 3D module. The T0 and T1 images of TMJ, maxilla and mandible were evaluated in axial, coronal, and sagittal planes.

The slice which had the greatest dimensions of both left and right condylar heads in all three planes was selected.[21-23] In each section, the landmarks were identified and lines were

Table 1: Descriptive statistics for TB and Advansync group.

Measurement	TB mean	SD	Advansync mean	SD	*P*-value	Significance
Age	12.62	0.38	13.25	1.54	0.08	NS
CVMI	2.70	0.68	3.30	0.95	0.12	NS
ANB	6.15	1.49	5.87	1.54	0.68	NS
Go-Gn to SN	28.70	2.40	29.00	3.23	0.81	NS

TB: Twin block, SD: Standard deviation, CVMI: Cervical vertebral maturation index, NS: Not significant

drawn to assess the following parameters. The landmarks and planes used are defined in [Table 2] and the parameters assessed are explained in [Table 3a and 3b]. The measurements made in the CBCT slices in an axial plane are depicted in [Figure 1a-d], in the sagittal plane are depicted in [Figure 2a-f] and for the transverse plane in [Figure 3]. For evaluating mandibular length, the plane was selected such that the most superior point in the condyle(Sco) and Pogonion(Pg) are in the same slice as described by Hilgers *et al*.[21]

The measurements were performed by the same examiner for five patients in each group with 1 month of interval between measurements. Bland and Altman plot was applied to assess the reproducibility, and no significant differences were found between the first and second measurements. The error of the method was calculated with the intraclass correlation coefficient test.

Statistical analysis

Data were analyzed with IBM. Statistical Package for the Social Sciences statistics software Version 23.0. Descriptive statistics such as mean and standard deviation were used to describe the data. The Shapiro–Wilk test for normality showed that the data were normally distributed, hence to find the significant difference between the bivariate samples in paired groups, the Paired sample t-test was used and for independent groups, the Unpaired sample *t*-test was used. In both the above statistical tools, $P \leq 0.05$ was considered as significant level.

RESULTS

CBCT measurements pre- and post-treatment for both TB and Advansync are presented in [Table 4]. Intragroup changes and intergroup differences are presented in [Table 5].

The results of paired *t*-tests comparing changes between T0 and T1 within the TB group showed a significant increase in the condylar dimensions, fossa depth, posterior joint space, mediolateral position of the condyle, and maxillary and mandibular length. A significant decrease in anterior joint space was also seen.

In the Advansync group, there was a significant increase in the condylar dimensions except in the condylar axis angle and medio-lateral condylar position. However, the changes in glenoid fossa dimensions and joint space were not significant. A significant increase in the mandibular length was also noted with an insignificant increase in maxillary length.

The mean difference between T1 and T0 observed in each group was compared and the result of the independent sample *t*-test is presented in [Table 5]. Although there was no significant difference in condylar changes between the groups, the TB group showed increased fossa depth when compared with the Advansync group. There was no significant difference in the increase in mandibular length between both the groups but there was a lack of significant increase in the maxillary length in the Advansync group when compared with the TB group.

DISCUSSION

Several theories have been suggested to explain the Modus operandi of functional appliances. While skeletal changes are the desired effects sought in functional appliance treatment, changes can be due to one or more combinations of the following reasons. Dentoalvelolar changes, mid face restriction, mandibular growth induction, redirection of condylar growth, deflection of ramal form, changes in the neuromuscular anatomy and function and finally the adaptive changes in the condyle and glenoid fossa.[24]

Studies by Elfeky *et al*.,[25] Vedhavathi and Chirag,[26] Yildirim *et al*.,[27] and Jiang *et al*.[28] evaluated the changes following TB appliance therapy using 3D models of CBCT images. These studies showed that there was an increase in condylar width, length and height, intercondylar distance and increase in the mandibular length, reduced anterior joint space, and increased posterior joint space. Vedhavathi and Chirag[26] also evaluated the effects of TB using 2D slices of CBCT images and found that there was an increase in the condylar volume, intercondylar distance, and mandibular length.

Dentoalveolar changes with minimum headgear effect have been reported with Advansync,[11] while another study showed both maxillary and mandibular changes comparable to Mandibular Anterior Repositioning Appliance.[10] Since 2D studies have their limitations, this prospective study was designed to evaluate the TMJ, maxillary, and mandibular

Table 2: Landmarks and planes.

Landmark	Description
Axial section	
C	Geometric centre of the condyle
MCo	Most medial point of the condyle
LCo	Most lateral point of the condyle
ACo	Most anterior point of the condyle
SCo	Most superior point of the condyle
PCo	Most posterior point of the condyle
Vomer	An unpaired facial bone in the midsagittal plane that rests between the left and right nasal cavities
Basion, B	Most posterior point of the occipital bone, anterior border of foramen magnum, and axial plane
Plane	
Mid sagittal plane	Line connection Vomer and Basion
Sagittal section	
ACo	Most anterior point of the condyle
SCo	Most superior point of the condyle
PCo	Most posterior point of the condyle
AE	The most inferior point in the articular eminence
EAM	Circular radiolucency defining the orifice of the external ear
EAMi	Most inferior point in external auditory meatus
SF	Superior aspect of glenoid fossa
Sigmoid notch (Infsig)	Most inferior point of sigmoid notch
Infsig'	Point describing the level of the sigmoid notch measured perpendicular to the posterior ramus tangent
POg	Most anterior midsagittal point along convexity of chin of mandibular body viewed sagittally
Go	Point midway along curvature of angle of mandible between inferior border of body and Posterior border of ramus of mandible viewed sagittally
ANS	Tip of bony anterior nasal spine
Planes	
True horizontal line	Tangential to the roof of the glenoid fossa
Coronal section	
LCo	Most lateral point of the condyle
MCo	Most medial point of the condyle

ANS: Anterior Nasal Spine

changes following Advansync appliance therapy using CBCT and to compare it with the changes produced by the TB. Since Advansync can be used in younger patients, the effects were compared to TB which is recommended during the pubertal growth spurt. The sample in our study consisted of growing children between the age of 12 and 15 years with a mean age

Table 3a: Parameters measured in the axial section [Figure 1].

Parameter	Description
Condylar width	Distance from LCo to MCo [Figure 1a]
Condylar length	Distance from ACo to PCo [Figure 1b]
Condylar axis angle	Angle between LCo-MCo and mid sagittal plane [Figure 1c]
Mediolateral condylar position	Linear measurement from the center of the condyle (C) to the mid sagittal plane perpendicularly [Figure 1d]

Table 3b: Parameters measured in the sagittal section [Figure 2].

Parameter	Description
Condylar length	Distance from ACo to PCo [Figure 2a]
Fossa width	Measured from AE to the most inferior point of the EAM (EAMi) [Figure 2b]
Fossa depth	Measured from SF to the plane formed by the fossa width [Figure 2b]
Superior joint space	Measurement from SCo to the SF [Figure 2c]
Anterior joint space	Linear distance from the anterior condyle to the corresponding glenoid fossa bone [Figure 2c]
Posterior joint space	Linear distance from posterior condyle to the corresponding glenoid fossa bone [Figure 2c]
CH	Measurement from SCo to the plane formed from Inc to Inc' [Figure 2d]
Maxillary length	Linear distance between ANS and PNS [Figure 2e]
Mandibular length	SCo Linear distance between POg and mandibular condyle in sagittal plane [Figure 2f]

ANS: Anterior Nasal Spine, PNS: Posterior nasal spine

of 12.62 ± 0.62 years in TB group and 13.5 ± 1.4 years in the Advansync group. Functional appliances produce maximum skeletal change when used during or immediately after the onset of pubertal peak.[20] For ethical reasons, a control group of untreated Class II was not included since this would involve exposing them to CBCT radiation at 2 time intervals.

TMJ adaptations and skeletal changes following functional appliance have been visualized by various techniques such as cephalograms,[8] single-proton emission computed tomography (CT),[24] CBCT,[25-27] and MRI.[29,30] CBCT techniques produces accurate images with high resolution and minimal distortion and allows the creation of three dimensional images in sagittal, coronal, and axial planes[31] In assessments of the craniofacial structures, CBCT was more adequate at an effective dose of only 50 μSv when compared to CT which requires around 2000 μSv.[31] It is possible to make precise measurements of craniofacial structures since there are no projections or overlapping of bilateral structures.

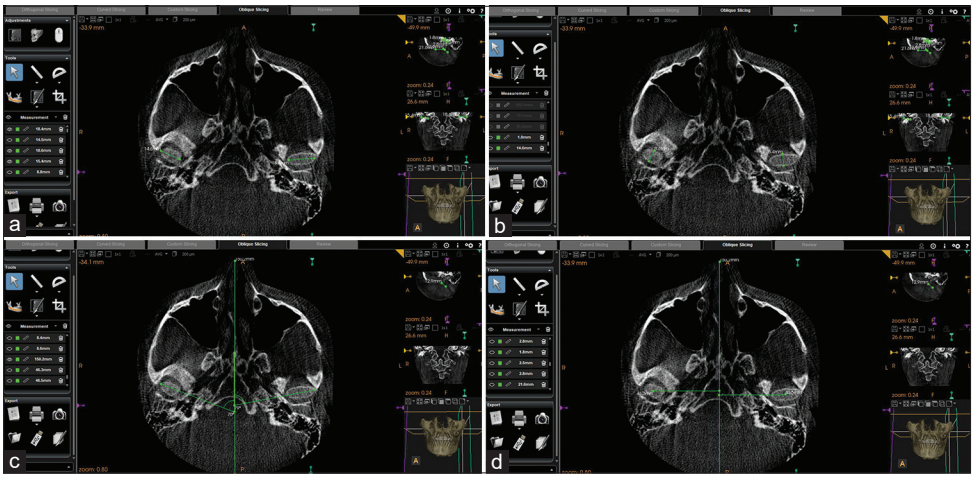

Figure 1: (a) Condylar width (b) Condylar length, (c) Condylar axis angle, (d) Mediolateral condylar position.

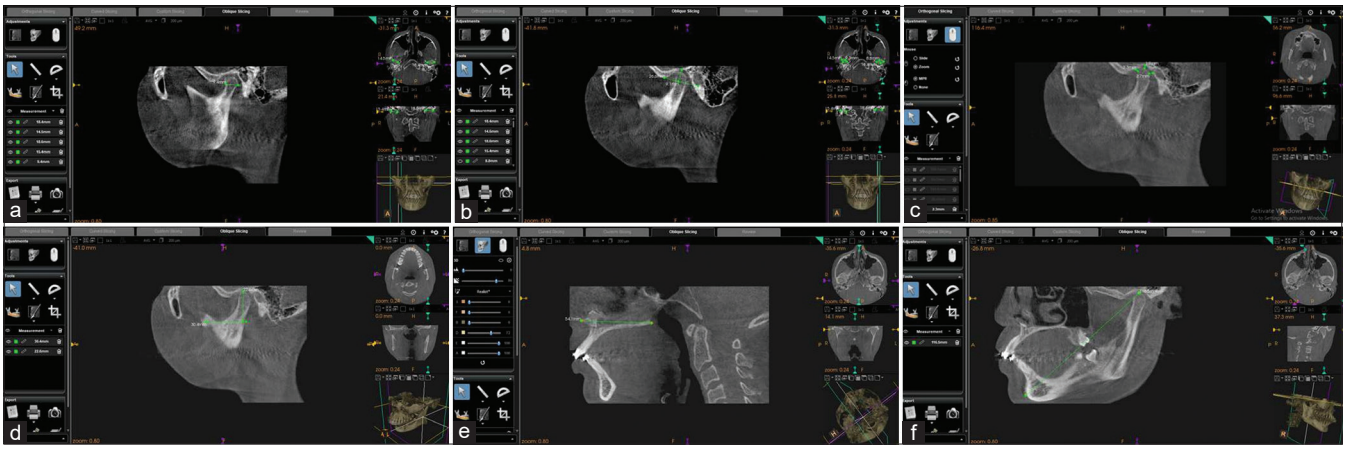

Figure 2: (a) Condylar length, (b) Fossa width and length, (c) Anterior joint space, Superior Joint space, Posterior Joint space, (d) Condylar height, (e) Maxillary length, (f) Mandibular length.

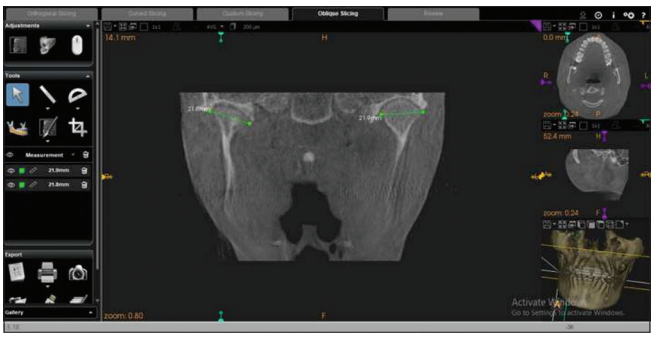

Figure 3: Condylar width.

Dahiya *et al.*[17] demonstrated that Advansync did bring about increase in the condylar volume but they did not compare it to any other appliance. Moreover, Da Neiva *et al.* showed that landmark identification was more reliable in 2D multiplanar view[32] and Fernandes *et al.* demonstrated that linear measurements were more accurate and reliable in 2D multiplanar view when compared with 3D rendered images.[33] Grauer *et al.* also suggests that the multiplanar view gives a more accurate quantitative assessment, whereas the 3D rendered objects may be adequate for qualitative assessment.[34] Hence, we choose to measure the condyle/glenoid fossa changes in a 2D multiplanar view.

The results of our study showed that there was a statistically significant increase in the condylar width, condylar height and condylar length in both TB and Advansync group and these changes were comparable [Table 4]. It has been proposed that the condyle can increase in size due to the activity of the lateral pterygoid muscles.[35]

The positional changes of condyle were assessed with the condylar axis angle and mediolateral condylar position [Table 5]. There was a reduction of condylar axis angle in both the groups but this was not statistically significant. Based on a previous study, this change might be interpreted

Table 4: Means and standard deviations of CBCT measurements in T0 and T1.

Variables	Twin block (Group A)			Advansync (Group B)		
	T0 (Mean±SD)	T1 (Mean±SD)	*P*-value	T0 (Mean±SD)	T1 (Mean±SD)	*P*-value
Condylar changes						
Condylar width (axial)	18.35±1.89	19.62±2	0.010*	17.43±1.52	18.50±1.39	0.005*
Condylar width (coronal)	18.42±1.99	19.68±1.95	0.021*	17.46±1.07	18.83±1.43	0.006*
ACo-PCo (axial)	7.17±1.0	7.99±0.90	0.09*	7.97±1.28	8.47±1.08	0.016*
ACo-PCo (sagittal)	7.49±0.83	8.16±0.84	0.021*	7.94±1.28	8.47±1.08	0.009*
Mediolateral condylar position	47.12±2.1	48.1±1.86	0.012*	47.02±2.84	47.03±2.47	0.97
Condylar axis angle	65±3.8	63±5.4	0.17	69.2±4.6	66.95±5.04	0.18
Condylar height	17.58±1.04	18.93±1.4	0.018*	17.54±1.59	18.59±1.4	0.012*
Gleniod fossa changes						
Fossa depth	6.86±0.82	8.11±0.74	0.001*	7.93±1.13	8.39±0.99	0.10
Fossa width	23.02±1.48	23.8±1.37	0.106	24.14±2.0	24.36±1.81	0.60
Joint space changes						
Anterior joint space	1.64±0.20	1.36±0.20	0.0001*	1.92±0.35	1.56±0.43	0.11
Superior joint space	2.1±0.33	2.34±0.53	0.29	2.27±0.49	2.49±0.50	0.17
Posterior joint space	1.96±0.24	2.10±0.27	0.01*	1.89±0.46	2.12±0.49	0.31
Maxilla and mandible						
Maxilla length	49.23±2.83	50.85±3.59	0.016*	51.8±1.24	51.87±1.13	0.76
Mandibular length	106.57±3.61	110.45±2.96	0.005*	109.49±3.16	112.46±3.37	0.005*

PCo: Posterior condylar point, ACo: Anterior condylar point, CBCT: Cone beam computed tomography, SD: Standard deviation, *$P<0.05$

Table 5: Comparison of changes between groups.

Variables	Twin block		Advansync		Intergroup difference
	Mean of difference	SD	Mean of difference	SD	*P*-value
Condylar changes					
Condylar width (axial)	1.27	1.24	1.07	0.93	0.68
Condylar width (coronal)	1.25	1.42	1.37	1.20	0.84
ACo-PCo (axial)	0.82	0.77	1.02	1.09	0.64
ACo-PCo (sagittal)	0.67	0.75	0.53	0.50	0.63
Mediolateral condylar position	0.95	0.96	0.006	0.060	0.057
Condylar axis angle	−2.00	4.08	−2.25	4.96	0.90
Condylar height	1.35	1.48	1.05	1.05	0.60
Gleniod fossa changes					
Fossa depth	1.24	0.80	0.46	0.81	0.04*
Fossa width	0.86	1.51	0.21	1.4	0.33
Joint space changes					
Anterior joint space	−0.28	0.01	−0.36	0.44	0.57
Superior joint space	0.23	0.12	0.21	0.34	0.86
Posterior joint space	0.14	0.19	0.07	0.22	0.45
Maxilla and mandible					
Maxilla length	1.62	1.7	0.06	0.78	0.019*
Mandibular length	3.88	1.92	2.97	0.93	0.20

PCo: Posterior condylar point, ACo: Anterior condylar point, SD: Standard deviation

as the inward rotation of the condylar axis produced condylar surface remodeling.[36]

Mediolateral condylar position showed a mild increase following TB but this was not statistically significant [Table 5], whereas in Advansync group, there was a decrease in the mediolateral condylar position [Table 5]. An increase in the intercondylar distance following TB appliance might be attributed to the deposition of bone in the posterior and superior aspects of the condyle.[26,27]

There was a significant increase in the fossa depth in TB group (P = 0.001), however this was not seen in the Advansync group. A CBCT study by Jiang *et al*.[28] showed

glenoid fossa remodeling that adapted to the condyle changes following TB therapy. Single-step advancement was done in the TB group whereas incremental advancement was done in the Advansync group as recommended by Terry and Dischinger hence which could have been the reason for the significant change in the fossa width in TB group.

An increase in the posterior joint space (P = 0.01) and a decrease in the anterior joint space (P = 0.001) in TB group were noted and these changes were statistically significant [Table 5]. The results seen in the TB group were in accordance with the previous studies.[25,28] These changes are attributed to the anterior and inferior movement of the condyle with forward positioning of the mandible by the appliance.

Increase in mandibular length by 3.88 mm (P = 0.005) following TB appliance therapy [Table 5] was in accordance with previous studies.[25,26,27] In Advansync group, there was an increase in the mandibular length by 2.97 mm (P = 0.005) [Table 5]. While this was similar to the findings of some studies,[10,17] other studies attributed the normalized changes to minimum skeletal changes and mostly dental changes.[15,16] Jayachandran *et al.*[11] showed that there was no change in the mandibular length when compared with the untreated controls. Change in the mandibular length >2 mm in both the groups within a period of 6–8 months may be considered as clinically significant.

TB group showed an increase in the maxillary length by 1.62 mm during the study period. Since the increase in maxillary length was insignificant in the Advansync group, it appears that the appliance has a restraining effect on maxilla which has been suggested by previous studies.[10,11] [Table 5] Study by Al Jewair *et al.* showed restriction of maxillary length by 1°(SNA) [10] and Jayachandran *et al.* demonstrated a reduction in maxillary length by 2°(SNA).[11] In contrast to our results, Elfeky *et al.*[25] showed a mild headgear effect in TB group when compared with the untreated controls.

Short term changes produced by TB and Advansync appliance are elaborated in this study. Further studies are needed to evaluate the long-term changes in TMJ following these appliances.

CONCLUSION

This prospective and clinical study comparatively evaluated condyle, glenoid fossa, maxillary, and mandibular changes following TB and Advansync appliance therapy using CBCT and the following conclusions were drawn.

1. There was a significant increase in the condylar height, width and length, mandibular length, fossa depth, superior joint space, and reduction in the anterior joint space following TB therapy
2. Advansync appliance had a significant increase in condylar width and height, mandibular length and restriction in the maxillary length
3. Comparison of TB and Advansync showed that TB had a greater increase in the fossa depth and Advansync had a greater restraining effect on the maxilla.

Declaration of patient consent

Institutional Review Board (IRB) permission obtained for the study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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