DENTAL MEDICINE

Original Research

Dentoskeletal effects of Twin Block appliance in patients with Class II malocclusion

Mahamad Irfanulla Khan[1], Praveen Kumar Neela[2], Nayeem Unnisa[3], Ajit Kumar Jaiswal[4], Nadeem Ahmed[5], Abhik Purkayastha[6]

1) Department of Orthodontics & Dentofacial Orthopedics, Oxford Dental College, Bangalore, India

2) Department. of Orthodontics & Dentofacial Orthopaedics, Kamineni Institute of Dental Sciences, Narketpally, Andhra Pradesh, India

3) General Dental Practice, Bangalore, India

4) Department. of Orthodontics & Dentofacial Orthopaedics, BJS Dental College, Ludhiana, Punjab, India

5) General Dental Practice, Max Dental Specialties, Bangalore, India

6) Welcare Dental Clinic, Kalyani-Nadia, West Bengal, India

Abstract

Background and aim. Class II malocclusions are most commonly seen in orthodontic practice and in the recent times Twin Block appliance has been the most popular and widely used among removable functional appliances for the correction of Class II malocclusion in growing patients. The aim of this retrospective study was to evaluate the dentoskeletal effects produced by the Twin Block appliance for the correction of Class II division 1 malocclusion with retrognathic mandible.

Methods. Pre-treatment (T1) and post-treatment (T2) lateral cephalograms of 30 patients treated with Twin Block appliance (mean age = 10.8 ± 1.2 years) for the correction of class II division 1 malocclusion were compared with the 30 untreated class II control patients (mean age 11.2 ± 0.8 years) who did not undergo any treatment during this period. Both the groups were evaluated for the dentoskeletal changes using 24 angular and linear cephalometric measurements. The differences between the pre and post-treatment were calculated using a paired t-test.

Results. The cephalometric analysis revealed that the Twin Block appliance stimulated mandibular growth and statistically significant differences were found between the two groups. Twin Block patients showed a statistically very high significant ($p<0.001$) increase in mandibular length (6.02 mm) compared with the control group (0.3 mm). “Headgear effect” on the maxilla, increase in lower anterior facial height, significant reduction of overjet, overbite and Class I molar relationship were achieved in the Twin Block group. However, no significant changes appeared in the control group.

Conclusion. The results of the present study conclude that the Twin Block appliance is effective in the treatment of Class II malocclusion and this is due to a combination of skeletal and dentoalveolar changes in both the arches.

Keywords: Twin Block, Class II division 1 malocclusion, functional appliances, dentoskeletal effect, cephalometry

DOI: 10.15386/mpr-1989

Manuscript received: 07.12.2020
Accepted: 07.01.2021

Address for correspondence:
drirfankhanmds@gmail.com

Introduction

Class II malocclusions are most commonly seen in orthodontic practice; they may be either skeletal or dental, presenting with different clinical manifestations. Globally, an approximate estimation shows over 20% prevalence of Class II malocclusion in North America, Europe and North Africa [1]. In 1981, McNamara study found that 60% of the Class II malocclusion occurred in children having retrognathic mandible [2]. The goal of the present-day orthodontic treatment is to attain optimal facial esthetics in addition to normal dental occlusion. This is achievable only if the underlying jaw bases are in harmony with each other.

Functional appliances have been in use from many years; several varieties of removable functional appliances like Activator, Bionator, Frankel, and Twin Block are used for the correction of Class II malocclusions [3]. The primary objective of using these functional appliances is to modify or redirect mandibular growth to correct a skeletal discrepancy [4].

Multiple evidence-based studies of functional appliances have reported the varying degrees of dentoskeletal effects in the treatment of Class II malocclusions [5-9]. In the recent times, Twin Block developed by William J. Clark is the most popular and widely used removable functional appliances for the correction of Class II malocclusion in growing patients due to increased patients acceptance and compliance, the separate upper and lower two-piece design of the appliance allows freedom of speech and mastication [10-15]. Several randomized controlled trials and systematic reviews have described the role of the Twin Block appliance on skeletal, dental and soft tissue structures in the treatment of Class II malocclusions [16-18].

Therefore this study aimed to retrospectively evaluate the dentoskeletal effects of Twin Block appliance in patients with Class II division 1 malocclusion.

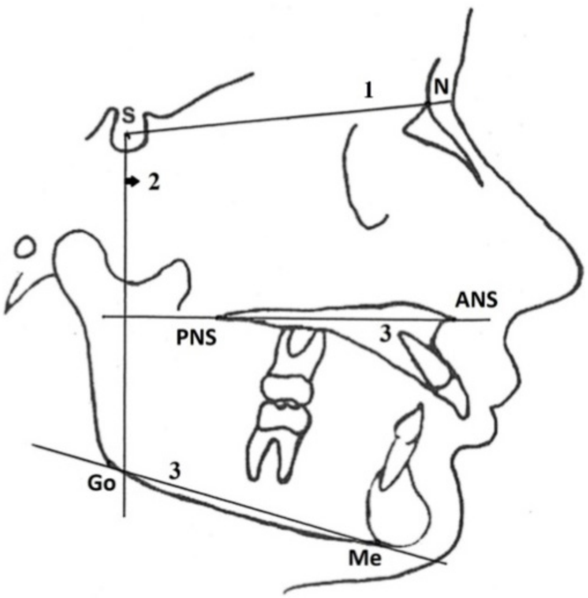
Methods

This study was approved by the Institutional Ethical Committee of Institutional Ethical Committee of YDC/05-08/03. Two groups of 30 subjects in each were considered for this retrospective cross-sectional study, records of the patients who had been treated with the Twin Block appliance were compared with the records of untreated children with Class II malocclusion. All the records were obtained from 5 different private dental offices based on the following inclusion criteria:

1) Skeletal Class II malocclusion (ANB 5° or greater)
2) Mandibular retrognathism
3) Average or horizontal growth pattern.
4) Full-cusp Angle Class II molar relationship on both sides
5) Overjet of 6 to10 mm
6) The age group of 9 to 12 years
7) All the subjects with same bite recording technique and standard Twin Block appliance design and treatment protocol suggested by Dr Clark.

The subjects excluded from the study were patients with severe maxillary prognathism, severe dental crowding (more than 5 mm), history of previous orthodontic treatment.

Twin Block Group: consisted of 30 patients (13 boys and 17 girls) with age between 9 to 12 years. The average age of the patients was 10 years 8 months at the time of the initial film. *Control group:* 30 untreated Class II subjects (12 boys and 18 girls) who received no treatment but were followed until the end of the study, records were selected based on the similarity of ages with the Twin Block group. The average age of this sample group was 11 years 2 months.



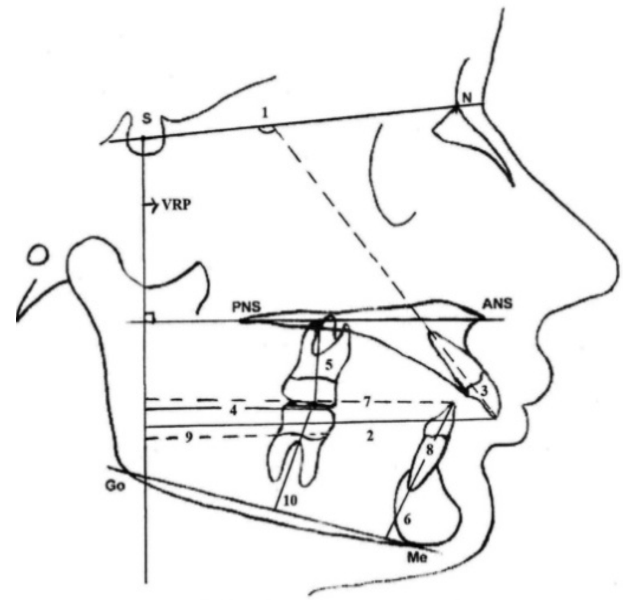


Figure 1 (left). Cephalometric reference planes: 1) S-N plane; 2) Vertical reference plane (VRP); 3) Horizontal reference plane (HRP).
Figure 2 (right). Dentoskeletal parameters: 1) UI-SN; 2) UI-VRP; 3) UI-HRP; 4) U6-VRP; 5) U6-HRP; 6) IMPA; 7) L1-VRP; 8) L1-HRP; 9) L6-VRP; 10) L6-HRP.
Palatal plane: the plane formed by joining ANS and PNS was used as a Horizontal Reference Plane (HRP) for maxillary teeth; *Mandibular plane:* the plane formed by joining Gonion and Menton. (HRP for mandibular teeth); *Vertical reference plane (VRP):* the reference plane constructed through sella turcica perpendicular to the palatal plane.

Cephalometric analysis

In this study, pre-treatment (T1) and post-treatment (T2, post appliance removal / equivalent time frame in controls) records of 30 patients treated with standard Twin Block appliance design and treatment protocol suggested by Dr Clark and control group (30 patients) were evaluated before and after functional therapy. All the pre-treatment and post-treatment cephalograms were traced on matte acetate paper, using a 0.03" lead pencil by one investigator with verification of anatomic outlines and landmarks by the two more investigators. A single average tracing was made in instances of bilateral structures. The cephalometric landmarks, reference planes and angular measurements were used as defined by Alexander Jacobson [19] and Thomas Rakosi [20].

The following Cephalometric reference planes (Figure 1) and Dentoskeletal parameters were used (Figure 2).

The horizontal movement of the maxillary teeth was measured from VRP, whereas vertical changes were measured relative to the palatal plane. Similarly, the mandibular plane and vertical reference plane were used to determine the mandibular teeth movement.

Statistical analysis

Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) software version 22 (SPSS Inc, Chicago, Illinois, USA). The differences between pre and post-treatment were calculated using a paired t-test. When data were not normally distributed, Wilcoxon signed-rank test was used. Man-Whitney U test was used to compare the changes between the two groups. The comparison was tested at 5% level of significance (*P*-value < 0.05 was considered statistically significant).

Results

Descriptive information and pre and post-treatment comparison between Twin Block and control groups are shown in table I. Whereas, group differences, in the percentage of changes between the two groups are presented in table II.

Table I. Descriptive information and pre (T1) and post-treatment (T2) comparison between Twin Block and Control groups.

Cehalometric Parameter	Twin Block (TB)			Control (C)		
	Pre treatment (T1) Mean± SD	Post treatment (T2) Mean± SD	p -value	Pre treatment (T1) Mean ± SD	Post treatment (T2) Mean ± SD	p-Value
SNA	81.44±3.01	80.75±3.65	0.01 *	82.33±3.0	81.95±3.55	0.106 NS
SNB	74.35±3.16	76.65±3.28	<0.001	74.20±2.50	74.54±2.57	0.111 NS
ANB	6.06±1.36	4.06±2.04	<0.001	6.60±2.0	6.10±2.01	0.16NS
MAX length	89.90±3.90	90.50±4.79	0.160 NS	87.80±3.80	88.50±4.69	0.158 NS
MAND length	107.20±5.17	113.22±4.32	<0.001	109.90±5.09	110.20±5.01	0.178 NS
WITS	4.88±1.52	2.14±1.94	<0.001	4.20±1.29	3.97±1.25	0.15 NS
BETA angle	22.16±3.54	27.00±3.14	<0.001	21.29±1.66	21.69±1.79	0.18 NS
AFH	110.20±5.17	116.22±4.33	<0.001	109.93±5.09	110.18±5.02	0.179 NS
PFH	73.36±3.74	76.30±3.86	<0.001	72.07±4.14	72.36±4.19	0.065 NS
Facial Convexity	9.36±4.97	6.22±6.33	<0.001	9.86±4.01	9.88±4.19	0.081 NS
U1-SN	116.00±6.61	108.74±7.20	<0.001	109.92±8.76	110.00±8.66	0.701 NS
U1-HRP	26.64±2.87	28.22±3.71	0.022*	27.62±2.85	28.14±3.15	0.002 *
U1-VRP	77.16±3.89	74.96±4.63	<0.001	74.97±5.44	74.98±5.62	0.924 NS
U6-HRP	20.60±1.89	20.83±2.02	0.114 NS	20.61±2.04	20.84±2.17	0.115 NS
U6-VRP	40.60±3.76	39.66±3.82	0.037 *	40.12±3.90	40.09±3.85	0.068 NS
L1-NB	7.64±2.18	8.88±2.34	<0.001	7.49±1.99	7.57±2.10	0.566NS
IMPA	101.56±5.75	103.72±6.10	0.037*	99.46±4.71	100.04±4.80	0.059 *
L1-HRP	41.32±2.72	39.90±3.02	0.011 **	39.76±4.30	39.84±4.29	0.566 NS
L1-VRP	68.20±3.57	71.36±4.00	<0.001	69.36±4.58	69.92±4.57	0.51NS
L6-HRP	28.66±2.11	31.04±2.96	<0.001	30.32±2.88	30.86±2.92	<0.001
L6-VRP	39.04±3.34	43.48±4.09	<0.001	40.80±4.45	41.12±4.41	<0.001
Overjet	9.40±2.13	3.68±1.74	<0.001	8.08±1.30	7.70±1.21	<0.001
Overbite	4.70±1.05	2.68±1.09	<0.001	4.44±0.92	4.18±1.00	0.003 **
Interincisal angle	110.76±7.28	114.60±9.25	0.033*	109.74±6.02	109.88±6.24	0.327 NS

Abbreviations: TB: Twin Block, C: Control, SD: Standard Deviation, AFH: Anterior Facial Height, PFH: Posterior Facial height, U1-HRP: Upper 1 to Horizontal reference plane, IMPA: Incisal Mandibular plane Angle, U1-VRP: Upper 1 to Vertical reference plane, U6-VRP: Upper 6 to Vertical reference plane, U6-HRP: Upper 6 to Horizontal reference plane, L1-HRP: Lower 1 to Horizontal Reference plane, L1-VRP: Lower 1 to Vertical Reference plane, L6-HRP: Lower 6 to Horizontal Reference Plane, L6-VRP: Lower 6 to Vertical Reference plane, U1-SN: Upper 1 to SN plane, HRP: Horizontal Reference Plane VRP: Vertical Reference Plane.

Notes: p > 0.05 = NS, * p < 0 .05 = Significant, ** p < 0 .01 = Highly Significant, *** p< 0 .001 = Very highly significant.

Table II. Mean changes between Twin Block vs Control groups.

Cephalometric Parameter	Twin Block (TB) % change Mean ±SD	Control (C) % change Mean± SD	TB vs C
SNA	0.60±2.73	0.46±1.00	<0.001
SNB	6.76±1.69	0.51±1.06	<0.001
ANB	33.17±44.69	5.21±20.44	<0.001
Max length	0.66.±4.69	0.47±3.56	0.09
Mand length	5.55±3.19	0.27±0.69	<0.001
WITS	55.18±42.73	6.90±20.44	<0.001
BETA angle	23.57±16.19	2.40±2.96	<0.001
AFH	5.55±3.10	0.24±0.84	<0.001
PFH	4.02±1.69	0.41±1.05	<0.001
Facial Convexity	88.18±186.19	0.39±10.63	<0.001
U1-SN	6.16±5.27	-0.08±0.94	<0.001
U1-HRP	6.42±13.24	1.83±2.76	0.016**
U1-VRP	2.86±2.98	0.00±1.00	<0.001
U6-HRP	4.14±5.20	1.11±3.46	0.014**
U6-VRP	-0.50±4.83	-0.05±1.83	0.502NS
L1-NB	18.65±18.88	7.94±6.99	0.003**
IMPA	2.22±4.74	0.58±0.56	0.009**
L1-HRP	2.25±4.91	0.23±1.78	0.034*
L1-VRP	4.67±3.40	0.82±0.81	<0.001
L6-HRP	8.29±6.83	1.79±1.51	<0.001
L6-VRP	11.43±5.85	0.81±1.08	<0.001
Overjet	60.76±15.46	4.60±3.58	<0.001
Overbite	42.96±19.86	6.27±8.74	<0.001
Interincisal angle	-3.63±7.60	-0.12±0.64	0.04*

Abbreviations: TB: Twin Block, C: Control, SD: Standard Deviation, AFH: Anterior Facial Height, PFH: Posterior Facial height, U1-HRP: Upper 1 to Horizontal reference plane, IMPA: Incisal Mandibular plane Angle, U1-VRP: Upper 1 to Vertical reference plane, U6-VRP: Upper 6 to Vertical reference plane, U6-HRP: Upper 6 to Horizontal reference plane, L1-HRP: Lower 1 to Horizontal Reference plane, L1-VRP: Lower 1 to Vertical Reference plane, L6-HRP: Lower 6 to Horizontal Reference Plane, L6-VRP: Lower 6 to Vertical Reference plane, U1-SN: Upper 1 to SN plane, HRP: Horizontal Reference Plane VRP: Vertical Reference Plane.
Notes: p > 0.05 = NS, * p < 0 .05 = Significant, ** p < 0 .01 = Highly Significant, *** p< 0 .001 = Very highly significant.

Cephalometric findings

A Class I molar relationship, significant reduction of overjet and overbite were observed in Twin Block therapy patients. Cephalometric findings of the Twin Block group and the control group are presented in table I.

Skeletal effects

A statistically significant increase in the mandibular length (6.02 mm) and SNB angle (2.3°) was observed in the Twin Block group compared with the control group 0.3 mm and 0.3° respectively. The Twin Block group experienced "Headgear effect" producing slight inhibition of forwarding maxillary growth as evidenced by the reduction seen in angle SNA (-0.7°) as compared with the small increase seen in angle SNA in the control subjects.

The ANB angle demonstrated a significant decrease when the two groups were compared. (SNA decreased, and SNB and Go-Me increased). In Twin-block group the ANB angle reduced by 2°, Wits reduced by 2.74 mm and increase in Beta angle by 4.8°, but there were only minor changes in the untreated control group and these differences were statistically significant. The skeletal vertical cephalometric variables showed an increase in the lower anterior facial height and posterior facial height in Twin Block group. Overall, Twin Block therapy produced a larger effect on the growth of the mandible than with untreated control subjects.

Dental effects

In Twin Block group maxillary incisors were retroclined, extruded, and distally tipped (U1/SN and U1-VRP decreased, U1-HRP increased), whereas the mandibular incisors were proclined (2.3°), intruded, and labially tipped (L1-NB, IMPA increased, and L1-MP decreased). Maxillary molar teeth were distalized (1 mm) and extruded (decreased U6-VRP and increased U6-HRP), contrarily, lower molars were moved mesially (4.5 mm) and extruded (L6-VRP and L6-MP increased) whereas in control group maxillary molar teeth were distalized (0.3 mm), and lower molars were moved mesially (0.5 mm). Significant decrease in overjet (5.72 mm) and overbite were observed at the end of treatment in the Twin Block patients compared with untreated Class II controls.

Discussion

Functional appliances are used in the treatment of Class II malocclusions caused by a retrognathic mandible. To what extent do these appliances bring about a clinically significant increase in growth still remains questionable, but several clinical studies and systematic reviews reported that their use brings favorable skeletal and dentoalveolar changes. Early correction of maxillary proclination in a severe skeletal Class II division 1 malocclusion may be useful to reduce the risk of trauma to prominent maxillary incisors and will improve the facial esthetics during adolescence [21].

Effects on the maxilla

The results of this study revealed a 'Headgear effect' on maxilla with the Twin Block group experiencing an inhibition of forwarding maxillary growth as evidenced by a 0.7° decrease in SNA angle as compared with the control subjects (0.3°). The "headgear effect" also was observed dentally as a 1.0 mm distalization effect on the upper molars in the Twin Block group. These results are similar to previous studies [10,11,22-25], but contradict others with no statistically significant reduction in SNA angle and maxillary length [26-30].

Effects on the mandible

In the scientific literature, there is a controversy over the effects of functional appliances on mandibular growth. Several evidence-based studies have reported that functional appliances increase the mandibular length in the treatment of Class II malocclusion. A statistically significant increase in mandibular length was observed in the Twin-block (6.02 mm) compared with the control group (0.3 mm). These findings were similar to previous studies by Mills and McCulloch [23] who reported a 6.5 mm increase in effective mandibular length, Toth and McNamara [27] reported a 3.0 mm increase in mandibular growth. In addition, Giuntini et al. [31], Khoja et al. [32], Pattanaik et al. [33,] and Ajami et al. [34] reported similar results of increased mandibular length.

Maxillo-mandibular changes

The sagittal relationship improved in the Twin Block group than in the controls, the greater reduction was seen in Twin-block group (ANB angle reduced by 2^{o}, Wits reduced by 2.7 4mm and increase in Beta angle by 4.8°). Toth and McNamara [27] reported a similar reduction in ANB angle (1.8°), Sharma et al. [25] reported ANB reduction by 2.9°, Khoja et al. [32] found ANB angle reduced by 1.82° and Ajami et al. [35] indicated a mean reduction in ANB angle by 1.76°. This reduction in the ANB angle was primarily due to an increase in SNB angle. This finding is in agreement with results reported by Clark [10,11,22], Illing et al. [16], Lund and Sandler [26], Mills and Mc Culloch. [28] and Trenouth [29].

The result of the present study indicates that skeletal discrepancy in sagittal direction is mainly corrected due to the increase in mandibular length, restriction of maxillary growth as validated by a reduction in ANB angle, reduction in Wits value and increase in Beta angle.

The vertical relationship of the jaws

Relative to the control group, the Twin Block applied a forward and downward force to the mandible and caused an increase in the lower anterior facial height and posterior facial height, which is similar to previous studies [10,23,25-30].

Dentoalveolar changes

In the Twin-block group, the maxillary first molars moved distally (1 mm). Lund and Sandler [26] noted 1.6 mm distal movement, Toth and McNamara [27] reported 1.5 mm, Mills and McCulloch [28] reported the distalization of the maxillary molars during Twin Block appliance treatment. Clark [10] also found distalization of the maxillary molars with the Twin-block appliance. Previous studies of Twin-block treatment indicated 'headgear effect' on the maxillary posterior teeth. Our study had a similar observation , in agreement with previous studies [10,22,29].

The mandibular molars in the Twin-block subjects showed extrusion (2.38 mm) and mesial movement (4.5 mm) significantly greater than in the control group (0.5 mm) which is similar to studies by Mills and McCulloch [26], Lund and Sandler [28] and Pattanaik S et al [34]. The effect on mandibular incisors is critical and variable in different studies. The mandibular incisors showed greater proclination 2.3° and were probably a result of the mesial force on the mandibular incisors induced by the protrusion of the mandible [9,16]. Lund and Sandler [26] reported 7.9° proclination, Toth and McNamara [27] by 2.8°, Mills and McCulloch [28] by 3.8°, Trenouth [29] by 1.4°, Khoja et al. [32] reported a significant increase in mandibular incisor proclination despite capping into the Twin Block appliance.

A significant decrease in overjet (5.72 mm) and overbite were observed at the end of treatment in the Twin Block group compared with untreated Class II controls. This finding is in accordance with studies by Clark [10], Illing et al. [16], O'Brien et al. [24], Sharma et al. [25], Trenouth [29], Khoja et al. [32] and Ajami et al [34].

Conclusions

Twin Block appliance stimulated the mandibular growth and improved facial esthetics in Class II malocclusion by a combination of changes in the skeletal as well as dentoalveolar structures.

"Headgear effect" was observed with the Twin Block group experiencing restricted maxillary growth and maxillary molar distalization.

Increase in lower anterior facial height, significant reduction in overjet and overbite and Class I molar relationship was achieved at the end of treatment in the Twin Block group, although no significant changes appeared in the control group.

References

1. Spalding PM. Treatment of Class II malocclusion. In: Bishara SE, editor. Textbook of Orthodontics. Philadelphia: WB Saunders; 2001: pp. 324-374.
2. McNamara JA Jr. Components of class II malocclusion in children 8-10 years of age. Angle Orthod. 1981; 51:177-202.
3. Graber TM, Rakosi T, Petrovic AG. Dentofacial Orthopedics with Functional Appliances 2nd ed. St Louis: Mosby; 1997: pp. 12-14.
4. Lee KY, Park JH, Tai K, Chae JM. Treatment with Twin-block appliance followed by fixed appliance therapy in a growing Class II patient. Am J Orthod Dentofacial Orthop. 2016;150:847-863.
5. Weislander L, Lagerström L. The effect of activator treatment on class II malocclusions. Am J Orthod. 1979;75:20-26.
6. Creekmore TD, Radney LJ. Frankel appliance therapy: orthopedic or orthodontic? Am J Orthod. 1983;83:89-108.
7. McNamara JA, Bookstein FL, Shaughnessy TG. Skeletal and dental changes following functional regulator therapy on class II patients. Am J Orthod. 1985;88:91-110.
8. Hansen K, Pancherz H. Long-term effects of Herbst treatment in relation to normal growth development: a cephalometric study. Eur J Orthod. 1992;14:285-295.
9. Cope JB, Buschang PH, Cope DD, Parker J, Blackwood HO 3rd. Quantitative evaluation of craniofacial changes with Jasper Jumper therapy. Angle Orthod. 1994;64:113-122.
10. Clark WJ. The twin block technique. A functional orthopedic appliance system. Am J Orthod Dentofacial Orthop. 1988;93:1–18.
11. Clark WJ. Twin Block Functional Therapy: Applications in Dentofacial Orthopedics. 3rd ed. New Delhi: Jaypee Brothers Medical Publishers (P) Ltd; 2015: pp.6-8.
12. Trenouth MJ. A functional appliance system for the correction of class II relationships. Br J Orthod. 1989;16:169-176.
13. Gill D, Sharma A, Naini F, Jones S. The twin block appliance for the correction of Class II malocclusion. Dent Update. 2005;32:158-160.
14. Varlik SK, Gültan A, Tümer N. Comparison of the effects of Twin Block and activator treatment on the soft tissue profile. Eur J Orthod. 2008;30:128-134.
15. Baysal A, Uysal T. Soft tissue effects of Twin Block and Herbst appliances in patients with Class II division 1 mandibular retrognathy. Eur J Orthod. 2013;35:71-81.
16. Illing HM, Morris DO, Lee RT. A prospective evaluation of Bass, Bionator and Twin Block appliances. Part I--The hard tissues. Eur J Orthod. 1998;20:501-516.
17. O'Brien K, Wright J, Conboy F, Sanjie Y, Mandall N, Chadwick S, 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;124:234-243.
18. Burhan A, Nawaya FR. Dentoskeletal effects of the Bite-Jumping Appliance and the Twin-Block Appliance in the treatment of skeletal Class II malocclusion: a randomized controlled trial. Eur J Orthod. 2015;37:330-337.
19. Jacobson A, Jaconson RL. Radiographic cephalometry from basic to 3-D imaging. 2nd ed. Hanover Park: Quintessence; 2006: pp. 60-62.
20. Rakosi T. An Atlas and Manual of Cephalometric Radiography. 1st ed. London: Wolfe Medical Publications; 1982: pp. 180-183.
21. Baccetti T, Franchi L, Toth LR, McNamara JA Jr. Treatment timing for Twin-block therapy. Am J Orthod Dentofacial Orthop. 2000;118:159-170.
22. Clark WJ. The twin block traction technique. Eur J Orthod. 1982;4:129–138.
23. Mills CM, McCulloch KJ. Treatment effects of the twin block appliance: a cephalometric study. Am J Orthod Dentofacial Orthop. 1998;114:15-24.
24. O'Brien K, Wright J, Conboy F, Appelbe P, Davies L, Connolly I, et al. Early treatment for Class II Division 1 malocclusion with the Twin-block appliance: a multi-center, randomized, controlled trial. Am J Orthod Dentofacial Orthop. 2009;135:573-579.
25. Sharma AK, Sachdev V, Singla A, Kirtaniya BC. Skeletal and dentoalveolar changes concurrent to use of Twin Block appliance in class II division I cases with a deficient mandible: a cephalometric study. J Indian Soc Pedod Prev Dent. 2012;30:218-226.
26. Lund DI, Sandler PJ. The effects of Twin-Blocks: a prospective controlled study. Am J Orthod Dentofacial Orthop. 1998;113:104-110.
27. Toth LR, McNamara JA Jr. Treatment effects produced by the twin-block appliance and the FR-2 appliance of Fränkel compared with an untreated Class II sample. Am J Orthod Dentofacial Orthop. 1999;116:597–609.
28. Mills CM, McCulloch KJ. Posttreatment changes after successful correction of Class II malocclusions with the twin block appliance. Am J Orthod Dentofacial Orthop. 2000;118:24–33.
29. Trenouth MJ. Cephalometric evaluation of the Twin-block appliance in the treatment of Class II Division 1 malocclusion with matched normative growth data. Am J Orthod Dentofacial Orthop. 2000;117: 54–59.
30. Lee RT, Kyi CS, Mack GJ. A controlled clinical trial of the effects of the Twin Block and Dynamax appliances on the hard and soft tissues. Eur J Orthod. 2007;29:272-282.
31. Giuntini V, Vangelisti A, Masucci C, Defraia E, McNamara JA Jr, Franchi L. Treatment effects produced by the Twin-block appliance vs the Forsus Fatigue Resistant Device in growing Class II patients. Angle Orthod. 2015;85:784-789.
32. Khoja A, Fida M, Shaikh A. Cephalometric evaluation of the effects of the Twin Block appliance in subjects with Class II, Division 1 malocclusion amongst different cervical vertebral maturation stages. Dental Press J Orthod. 2016;21:73-84.
33. Pattanaik S, Puvvula N, Mohammad N. Accelerating Treatment of Skeletal Class II Malocclusion using Fixed Twin Block Appliances. Int J Clin Pediatr Dent. 2018;11:146-150.
34. Ajami S, Morovvat A, Khademi B, Jafarpour D, Babanouri N. Dentoskeletal effects of class II malocclusion treatment with the modified Twin Block appliance. J Clin Exp Dent. 2019;11:e1093-e1098.