ORIGINAL RESEARCH

Comparison of Skeletal Changes in the Temporomandibular Joint between the Twin Block Appliance and Fixed Functional Appliance: A Longitudinal Follow-up Study

Bhakti Halapanavar[1], Padmini MN[2], Sonali Deshmukh[3], Sunnypriyatham Tirupathi[4], Afshan S Waremani[5], Aniket Kasodekar[6]

Abstract

Aim: This current study evaluated and compared the skeletal changes in the head of the condyle, glenoid fossa, and articular space between the twin block appliance and PowerScope™ a fixed functional appliance.

Materials and methods: This study was a pilot, randomized, single-blinded, assessing the skeletal changes in the components of the temporomandibular joint (TMJ) using cone-beam computed tomography (CBCT). The study was conducted in 20 subjects in the age range of 11–14 years with class II division 1 malocclusion. These subjects were distributed randomly between two groups with an allocation ratio of **1:**1 (group I—twin block and group I—PowerScope™). Follow-ups of both groups were done till desirable skeletal correction was attained (clinical edge-to-edge incisor relation).

Results: Condylar parameters such as position, height, and length were evaluated bilaterally in the CBCT scans. After using both devices, there was an increase in all condylar qualities; however, the twin block appliance showed a more noticeable difference, which has been determined to be statistically significant. In the twin block group, there was an average decrease of 0.56 mm in the anterior articular space and an increase of 1.2 and 2.64 mm in the middle and posterior articular spaces, respectively. In the PowerScope™ group, there was an average decrease of 0.23 mm in the anterior articular space and an increase of 2.55 and 1.85 mm in the middle and posterior articular spaces, respectively. In the case of the twin block device, the change in glenoid fossa angle was observed to be 6.1 mm on both sides and a mean difference of 1.25 mm on the right-side and 1.75 mm on the left-side was observed in the case of PowerScope™. The difference was established to be significant with a $p < 0.05$ in all cases.

Conclusion: Condylar attributes increased after the application of both devices but the difference was more pronounced in the case of twin block appliances. The difference in articular space (middle and posterior) between the twin block group and PowerScope™ group, was not significant statistically. In the present study, the remodeling in the glenoid fossa was greater in the twin block group compared to the PowerScope™ group.

Keywords: Children, Functional therapy, Growth, PowerScope™, Skeletal, Twin block.

International Journal of Clinical Pediatric Dentistry (2024): 10.5005/jp-journals-10005-2727

Introduction

Mandibular retrognathia, which results in skeletal class II malocclusion during active skeletal growth and has a profoundly unsightly effect on facial profile, is frequently corrected using the functional orthopedic method.[1] Adaptation of the condylar cartilage to mandibular forward positioning constitutes the fundamental rationale for orthodontic functional therapy. Detachable or fixed functional appliances aid in forward mandibular relocation to maximize the development of the face skeleton, potentially by adaptive alterations in the glenoid fossa and growth regulation of the condylar cartilage.[2,3] The twin block appliance is the most widely used detachable functional appliance in terms of patient acceptance and effectiveness, but it requires several phases of therapy, which adds significantly to the appliance's duration and expense.[4] In contrast, fixed functional devices that can be worn full-time in association with multibracket therapy facilitate the correction of class II malocclusion and dental anomalies in a single phase, resulting in shorter and less expensive treatment courses.[5] Several fixed functional devices are routinely used in dentofacial treatments which include the rigid type Herbst, the Jasper Jumper, and the Churro Jumper devices, and the semirigid (or hybrid) appliances like Eureka Spring, Forsus Fatigue Resistant device, and the recent introduced PowerScope™.[6] Research has indicated that the utilization of rigid appliances

[1,3]Department of Orthodontics & Dentofacial Orthopedics, Dr DY Patil Dental College and Hospital, Dr DY Patil Vidyapeeth (Deemed to be University), Pune, Maharashtra, India

[2]Department of Orthodontics, Government Dental College and Research Institute, Bengaluru, Karnataka, India

[4]Department of Pediatric and Preventive Dentistry, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, Chennai, Tamil Nadu, India

[5]Department of Orthodontics, Dayananda Sagar College of Dental Sciences, Bengaluru, Karnataka, India

[6]Department of Orthodontics, Maratha Mandal's Nathajirao G. Halgekar Institute of Dental Sciences & Research Centre, Belagavi, Karnataka, India

Corresponding Author: Sonali Deshmukh, Department of Orthodontics & Dentofacial Orthopedics, Dr DY Patil Dental College and Hospital, Dr DY Patil Vidyapeeth (Deemed to be University), Pune, Maharashtra, India, Phone: +91 9371009387, e-mail: sonalivdeshmukh@gmail.com

How to cite this article: Halapanavar B, MN P, Deshmukh S, *et al.* Comparison of Skeletal Changes in the Temporomandibular Joint between the Twin Block Appliance and Fixed Functional Appliance: A Longitudinal Follow-up Study. Int J Clin Pediatr Dent 2024;17(1):7–14.

Source of support: Nil

Conflict of interest: None

has been beneficial in attaining a broader skeletal effect. This is primarily because the therapy-induced anterior posture of the jaw stimulates adaptive osseous remodeling processes in the temporomandibular joint (TMJ).[7]

Cone-beam computed tomography (CBCT) is another important advance in orthodontic imaging studies on functional jaw orthopedic to quantify the skeletal changes produced by functional devices.[8] The benefits of CBCT over typical CT systems include reduced radiation exposure and expense.[9] This technique has been proven to have high accuracy compared to other imaging techniques such as magnetic resonance imaging (MRI).[10] With the aid of CBCT, physicians, and researchers may more accurately image the TMJ and assess changes in the condyle, glenoid fossa, and articular space in three dimensions as a result of functional appliance therapy. Using CBCT, the current study aimed to assess and compare the skeletal alterations in the glenoid fossa, condylar head, and articular space with fixed functional appliance and Twin block appliance. PowerScope™ appliance was selected as the fixed functional appliance in this study as studies pertaining to this appliance are lacking in the reported literature.

Materials and Methods

This study was a pilot, randomized, single-blinded, assessing the skeletal changes in the glenoid fossa, condylar head, and articular space between the twin block appliance and fixed functional appliance using CBCT. The study was conducted in 20 subjects in the age range of 11–14 years with class II division 1 malocclusion increased overjet between 6 and 7 mm and deep bite. All the subjects were assessed for skeletal maturity (cervical vertebral maturity indicators) and were staged amidst cervical vertebral maturation index stages II and III. Subjects with a history of periodontal disease, previous orthodontic treatment, TMJ disease, and systemic diseases affecting bone metabolism were excluded from the study. A detailed case history, clinical examination, extraoral photographs, intraoral photographs with orthopantomogram, and lateral cephalogram were obtained at the start of the study. Cephalometric analysis was performed to confirm the retrognathic mandible, orthognathic maxilla, and growth pattern. All the subjects were informed about the procedures to be performed and signed informed consent was obtained from the parent/guardian, as the subjects were minors. A total of 20 subjects conforming to the inclusion criteria mentioned above were divided into two groups of 10 participants each. Group I ($n = 10$) was fitted with a twin block appliance and group II ($n = 10$) was treated with a PowerScope™ appliance. Individuals who satisfied the requirements were added one at a time and assigned at random, 1:1, to either the twin block or PowerScope™ groups. To guarantee even participants in each group, a block of six numbers—three odd and three even—was used after a random number table. The PowerScope™ was assigned even numbers, and the twin block was assigned odd numbers. The cards were placed in opaque sealed envelopes with numbers inscribed on them. The participant's allocated intervention was concealed from the examiner who evaluated the CBCT. Prior to the measurements, patient information was hidden and their numbers were changed at random. The group allocation process was concealed and randomized using sequentially numbered opaque, sealed envelopes in order to reduce the possibility of bias. There was no need for interim analyses. Intervention for group I, impression and bite registration were taken and standard design twin block was fitted to achieve class I occlusion. Subjects were instructed to wear the appliance 24 hours daily and maintain good oral hygiene. Initial follow-up was carried out at 10 days of insertion and further follow-ups were carried out at 4 weeks intervals up to 7–9 months. Trimming of maxillary blocks was started upon achievement of the pterygoid reflex. Trimming was carried out on both sides of the maxillary bite block (1–2 mm each side/month) so as to encourage eruption of lower molars leaving a wedge-shaped inclined plane in the premolar region. The total duration from placing of twin block appliance to the attainment of class I occlusion was 7–9 months, which was successfully implemented in eight of the 10 participants since two subjects did not turn up for follow-ups. For Group II, preadjusted (0.022×0.028) edgewise McLaughlin, Bennett, and Trevisi brackets (American Orthodontics, Sheboygan, Wisconsin, United States of America) were bonded to the subjects' teeth. After initial leveling and aligning, U/L rectangular stainless steel archwires of dimensions 0.019×0.025 were placed for 1 month. Later, PowerScope™appliance (American Orthodontics, Sheboygan, Wisconsin, United States of America) was placed. Initial follow-up was carried out at 10 days of insertion and further, follow-ups were carried out at four weeks intervals till the end of the study. Activation of the appliance in (2 or 3 mm) was done until edge-to-edge bite was achieved. Similar to group I, the total duration initiation of therapy block appliance to attainment of class I occlusion was 7–9 months, which was successfully implemented in eight of the 10 participants since two subjects lost to follow-up.

Cone-beam Computed Tomography and Data Collection

Cone-beam computed tomography (CBCT) scans were used to quantify the skeletal alterations that the application of functional devices induced in the condylar head, glenoid fossa, and articular space. Before beginning treatment, CBCT scans of the right and left TMJ were performed using the KODAK 9000 three-dimensional (3D) Extraoral Imaging System (Carestream Health, Rochester, New York) at an exposure time of 24 seconds and a dose of 218 mGymm.[11] The purpose of the scans was to evaluate changes in the glenoid fossa and articular space, as well as the position, length, and height of the condyles. Data was exported to CS 3D imaging software (Carestream Health, Rochester, New York) as images in digital imaging and communications in medicine format. The measurements on the CBCT scan were made using traditional sagittal slicing, a made-up horizontal line that goes through the external auditory meatus. The drawing of the acoustic meatus was made parallel to the Frankfurt horizontal plane. After aligning the CBCT section to achieve the maximal length and width of the external auditory meatus, a perpendicular to the FH plane was drawn to identify the external auditory meatus's midpoint. A line parallel to the perpendicular to the external auditory meatus' midpoint was drawn from the condylar head's center to produce a linear measurement. By drawing a tangent to the anterior and posterior slopes of the glenoid fossa, the glenoid fossa angle was calculated. For the articular space, a linear measurement between the anterior and posterior slopes of the glenoid fossa and the condylar head at three distinct locations—the anterior, middle, and posterior was made. The condylar head's size was measured linearly between points on its anterior and posterior curvatures, and the condyle's height was measured by drawing a perpendicular from the point on its highest point to a tangent to the deepest point on the sigmoid notch. After the course of therapy, study models were assembled, and upper and lower impressions were made. A lateral cephalogram, as well as extraoral and intraoral photos, were collected during the postadvancement period.

Statistical Analysis

One researcher tracked down and examined every CBCT scan. To minimize errors resulting from investigator tiredness, two CBCTs were evaluated in a single day. Two independent analyses of five randomly chosen CBCT scans were conducted in order to ascertain the intrainvestigator error. To make sure the computed values agreed upon, Altman's analysis was used. The evaluated errors fell within the acceptable range. The acquired data was statistically analyzed. The paired and unpaired *t*-tests were used to tabulate the means, standard errors, and standard deviations. The *p*-values of <0.05 were deemed statistically significant in the analysis of proportions. The statistical analysis of the gathered data was performed using Statistical Package for the Social Sciences statistics for Windows, version 22.0.

Results

The initial participants that were screened for this pilot study consisted of 20 patients. Two patients were excluded from each group—three participants failed to attend follow-up records for 3 consecutive months, and one moved away. A total of 16 participants who fulfilled the inclusion criteria were enrolled and continued to undergo follow-up appointments as per protocol. Table 1 shows variables of age and gender distribution of subjects in the study groups. The average ages of the male and female participants were 12.5 years and 13.08 years, respectively. The number of male participants was significantly higher than the females.

Comparison of Condylar Properties between Twin Block Appliance and PowerScope™ Appliance Pre- and Posttreatment on CBCT Scans

Condylar position (Figs 1 and 2), height (Figs 3 and 4), and length (Figs 5 and 6) were estimated by CBCT scanning of the left and right-sides in both the groups under study. Forward positioning of the mandibular condyle was observed on both sides and for both the appliances used after the therapy duration (Table 2). The shift was more prominent on the left-side in both the twin block appliance (mean difference 2.48 mm) and PowerScope™ (mean difference

Table 1: Mean age and gender distribution of subjects in the study groups

	Twin block appliance		*PowerScope appliance*	
Gender	*Number of participants (% of the total number of participants)*	*Mean age in years standard deviation (±SD)*	*Number of participants (% of the total number of participants)*	*Mean age in years (±SD)*
Male	5 (62.5%)	12.5 ± 2.5	6 (75.0%)	12.5 ± 1.7
Female	3 (37.5%)	12.4 ± 1.9	2 (25.0%)	13.3 ± 0.6

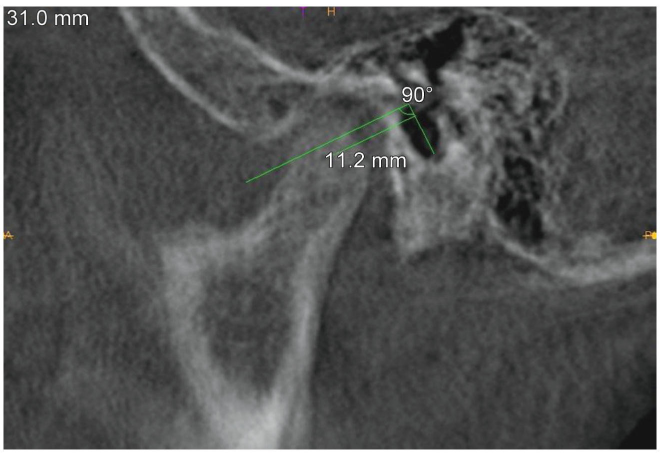

Fig. 1: Cone-beam computed tomography (CBCT) scan of condylar position pretreatment

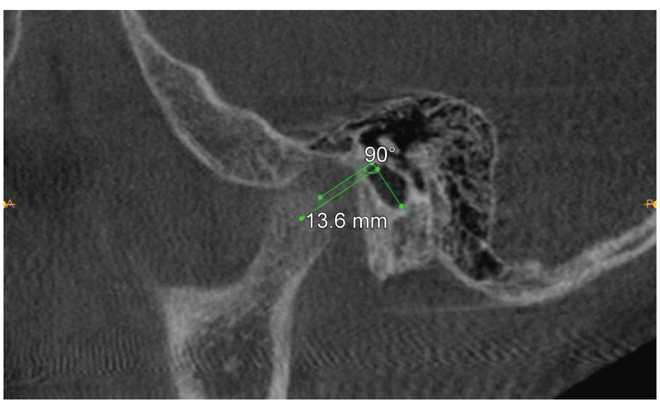

Fig. 2: Cone-beam computed tomography (CBCT) scan of condylar position posttreatment

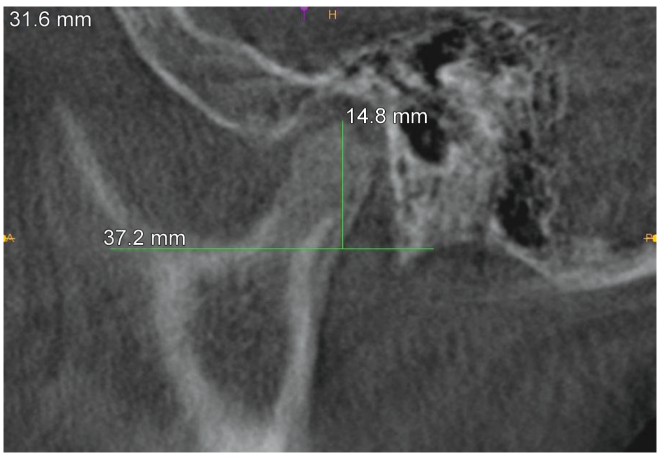

Fig. 3: Cone-beam computed tomography (CBCT) scan of condylar height pretreatment

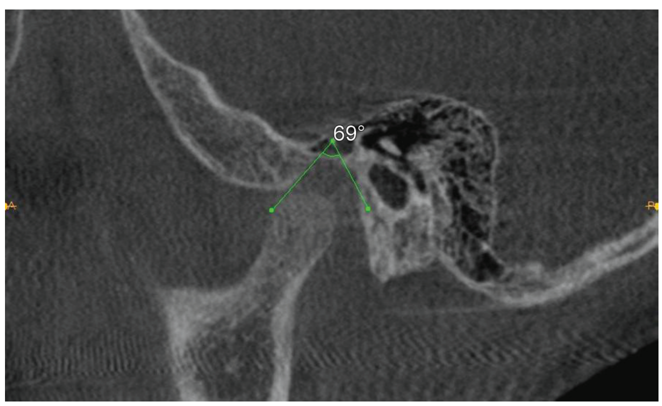

Fig. 4: Cone-beam computed tomography (CBCT) scan of condylar angle posttreatment

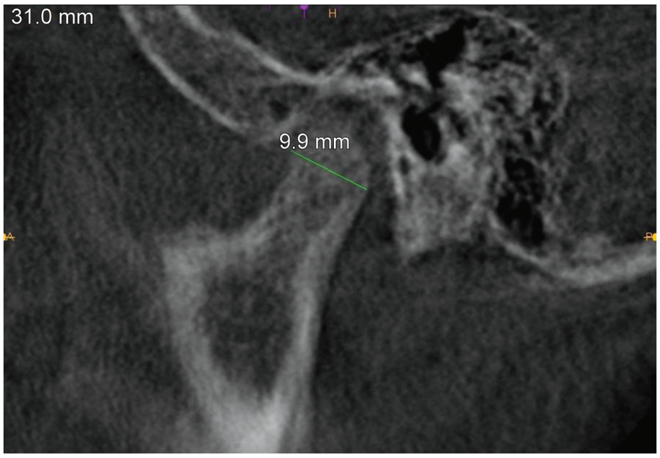

Fig. 5: Cone-beam computed tomography (CBCT) scan of condylar length pretreatment

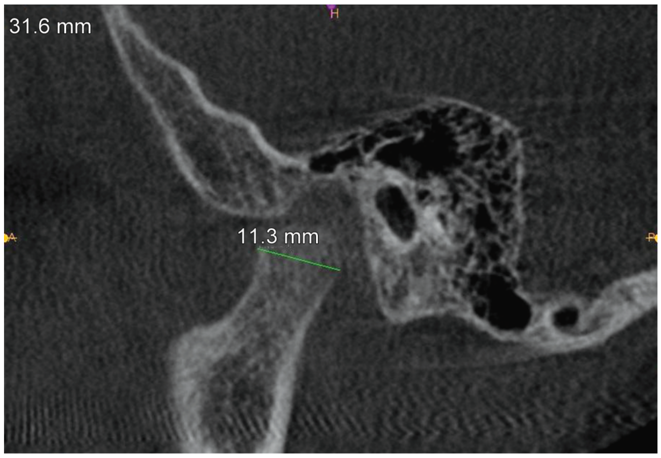

Fig. 6: Cone-beam computed tomography (CBCT) scan of condylar length posttreatment

Table 2: Comparison of condylar properties between twin block appliance and PowerScope appliance pre- and posttreatment on CBCT scans

	Twin block appliance (n = 8)				*PowerScope appliance (n = 8)*			
Condylar properties	*Pretreatment mean (±SD) in mm*	*Posttreatment mean (±SD) in mm*	*Mean difference*	*p-value*	*Pretreatment mean (±SD) in mm*	*Posttreatment Mean (±SD) in mm*	*Mean difference*	*p-value*
Condylar position								
Right	11.88 (±1.05)	13.28 (±0.93)	2.00	0.000*	11.42 (± 1.38)	12.35 (± 1.36)	0.93	0.001*
Left	11.40 (±1.17)	13.88 (±0.95)	2.48	0.000*	11.48 (± 0.49)	12.72 (± 0.57)	1.24	0.000*
Condylar height								
Right	12.37 (±1.59)	14.83 (±1.36)	2.45	0.000*	15.0 (± 1.90)	15.76 (± 1.99)	0.72	0.005*
Left	12.41 (±1.71)	14.76 (±1.39)	2.35	0.000*	15.29 (± 1.93)	15.99 (± 2.10)	0.70	0.003*
Condylar length								
Right	8.10 (±1.33)	9.57 (±1.13)	1.47	0.000*	9.85 (± 0.52)	10.06 (± 0.66)	0.21	0.042*
Left	8.12 (±1.10)	9.82 (±1.01)	1.70	0.000*	9.69 (± 0.54)	10.00 (± 0.76)	0.31	0.012*

Paired *t*-test; significance, 2-tailed; *, $p < 0.05$

1.24 mm) as compared to the right-side (2.00 mm and 0.93 for twin block and PowerScope, respectively). The change in the position of the condyle was more pronounced in the case of the twin block appliance compared to PowerScope™ on both left and right-sides (Table 2). A similar trend was observed for condylar height (mean difference 2.45 mm for the right-side and 2.35 mm for the left-side), length (1.47 mm for the right-side and 1.70 mm for the left-side) for twin block, and that condylar height (0.72 mm for right-side and 0.70 mm for left-side), and length (0.21 mm in right-side and 0.31 mm for left-side) in case of PowerScope™. This shows there is an increase in all condylar attributes after the application of both devices but the difference was more pronounced in the case of twin block appliances, which has been found to be statistically significant.

Comparison of Articular Space between Twin Block Appliance and PowerScope™ Appliance Pre- and Posttreatment on CBCT Scans

Three distinct places along the glenoid fossa and condylar head are measured linearly (Figs 7 to 10). In the twin block group, there was an average decrease of 0.56 mm in the anterior articular space and an increase of 1.2 and 2.64 mm in the middle and posterior articular spaces, respectively. In the PowerScope™ group, there was an average decrease of 0.23 mm in the anterior articular space and an increase of 2.55 and 1.85 mm in the middle and posterior articular spaces, respectively. After the course of treatment, there is a reduction in the anterior region's articular space (0.85 mm on the right-side and 0.58 mm on the left). In this regard, the PowerScope™ equipment showed a little increase in anterior articular space following therapy (Table 3). However, a notable increase in articular space was noted with the PowerScope™ device (2.67 and 2.44 mm on the right and left-side, respectively) and twin block device (2.51 mm on the right-side and 2.77 mm on the left-side). In comparison, the increase in middle articular space was higher in the case of the PowerScope™ device. A similar trend was observed in the difference between posterior articular space pre and posttreatment. As seen in the case of the middle articular space, the effect of the PowerScope™ device is greater (2.00 mm on the right-side and 1.70 mm on the left-side) compared to the twin block device (1.2 mm on both the right and left-side). All the measurements were found to be statistically significant with $p < 0.05$ as determined by the independent *t*-test, except the difference in articular space (middle and posterior) between the twin block group and PowerScope™ group, which was not significant statistically (Table 3).

Comparison of Glenoid Fossa Angle between Twin Block Appliance and PowerScope™ Appliance Pre- and Posttreatment on CBCT Scans

Changes in glenoid fossa angles (Figs 11 and 12) prior to insertion of devices and posttreatment were measured *via* CBCT scans. In the

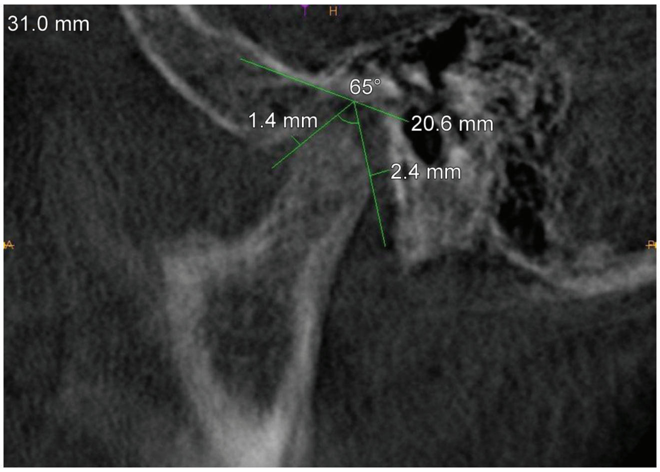

Fig. 7: Cone-beam computed tomography (CBCT) scan of articular space anterior and posterior pretreatment

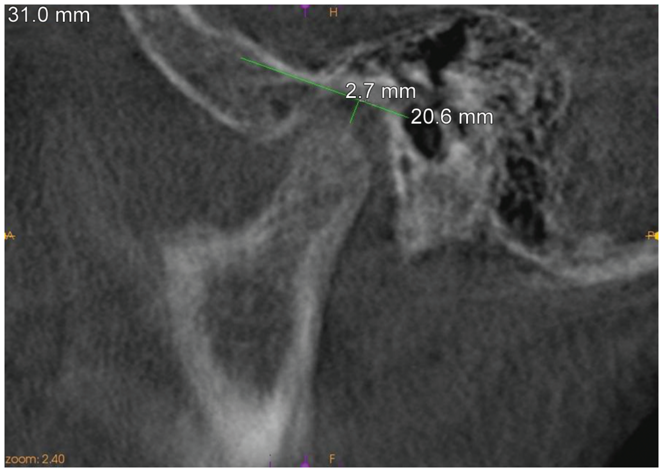

Fig. 9: Cone-beam computed tomography (CBCT) scan of articular space middle pretreatment

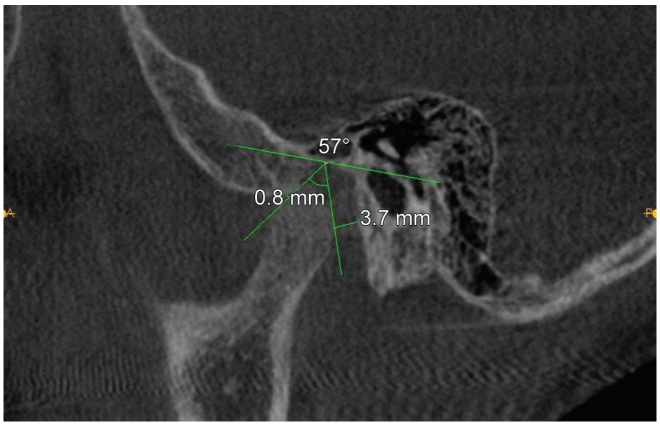

Fig. 8: Cone-beam computed tomography (CBCT) scan of articular space anterior and posterior posttreatment

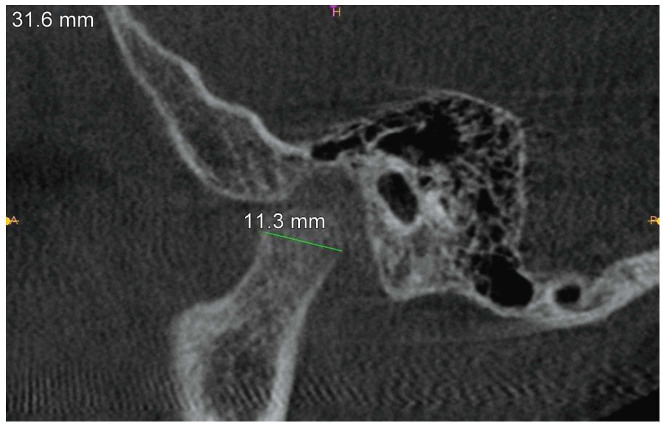

Fig. 10: Cone-beam computed tomography (CBCT) scan of articular space middle posttreatment

Table 3: Comparison of articular space and glenoid fossa angles between twin block appliance and PowerScope appliance pre- and posttreatment on CBCT scans

	Twin block appliance (n = 8)				*PowerScope appliance (n = 8)*			
Skeletal attributes	*Pretreatment mean (±SD) in mm*	*Posttreatment mean (±SD) in mm*	*Mean difference*	*p-value*	*Pretreatment mean (±SD) in mm*	*Posttreatment mean (±SD) in mm*	*Mean difference*	*p-value*
Articular space-anterior								
Right	2.37 (±0.28)	1.52 (±0.29)	−0.85	0.000*	1.41 (± 0.29)	1.14 (± 0.13)	0.27	0.028*
Left	2.03 (±0.32)	1.44 (±0.36)	−0.58	0.000*	1.49 (± 0.27)	1.30 (± 0.22)	0.19	0.004*
Articular space-middle								
Right	2.46 (±0.28)	4.97 (±0.57)	2.51	0.061	2.51 (± 0.43)	5.18 (± 0.57)	2.67	0.000*
Left	2.38 (±0.15)	5.16 (±0.49)	2.77	0.039*	2.86 (± 0.58)	5.30 (± 0.56)	2.44	0.000*
Articular space-posterior								
Right	2.66 (±0.65)	3.86 (±0.67)	1.2	0.000*	3.00 (± 0.53)	5.00 (± 0.96)	2.00	0.000*
Left	2.61 (±0.35)	3.81 (0.41)	1.2	0.000*	3.09 (± 0.40)	4.79 (± 0.61)	1.70	0.000*
Glenoid-fossa angle								
Right	79.22 (±8.51)	73.11 (±8.81)	6.11	0.000*	80.75 (± 4.74)	79.50 (± 3.93)	1.25	0.006
Left	74.67 (±10.60)	68.56 (±10.48)	6.11	0.000*	81.63 (± 3.58)	79.88 (± 3.36)	1.75	0.001

Paired *t*-test; significance, 2-tailed; *, $p < 0.05$

case of the twin block device the change in glenoid fossa, angle was observed to be 6.1 mm on both sides and a mean difference of 1.25 mm on the right-side and 1.75 mm on the left-side was observed in the case of PowerScope™ (Table 3). The difference was established to be significant with a $p < 0.05$ in all cases. As observed from the data in the table the mean difference in the case

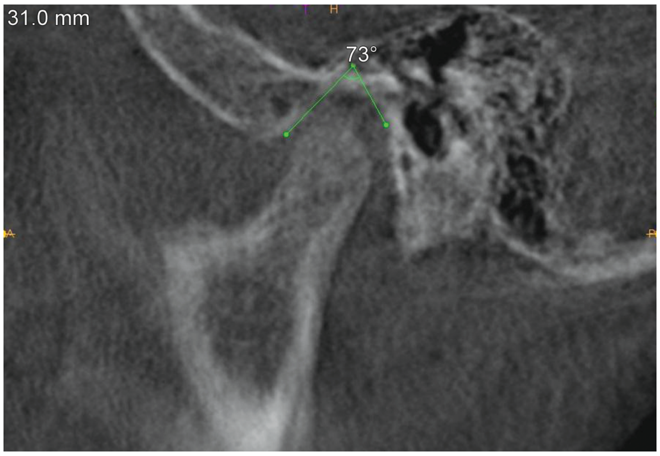

Fig. 11: Cone-beam computed tomography (CBCT) scan of condylar angle pretreatment

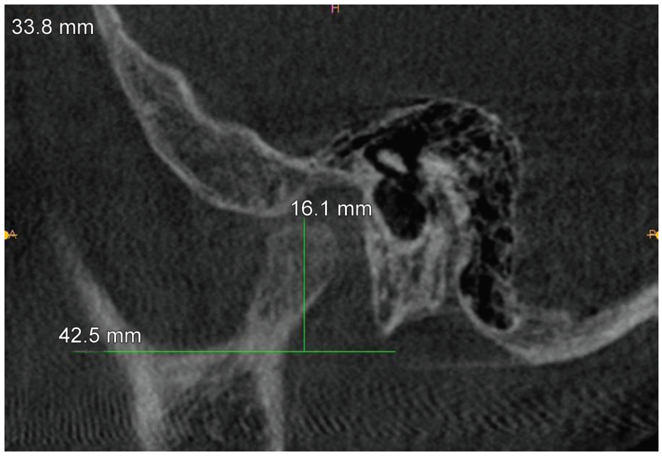

Fig. 12: Cone-beam computed tomography (CBCT) scan of condylar height posttreatment

of the twin block device was six times that of the mean difference observed in PowerScope™ device. Changes in the anterior and posterior slope of the glenoid fossa may have led to a decrease in glenoid fossa angle in both the twin block group (6.11 mm) and in the PowerScope™ group (1.50 mm), but a greater forward remodeling was seen with the twin block group compared to the PowerScope™ group (Table 3).

Discussion

Functional jaw orthopedics or growth modulation therapy by use of functional appliances is applied during the treatment of class II malocclusion with mandibular deficiency,[12] which is the most common finding in class II malocclusion particularly in children.[13] Studies have shown that the maximum benefit of functional appliances is achieved during or slightly after the onset of the pubertal peak.[14] In our study, the average age of the subjects was 13.08 years, which is in the optimum age range for the use of functional devices. Of the several techniques used to assess TMJ changes following functional device therapy, we selected CBCT because of accuracy, reliability, and other advantages[8] and this was employed to study changes in condylar properties, articular space, and glenoid fossa angle in subjects fitted with twin block and PowerScope™ devices as a comparison between the two techniques.

Condyle

Treatment Effects of Twin Block and PowerScope™ on Condyle

In the present study, the effect produced by the twin block on the condyle is comparatively significant and greater. The forward positioning of the condyle was twice the amount seen in the twin block compared to PowerScope™ (Tables 4 and 5). These results are in agreement with Wadhawan et al.[11] where an MRI study concluded that a forward condylar shift of 1.2 mm was seen between pretreatment and posttreatment of functional appliance therapy. The condylar length and the height were significantly increased in the twin block group proving to have a greater influence on these structures compared to PoweScope™ group. In the case of the twin block appliance, an increase of 1.55 mm in condylar length (sagittal plane) and 2.4 mm in condylar height (Table 2) was observed. Similarly, in the case of the PowerScope™ device condylar length also increased by 0.21 and 0.31 mm on the left and right-side, respectively (mean value = 0.26 mm) (in the sagittal plane) (Table 2). Condylar height increased by 0.70 and 0.71 mm on the left and right-sides, respectively (mean value = 0.71 mm) (in the vertical plane) (Table 2). This contributed to an overall increase in the mandibular length, indicating that a combination of functional appliances and possible growth has brought about these changes, as seen in previous studies with other devices.[15,16] The possible reason for the twin block producing a greater result can be attributed to the lateral movement produced easily even when the appliance is in use.

Glenoid Fossa

Treatment Effects of Twin Block and PowerScope™ on the Glenoid Fossa

Studies by Rabie et al. have shown that mandibular protrusion resulted in a considerable increase in bone formation in the glenoid fossa particularly in the posterior and middle regions.[2] Similar changes were reported in the present study. These changes can be explained by a decrease in glenoid fossa angle for both twin block appliance as well as PowerScope™ appliance (6.11 and 1.25, respectively) (Table 3) which indicates deposition of bone on the posterior slope and resorption of bone in the anterior slope of the glenoid fossa. The decrease in glenoid fossa angle was much more pronounced in the case of the twin block device compared to the PowerScope™ device, with the effect almost identical on the right and left-sides. The glenoid fossa remodeling, which has been described to start at the inferior part of the anterior surface of the postglenoid spine and gradually decrease toward the superior section of the fossa, may be the cause of the alterations in the glenoid fossa angle found in this study.[15] The results of the aforementioned investigation are consistent with our findings in the glenoid fossa. In the current trial, the twin block group experienced six times as much glenoid fossa remodeling as the PowerScope™ group (Tables 4 and 5).

Articular Space

Treatment Effects of Twin Block and PowerScope™ on Articular Space

Measurements of articular space were made at the anterior, posterior, and middle areas. When comparing the middle anterior

Table 4: Comparison of the mean difference between pretreatment and posttreatment on right-side CBCT scans among subjects treated with twin block and PowerScope appliances

Structural attributes	*Twin block (mean difference ± SD)*	*PowerScope (mean difference ± SD)*	*t-value*	*p-value*
Condylar position	2.00 ± 0.19	0.93 ± 0.46	4.684	0.004*
Articular space anterior	0.85 ± 0.10	0.77 ± 0.28	6.275	0.03*
Articular space middle	2.51 ± 0.44	2.67 ± 0.40	0.985	0.89
Articular space posterior	1.2 ± 0.13	2.00 ± 0.55	1.262	0.07
Glenoid fossa angle	6.11 ± 2.14	1.25 ± 1.58	9.243	0.001*
Condylar length	1.47 ± 0.38	0.21 ± 0.24	6.845	0.02*
Condylar height	2.45 ± 0.37	0.72 ± 0.41	7.264	0.007*

Independent *t*-test; significance, 2-tailed ; *, $p < 0.05$

Table 5: Comparison of the mean difference between pretreatment and posttreatment on left-side CBCT scans among subjects treated with twin block and PowerScope appliances

Structural attributes	*Twin block (mean difference ± SD)*	*PowerScope (mean difference ± SD)*	*t-test*	*p-value*
Condylar position	2.48 ± 0.26	1.24 ± 0.50	8.351	0.01*
Articular space anterior	0.58 ± 0.10	0.19 ± 0.12	3.121	0.04*
Articular space middle	2.77 ± 0.39	2.44 ± 0.86	0.895	0.35
Articular space posterior	1.20 ± 0.22	1.70 ± 0.35	0.563	0.56
Glenoid fossa angle	6.11 ± 1.9	1.75 ± 0.89	10.562	0.001*
Condylar length	1.70 ± 0.25	0.31 ± 0.26	4.154	0.03*
Condylar height	2.35 ± 0.51	0.70 ± 043	7.622	0.005*

Independent *t*-test; significance, 2-tailed ; *, $p < 0.05$

area in both appliances to the anterior and posterior specific spaces, there was a noticeable rise. In the case of the PowerScope™ instrument, the increase was more noticeable. Our results, however, differ from those of previous studies that employed a CT scan to measure changes in TMJ volume following a Forsus fixed functional appliance, finding a decrease in posterior space volume and an increase in anterior articular space volume.[17] Using both appliances resulted in a statistically significant increase in mandibular length because distinct skeletal alterations were observed in the sagittal and vertical planes with respect to the condyle and in the sagittal plane with regard to the glenoid fossa. When compared to the results obtained utilizing the twin block appliance, the skeletal alterations seen in the condyle-glenoid fossa complex as a result of the PowerScope™ appliance were lower in magnitude (Tables 4 and 5). Prior research has demonstrated that dentoalveolar correction accounts for the majority of the overall class II malocclusion correction achieved with fixed functional appliances.[18,19] However, this study solely assessed skeletal alterations in the C-GF region; it did not consider changes in dentoalveolar structures prior to or during functional device treatment. In addition to the skeletal changes brought about by the twin block and PowerScope™ appliance in the C-GF region, other factors that should be taken into account include the appliance's relief of dental intercuspation and the patient's inherent genetic predisposition favoring residual sagittal growth of the mandible. The growth regulation therapy utilizing functional appliances is governed by a complex interplay of elements that may have contributed to the mandible's sagittal correction. The circadian rhythm of periodontal ligament (PDL) proliferation and differentiation may be a variable in the response to intermittent force (twin block appliance). In the PDL, maximal cell proliferation happens when the animals are at rest—during the day for rats and the night for humans. The crucial rate-limiting stage of osteoblast formation, differentiation to preosteoblasts, takes place in the late resting and early arousal phases. This data suggests that wearing a removable appliance at night is more effective than wearing the same appliance for an equal time during the day which might be a possible reason for the superior results of the twin block compared to the PowerScope™ appliance. In the present study both twin block and PowerScope™ appliances were effective in correcting molar relationships and reducing overjets in class II division I malocclusion. However, the twin block was more effective than the PowerScope™ which brought about a greater anterior shift in the condylar position, an increase in condylar length and condylar height, with a decrease in glenoid fossa angle and anterior articular space. No studies have yet been published on the clinical effects of PowerScope™ appliance. More evidence is required in order to substantiate the long-term skeletal and dentoalveolar effects caused by PowerScope™ appliance.

Conclusion

According to the study's findings, the mandibular condyle shifted forward by an average of 1.99 mm after 7–9 months of twin block therapy and 1.08 mm after PowerScope™ therapy. This suggests that the twin block group saw a bigger forward mandibular condylar shift than the PowerScope™ group. Although both the twin block and PowerScope™ groups showed an increase in condylar length and height, there was a greater increase in condylar length and height in the twin block group (i.e., 1.58 and 2.40 mm, respectively) compared to the PowerScope™ group (i.e., 0.26 and 0.71 mm, respectively), indicating a greater increase in mandibular length, following twin block appliance therapy. Changes in the anterior and posterior slope of the glenoid fossa may have led to a decrease in glenoid fossa angle in both the twin block group (6.11 mm) and in the PowerScope™ group (1.50 mm), but a greater forward remodeling was seen with the twin block group compared to the PowerScope™ group. There was an average decrease in the anterior articular space by 0.56

mm and an increase in posterior and middle articular space by 1.2 and 2.64 mm, respectively in the twin block group and an average decrease in the anterior articular space by 0.23 mm and an increase in middle and posterior articular space by 2.55 and 1.85 mm, respectively in PowerScope™ group. This indicates a greater forward shift in the condyle and changes in the glenoid fossa in the twin block group.

References

1. Siara-Oldsa NJ, Pangrazio-Kulbershb V, Bergerc J, et al. Long-term dentoskeletal changes with the bionator, herbst, twin block, and MARA functional appliances. Angle Orthod 2010;80(1):18–29. DOI: 10.2319/020109-11.1
2. Rabie AB, Zhao Z, Shen G, et al. Osteogenesis in the glenoid fossa in response to mandibular advancement. Am J Orthod Dentofacial Orthop 2001;119(4):390–400. DOI: 10.1067/mod.2001.112875
3. Rabie AB, Xiong H, Hagg U. Forward mandibular positioning enhances condylar adaptation in adult rats. Eur J Orthod 2004;26(4):353–358. DOI: 10.1093/ejo/26.4.353
4. O'Brien K, Wright J, Conboy F, et al. Effectiveness of early orthodontic treatment with the Twin-block appliance: a multicenter, randomized, controlled trial. Part 1: dental and skeletal effects. Am J Orthod Dentofacial Orthop 2003;124(3):234–243. DOI: 10.1016/S0889540603003524
5. Cacciatore G, Ghislanzoni LT, Alvetroc L, et al. Treatment and post-treatment effects induced by the Forsus appliance - a controlled clinical study. Angle Orthod 2014;84(6):1010–1017. DOI: 10.2319/112613-867.1
6. Papadopoulos MA. Orthodontic Treatment of Class II Malocclusion in Non-compliant Patient. China: Elsevier Publishing; 2000. p. 10–12.
7. Kinzinger G, Ostheimer J, Förster F, et al. Development of a new fixed functional appliance for treatment of skeletal class II malocclusion – first report. J Orofac Orthop 2002;63(5):384–399. DOI: 10.1007/s00056-002-0118-1
8. Hilgers ML, Scarfe WC, Scheetz JP, et al. Accuracy of linear temporomandibular joint measurements with cone-beam computed tomography and digital cephalometric radiography. Am J Orthod Dentofacial Orthop 2005;128(6):803–811. DOI: 10.1016/j.ajodo.2005.08.034
9. LeCornu M, Cevidanes LH, Zhu H, et al. Three-dimensional treatment outcomes in class II patients treated with the Herbst appliance: a pilot study. Am J Orthod Dentofacial Orthop 2013;144(6):818–830. DOI: 10.1016/j.ajodo.2013.07.014
10. Baumgaertel S, Palomo JM, Palomo L, et al. Reliability and accuracy of cone-beam computed tomography dental measurements. Am J Orthod Dentofacial Orthop 2009;136(1):19–25. DOI: 10.1016/j.ajodo.2007.09.016
11. Wadhawan N, Kumar S, Kharbanda OP, et al. Temporomandibular joint adaptations following two-phase therapy: an MRI study. Orthod Craniofac Res 2008;11(4):235–250. DOI: 10.1111/j.1601-6343.2008.00436.x
12. Konik M, Pancherz H, Hansen K. The mechanism of class II correction in late Herbst treatment. Am J Orthod Dentofacial Orthop 1997;112(1):87–91. DOI: 10.1016/s0889-5406(97)70278-6
13. McNamara JA Jr. Components of class II malocclusion in children 8-10 years of age. Angle Orthod 1981;51(3):177–202. DOI: 10.1043/0003-3219(1981)051<0177:COCIMI>2.0.CO;2
14. Baccetti T, Franchi L, Toth LR, et al. Treatment timing for twin block therapy. Am J Orthod Dentofacial Orthop 2000;118(2):159–170. DOI: 10.1067/mod.2000.105571
15. Ruf S, Pancherz H. Temporomandibular joint growth adaptation in Herbst treatment: a prospective magnetic resonance imaging and cephalometric roentgenographic study. Eur J Orthod 1998;20(4):375–386. DOI: 10.1093/ejo/20.4.375
16. Ruf S, Baltromejus S, Pancherz H. Effective condylar growth and chin position changes in activator treatment: a cephalometric roentgenographic study. Angle Orthod 2001;71(1):4–11. DOI: 10.1043/0003-3219(2001)071<0004:ECGACP>2.0.CO;2
17. Arici S, Akan H, Yakubov K, et al. Effects of fixed functional appliance treatment on the temporomandibular joint. Am J Orthod DentofacialOrthop 2008;133(6):809–814. DOI: 10.1016/j.ajodo.2006.07.035
18. Zymperdikas VF, Koretsi V, Papageorgiou SN, et al. Treatment effects of fixed functional appliances in patients with class II malocclusion: a systematic review and meta-analysis. Eur J Orthod 2016;38(2):113–126. DOI: 10.1093/ejo/cjv034
19. Servello DF, Fallis DW, Alvetro L. Analysis of class II patients, successfully treated with the straight-wire and Forsus appliances, based on cervical vertebral maturation status. Angle Orthod 2015;85(1):80–86. DOI: 10.2319/102513-780.1