Submitted: 25 February, 2023 Accepted: 30 March, 2023 Published: 03 September, 2024 DOI:10.22514/jocpd.2024.110

Journal of Clinical Pediatric Dentistry

ORIGINAL RESEARCH

Prediction on the chin advancement of the twin block functional appliance in growing Chinese patients using the cephalometric markers: a retrospective study

Jingya Dong[1,†], Yan Zhang[1,†], Qingjuan Shi[1], Feiou Lin[1], Rongdang Hu[1], Yi Wang[1,*], Hong Zheng[1,*]

[1] Department of Orthodontics, School & Hospital of Stomatology, Wenzhou Medical University, 325027 Wenzhou, Zhejiang, China

***Correspondence**
y.wang@wmu.edu.cn
(Yi Wang);
h.zheng@wmu.edu.cn
(Hong Zheng)

† These authors contributed equally.

Abstract

In spite of the widespread use of functional appliances, broad variations were applied the treatment response. The aim of this study is to investigate the pre-treatment cephalometric predictors on the chin advancement of twin-block in growing Chinese patients with class II malocclusion. After screening, 90 patients treated by twin-block were included in the study. The treatment outcome was assessed by the alterations in the distance of skeletal pogonion (Pog) to the vertical reference plane perpendicular to the Frankfurt plane (ΔPog-VRP). Moreover, ΔPog-VRP was divided by the cranial growth indicated by the Nasion to Basion changes (ΔN-Ba) to minimize the growth discrepancy among individuals (adjΔPog-VRP). Patients with ΔPog-VRP/adjΔPog-VRP above the median value were categorized into good response group (GRG/adjGRG, N = 45), while the rest were poor response group (PRG/adjPRG, N = 45). Independent *t*-test was used to compare the pre-treatment cephalometric measurements between GRG/adjGRG and PRG/adjPRG. Stepwise multivariate regression models were used to determine the pre-treatment cephalometric predictors for the chin advancement. Generally, there were not any significant differences between GRG/adjGRG and PRG/adjPRG regarding age, gender and cervical stage before twin-block treatment. Patients from GRG had significantly reduced cephalometric measurements in the vertical dimensions, including ∠N-Go-Me, ∠Mandibular plane-Occlusal plane (∠MP-OP) and the sum of angles ($p < 0.05$) in comparison to PRG. When the individual growth was taken account, similar findings were observed. The patients from adjGRG had a significantly lower ∠Sella Nasion line-MP (∠SN-MP), ∠Ar-Go-Me and ∠N-Go-Me, as well as an increased Posterior facial height (PFH)/Anterior facial height (AFH) ($p < 0.05$) compared with their counterparts. ∠N-Go-Me variable was the independent predictor on Pog advancement with ($\beta = -0.26$, 95% CI: −0.06 to −0.01, $p = 0.01$) and without ($\beta = -0.29$, 95% CI: −0.06 to −0.01, $p < 0.01$) adjustments on individual growth. The results of this study showed that patients with a reduced N-Go-Me angle are more likely to experience a greater chin advancement following twin-block treatment.

Keywords

Class II malocclusion; Functional appliance; Twin-block; Cephalometric markers

1. Background

Class II malocclusion is one of the most prevalent orthodontic conditions worldwide, affecting around one third of the populations. Based on the recent meta-analysis from 37 studies enrolling around 11,000 subjects, the prevalence of Class II malocclusion in Chinese school children, calling for proactive and effective interventions, was estimated to be 9.91% (95% CI: 7.41%–13.79%) [1]. For decades, several types of functional appliances including twin-block, activator, herbst, bionator, *etc.* have been applied to correct class II division 1 malocclusion in actively growing patients [2]. So far, the nature of the treatment effect induced by functional appliances is still controversial. Some studies revealed marked skeletal alterations following functional appliance treatment, either as an increase in mandibular length [3, 4] or as a favorable growth of condyle and chin advancement position [5, 6]. At the same time, others claimed that the successful effects of functional appliances were mainly attributed to dento-alveolar components, rather than the skeletal effects [7, 8]. In spite of the disputed arguments, functional appliances are still widely used as they bring a harmonious facial profile in growing individuals.

Twin-block, firstly introduced by Clark, consists of an upper and lower block. It positions the mandibular forward by interlocking the occlusal bite block [9]. Due to the small size and no visible extraoral components, it is generally better accepted by teenagers [3], and it is one of the clinic's mostly used functional appliances. Many studies have demonstrated the beneficial effects of twin-block, including an increased growth and forward movement of the mandible, proclination of the lower incisors, retroclination of the upper incisors, distal movement of the upper molars, and mesial movement of the lower molar [10]. Moreover, enlargement in the oropharynx and hypopharynx airway dimensions was also observed following twin-block treatment [11]. A recent study further showed that twin-block treatment resulted in the volumetric improvement in the mandibular region as demonstrated by the 3-dimensional photographs [12].

The treatment effects of functional appliances have been well validated, however, the skeletal and dental response to the treatment vary from patient to patient, possibly due to the discrepancy in the dental-skeletal patterns among individuals [13]. Therefore, studies have been conducted to determine whether the pretreatment cephalometric markers could predict good response following functional appliance treatment [14–20]. It is well demonstrated that a decreased gonial angle may be a good predictor for greater increment in mandibular growth [14] and chin point advancement [15, 16]. Moreover, overbite, inclination of the lower incisor and lip, mandibular length, ramus height, and anterior and posterior face height are suggested to be significantly associated with the treatment response, depending on the functional appliance and the outcome measurement [17–19]. On the contrary, some argue that no relationship exists between mandibular morphology, vertical skeletal pattern and favorable dentoalveolar/skeletal responses to twin-block therapy [20].

Most of the studies that determine the cephalometric predictors were conducted on white Caucasians [14–20]. Whether such association could be generalized to other races remain to be further explored. Indeed, markedly different skeletal profiles exist between Chinese and Caucasians with Class II Division 1 malocclusion. For example, the Chinese tend to have a significantly more prognathic maxilla and less retrusive mandible, as compared with Caucasians [21]. As such, this present study aimed to investigate the association of pretreatment cephalometric markers with chin advancement following twin-block treatment in Chinese subjects at pubertal stage.

2. Methods

2.1 The inclusion criteria

This retrospective study was carried out following STROBE (Strengthening the Reporting of Observational studies in Epidemiology) statement. A total of 200 growing patients who consecutively completed twin-block treatment at the Department of Orthodontics, School of Stomatology, Wenzhou Medical University from Jan 2015 to June 2020 were screened. The inclusion criteria were as follows: (1) Overjet >7 mm with angle class II division I malocclusion; (2) $\angle$A-N-B $>4°$; (3) Cervical stage (CS) was assessed by means of the cervical vertebral maturation method [22]. CS 3–4 at the beginning of functional treatment (T1), CS 4–5 at the end of therapy (T2); (4) Lateral cephalometric graphs available at T1 and T2; (5) No adjunct orthodontic treatment either before or during the twin-block therapy; (6) Patients with good compliance, indicated by self-reported full-time wear of twin-block appliance. A total of 90 subjects were included in the study after screening.

2.2 Treatment protocol

All the patients were treated by two specialists (HZ & QS). The basic design of the Twin-block was as previously described with brief modification [23]. In particular, the upper anterior teeth were engaged in the device with maxillary labial bow. Bite registration was recorded with the incisors in an edge-to-edge position. All the patients were instructed to wear twin-block for 24 h except during sports and tooth brushing. The patients were reassessed every 4–6 week till the completion of the treatment. The acrylic of the posterior bite block was kept intact to allow vertical control. The treatment duration was within 9–12 months till class I molar relationship was achieved.

2.3 Cephalometric analysis

The lateral Cephalometric images were taken by Sirona Orthophos XG (Dentsply Dental Systems GmbH, Germany; Exposure setting: 73 kV, 15 mA) prior to and 3 months after the removal of twin-block. The reference points and lines are displayed in Fig. 1. Posterior facial height (PFH) refers to distance from S to Go and anterior facial height (AFH) refers to the distance from N to Me. Anterior upper facial height (AUFH) refers to the distance from N to ANS (Anterior nasal spine, ANS), and anterior lower facial height (ALFH) refers to the distance from ANS to Me. A Vertical reference plane (VRP) was constructed perpendicular to the Frankfort horizontal plane (FH) through S. Facial plane (FP) was made from N to Pog. Esthetic plane (EP) referred to the line from Prn to Pog'. Occlusal plane (OP) was established through the midpoint of the upper and lower central incisor edges to the occlusal surface of the upper and lower first molars. Palatal plane (PP) was constructed from ANS to PNS (Posterior nasal spine, PNS). Tweed's triangle analysis including Frankfurt mandibular incisor angle (FMIA) and incisor mandibular plane (MP) angle (IMPA) was documented. Jarabak sum of angles (saddle angle + articular angle + gonial angle) was also recorded.

All the tracing on the lateral cephalometric graphs was done by a single examiner (JD) with the use of cephalometric software Uceph (1.0, Sichuan University, Chengdu, China). One week after the first measurement, 20 cephalometric graphs were randomly retraced and reassessed. The intraclass correlation coefficient (ICC) value was more than 0.90 (0.90–0.99) for all the variables measured, indicating a minimal measurement error of the tracings. The assessment of the CS was performed by JD and verified by HZ. Disagreements were discussed till satisfaction was reached by both.

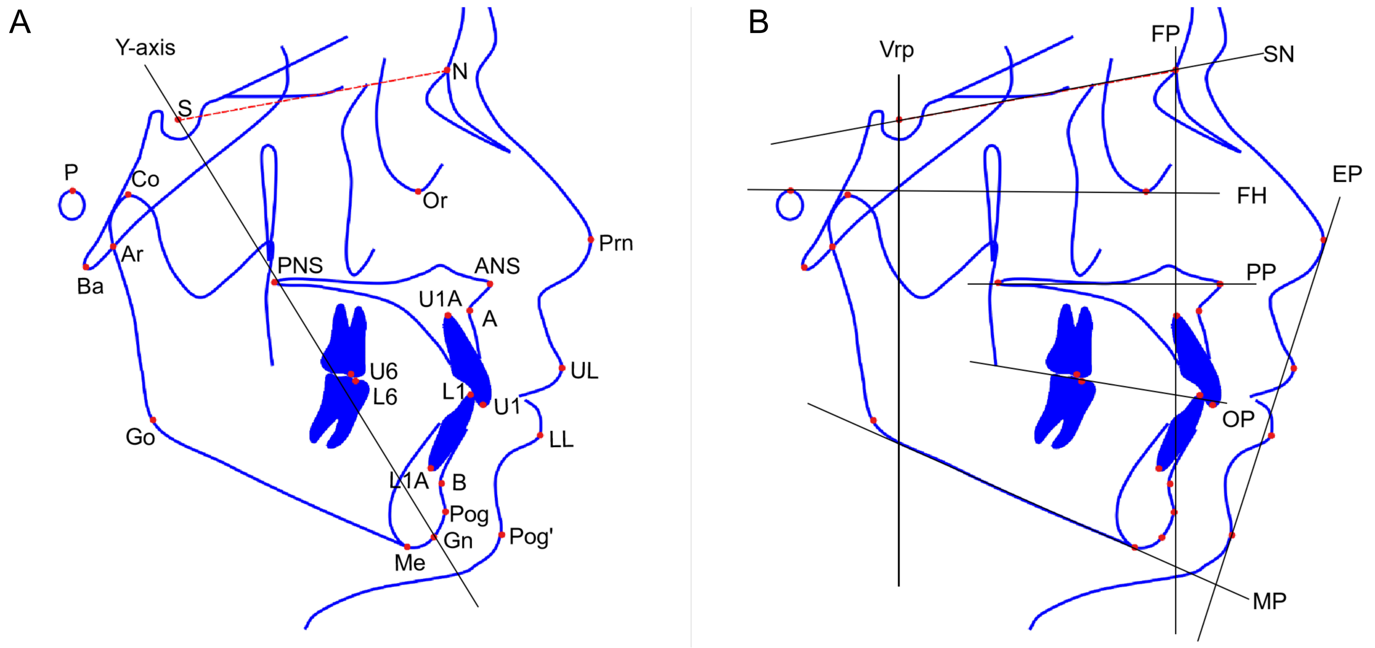

FIGURE 1. Cephalometric measurements used in this study. (A) reference points; (B) reference lines. Abbreviations: Nasion (N), sella point (S), condylion (Co), articulare (Ar), basion (Ba), gonion (Go), anterior nasal spine (ANS), posterior nasal spine (PNS), point A (A), point B (B), pogonion (Pog), soft tissue pogonion (Pog'), gnathion (Gn), menton (Me), subnasale (Sn), labrale superius (UL), labrale inferius (LL) , upper incisor edge (U1), upper incisor apex (U1A), lower incisor edge (L1), lower incisor apex (L1A), porions (P), orbitale (Or), pronasale (Prn), the midpoint of mesial cusps of upper first molars (U6) and lower first molar (L6).

2.4 Data curation and statistical analysis

The descriptive numerical data were described as mean (standard deviation, SD), and categorical data were described as N (%). The Shapiro-Wilk test was used to test the normality of the distribution. The outcome was the alteration in Pog-VRP following treatment. Those with ΔPog-VRP value above the median were categorized in to good response group (GRG), while the rest were catogorized into poor response group (PRG). To minimize the growth and development differences among individuals, ΔPog-VRP was further divided by the alteration in the cranial base length (ΔN-Ba) [24]. Accordingly, subjects with adjΔPog-VRP (ΔPog-VRP/ΔN-Ba) above the median were grouped as adjGRG, while the rest were adjPRG.

Sample size calculation was performed with G*Power 3.1 (Heinrich-Heine-Universität, Düsseldorf, Germany) [25], according to our preliminary sample (N = 20), in which the standard deviation (SD) of ∠N-Go-Me was 4.0. To detect an anticipated difference of 3.0 between GRG and PRG at a ratio of 1:1, at least 32 individuals were required in each group to achieve a 90% power with one-sided $\alpha = 0.05$.

Independent students' t test was used to compare the numerical results between the groups (GRG *vs.* PRG; adjGRG *vs.* adjPRG) if the data was normally distributed, otherwise Mann-Whitney U test was performed. The Chi-square test was performed for the categorical results. Spearman correlation was performed to assess the association of ∠N-Go-Me with continuous variable ΔPog-VRP and adjΔPog-VRP. As for the multivariate regression analysis, the predictive variables to determine the treatment outcome included age, gender, CS and baseline cephalometric measurements with step-wise method. The statistical analysis was performed with SPSS19 (IBM, Armonk, NY USA). A two-tailed $p < 0.05$ was set as statistically significant.

3. Results

Based on the advancement of Pog, 45 subjects with ΔPog-VRP above the median (>2.3 mm) were categorized into GRG, while the rest half were PRG (≤2.3 mm). The demographic information was shown in Table 1. In general, there was no significant difference between PGR and GRG in age (PRG, 11.2 ± 1.1 years; GRG, 10.8 ± 1.0 years, $p = 0.11$), gender (PRG, 23/45 males; GRG, 20/45 males, $p = 0.53$) and CS (PRG, 42/45 with CS3; GRG, 44/45 with CS3, $p = 0.31$). When ΔPog-VRP was adjusted by the individual growth (ΔN-Ba), those with ΔPog-VRP/ΔN-Ba >0.3 were deemed as having good response (adjGRG), while the rest (≤0.3) half were categorized into adjPRG. The two groups were comparable in age (adjPRG, 10.9 ± 1.1 years; adjGRG, 11.0 ± 1.0 years, $p = 0.17$), gender (adjPGR, 22/45 males; adjGRG, 21/45 males, $p = 0.83$) and CS (PRG, 42/45 with CS3; GRG, 44/45 with CS3, $p = 0.31$).

The cephalometric measurements for PRG and GRG were displayed in Table 2. Subjects from GRG had a significantly lower value of ∠N-Go-Me (71.8° ± 4.4° *vs.* 73.8° ± 3.9°, $p = 0.03$), ∠MP-OP (17.0° ± 3.9° *vs.* 18.7° ± 3.7°, $p = 0.04$), and sum of angles (393.4° ± 5.4° *vs.* 395.7° ± 5.1°, $p = 0.04$). All of these baseline values corresponds to the vertical dimensions. In addition, numerical but non-significant differences were observed in ∠SN-MP (32.8° ± 6.1° *vs.* 35.0° ± 5.6°, $p = 0.07$) and L1-MP (38.8 ± 2.7 mm *vs.* 39.7 ± 2.7

TABLE 1. Baseline demographic characteristics on individuals with different treatment response.

	PRG (N = 45)	GRG (N = 45)	p	adj_PRG (N = 45)	adj_GRG (N = 45)	p
Age	11.2 (1.1)	10.8 (1.0)	0.11	10.9 (1.1)	11.1 (1.0)	0.17
Male	23 (51.1)	20 (44.4)	0.53	22 (48.9)	21 (46.7)	0.83
CS						
CS3	42 (93.3)	44 (97.8)	0.31	42 (93.3)	44 (97.8)	0.31
CS4	3 (7.7)	1 (2.2)		3 (7.7)	1 (2.2)	

PRG: poor response group; GRG: good response group; CS: Cervical stage.

mm, $p = 0.10$).

Similar results in the vertical dimensions were observed between adjPRG and adjGRG (Table 3). A significantly smaller value of ∠SN-MP (32.4° ± 5.5° *vs.* 35.4° ± 6.0°, $p = 0.02$), ∠N-Go-Me (71.6° ± 4.1° *vs.* 74.0° ± 4.0°, $p < 0.01$), sum of angles (393.1° ± 4.6° *vs.* 396.1° ± 5.7°, $p < 0.01$) and ∠Ar-Go-Me (119.4° ± 5.6° *vs.* 121.6° ± 6.0°, $p = 0.04$) were found in the subject from adjGRG, with reference to that of adjPRG. Moreover, subjects in adjGRG showed a significantly higher ratio of PFH/AFH (66.4 ± 3.8% *vs.* 64.4 ± 5.0%, $p = 0.04$). A marginal significant difference was observed in ∠MP-OP (17.1° ± 3.8° *vs.* 18.6° ± 2.9°, $p = 0.05$).

Next, those variables with $p < 0.10$ in Tables 2 and 3, together with age, gender and CS were included in the regression analysis to determine their association with the treatment outcome. As shown in Table 4, age ($\beta = -0.21$, 95% CI, −0.19 to −0.003, $p = 0.04$), and ∠N-Go-Me ($\beta = -0.26$, 95% CI, −0.06 to −0.01, $p = 0.01$) were found to be the independent predictors of Pog advancement (Model 1). In addition, when the Pog advancement was adjusted by ΔN-Ba, we found that only ∠N-Go-Me ($\beta = -0.29$, 95% CI −0.06 to −0.01, $p < 0.01$) was included in the final model (Model 2). Additionally, the significant linear correlation of ∠N-Go-Me with ΔPog-VRP ($R^2 = 0.09$, $p < 0.01$) and ΔadjPog-VRP ($R^2 = 0.09$, $p < 0.01$) was depicted in the scatter plot (Fig. 2).

4. Discussion

A predictable change in the facial esthetics can only be achieved if the pretreatment profile is fully realized and the amount/direction of the growth can be estimated. The present study shows that pretreatment ∠N-Go-Me is the statistically significant cephalometric variable that predicts the advance movement of chin position following twin-block treatment. Our findings suggest that the twin-block could produce greater chin advancement if patients are properly selected based on lower gonial angle.

Given the variance in the treatment outcome assessments for functional appliances, different pre-treatment cephalometric measurements have been suggested to predict favorable treatment outcome. For example, Caldwell *et al.* [17] demonstrated that overbite and ∠S-N-B were associated with a reduction in overjet. Ahn *et al.* [18] indicated that horizontal growth pattern, retrusive mandibular incisor, and retrusive lower lip were in favor of good response. Patel *et al.* [19] showed that mandibular length, ramus height, and anterior and posterior lower face height were predictors for significant ∠A-N-B reduction. Moreover, it was suggested that growing patients with ∠Co-Go-Me smaller than 125.5° were expected to experience a greater increment in mandibular length indicated by Co-Gn [14]. Similar results were obtained in other studies, in which ∠Co-Go-Me was significantly associated with chin position advancement [15, 16]. The outcome of twin-block was assessed by the advancement of skeletal Pog point in the present study since chin position was more directly related to the balance and harmony of the facial profile. Whereas an increase in the size of mandible cannot fully reflect the advancement of the mandibular as it might be camouflaged by the growth in the vertical dimensions [26]. Therefore, it has to be noted that less changes in Pog advancement does not necessarily means that the TB was not as successful in patents with higher vertical angle as the lower ones. Moreover, the skeletal Pog was chosen over soft tissue Pog' due to the relatively large individual variation and low accuracy of soft tissue measurements [27].

The present study showed that the favorable group had a smaller ∠SN-MP, ∠Ar-Go-Me, ∠N-Go-Me, ∠MP-OP and sum of angles, as well as an increased PFH/AFH ratio. Interestingly, most of the differences in the above variables markedly increased when the cohort was regrouped into adjGRG and adjPRG. These findings suggested that a low divergent skeletal pattern would likely have a greater chin advancement following twin-block treatment. This was in agreement with a previous study, in which a horizontal growth pattern was associated with better treatment outcome following bionator therapy in Class II patients [18]. Notably, lower gonial angle (∠N-Go-Me) was found to be significantly associated with the treatment outcome after adjusting the confounders. In the Bjork-Jarabak analysis, the gonial angle, which is divided into upper and lower gonial angle, provides information on the relationship between the ramus and corpus of the mandible. A decreased gonial angle indicates a more horizontal growth pattern, which is accompanied by counter-clock rotation of the mandibular and reduced anterior face height [28]. Specifically, the upper gonial angle indicates how oblique the ramus is, and lower gonial angle suggests the slants of mandibular body [29]. Indeed, the gonial angle (∠Co-Go-Me) has been demonstrated to predict the treatment outcome in previous studies [15, 16, 30]. However, their analysis did not specify the information on the upper and lower gonial angle. The present study extends previous findings by showing that a smaller lower gonial angle is associated with greater chin advancement following twin

TABLE 2. Baseline cephalometric characteristics on the subjects from poor response group (PRG) and good response group (GRG).

Baseline cephalometric variables	PRG (N = 45)	GRG (N = 45)	*p*
	Mean (SD)	Mean (SD)	
AP			
S-N-Pog (°)	76.3 (3.8)	76.6 (3.2)	0.69
Ar-Go-N (°)	47.5 (4.0)	47.4 (3.3)	0.90
S-N-A (°)	81.9 (4.0)	82.2 (3.6)	0.79
S-N-B (°)	75.8 (3.6)	76.0 (3.2)	0.77
A-N-B (°)	6.2 (2.4)	6.2 (1.9)	0.99
Pog-N-B (°)	1.1 (0.9)	1.1 (0.9)	0.90
Overjet (mm)	7.9 (2.2)	7.6 (2.1)	0.63
Inter-incisor (°)	112.0 (9.1)	111.5 (8.4)	0.80
UL-EP (mm)	3.8 (2.4)	3.7 (2.3)	0.75
LL-EP (mm)	2.6 (3.1)	3.1 (2.5)	0.41
Pog-VRP (mm)	58.7 (5.5)	57.6 (4.7)	0.35
Vertical			
SN-MP (°)	35.0 (5.6)	32.8 (6.1)	0.07
Na-S-Ar (°)	125.1 (4.6)	124.4 (4.7)	0.49
Ar-Go-Me (°)	121.3 (5.5)	119.7 (6.2)	0.18
Na-Go-Me (°)	73.8 (3.9)	71.8 (4.4)	**0.03**
S-Ar-Go (°)	149.3 (4.9)	149.8 (5.1)	0.64
Y-axis (°)	59.3 (3.0)	59.6 (3.1)	0.63
ANS-Me (mm)	61.1 (4.0)	60.4 (4.0)	0.49
N-ANS (mm)	49.8 (2.5)	49.3 (2.9)	0.41
N-Me (mm)	108.5 (5.2)	107.4 (5.4)	0.31
PFH/AFH (%)	64.7 (4.6)	66.1 (4.5)	0.16
AUFH/ALFH (%)	81.8 (5.9)	81.7 (5.5)	0.96
Overbite (mm)	3.9 (1.2)	3.9 (1.1)	0.93
FMIA (°)	56.1 (6.7)	54.9 (6.1)	0.38
IMPA (°)	101.2 (6.6)	103.3 (6.8)	0.13
MP-OP (°)	18.7 (3.7)	17.0 (3.9)	**0.04**
OP-FH (°)	5.2 (3.3)	5.5 (3.1)	0.62
SN-OP (°)	16.3 (5.1)	15.7 (4.8)	0.56
Sum-of-angles (°)	395.7 (5.1)	393.4 (5.4)	**0.04**
Dento-Alveolar			
U1-FP (mm)	13.8 (2.9)	13.5 (2.9)	0.63
L1-FP (mm)	6.4 (2.8)	5.9 (2.5)	0.43
U1-PP (mm)	26.4 (2.2)	26.5 (2.4)	0.75
U6-PP (mm)	19.9 (1.8)	20.1 (1.9)	0.51
L1-MP (mm)	39.7 (2.7)	38.8 (2.7)	0.10
L6-MP (mm)	29.6 (2.2)	29.2 (2.5)	0.40
Mandibular dimensions			
Co-Gn (mm)	101.5 (5.6)	100.8 (5.0)	0.50
Go-Me (mm)	62.6 (4.5)	62.4 (3.7)	0.84
Go-Pog (mm)	68.4 (4.5)	68.4 (3.9)	0.96
Go-Co (mm)	50.7 (4.8)	50.8 (4.5)	0.90
Cranial Base dimensions			
N-Ba (mm)	97.9 (4.4)	99.1 (4.1)	0.20
S-Ar (mm)	33.5 (3.5)	33.9 (3.2)	0.53

SD: standard deviation. Bold indicates $p < 0.05$.

TABLE 3. Baseline cephalometric characteristics on the subjects from adjusted poor response group (adjPRG) and adjusted good response group (adjGRG).

Baseline cephalometric variables	adjPRG (N = 45)	adjGRG (N = 45)	*p*
AP			
S-N-Pog (°)	76.1 (3.9)	76.8 (3.0)	0.33
Ar-Go-N (°)	47.5 (3.9)	47.4 (3.5)	0.88
S-N-A (°)	81.8 (4.1)	82.3 (3.5)	0.56
S-NB (°)	75.6 (3.8)	76.1 (3.0)	0.53
A-N-B (°)	6.2 (2.1)	6.2 (2.2)	0.97
Pog-N-B (°)	1.0 (0.8)	1.2 (0.9)	0.21
Overjet (mm)	7.8 (1.9)	7.7 (2.3)	0.77
Inter-incisor (°)	111.4 (8.4)	112.0 (9.1)	0.73
UL-EP (mm)	3.9 (2.3)	3.6 (2.4)	0.56
LL-EP (mm)	3.0 (2.9)	2.7 (2.7)	0.56
Pog-VRP (mm)	58.4 (5.0)	57.9 (5.3)	0.68
Vertical			
SN-MP (°)	35.4 (6.0)	32.4 (5.5)	**0.02**
Na-S-Ar (°)	124.9 (4.7)	125.7 (4.6)	0.84
Ar-Go-Me (°)	121.6 (6.0)	119.0 (5.8)	**0.04**
Na-Go-Me (°)	74.0 (4.0)	71.6 (4.1)	**0.007**
S-Ar-Go (°)	149.6 (4.9)	149.5 (5.2)	0.92
Y-axis (°)	59.5 (2.9)	59.5 (3.2)	0.99
ANS-Me (mm)	61.3 (3.9)	60.2 (4.0)	0.20
N-ANS (mm)	49.9 (2.9)	49.2 (2.5)	0.25
N-Me (mm)	108.8 (5.7)	107.1 (4.8)	0.11
PFH/AFH (%)	64.4 (5.0)	66.4 (3.8)	**0.04**
AUFH/ALFH (%)	81.6 (5.5)	82.0 (5.9)	0.74
Overbite (mm)	3.8 (1.2)	4.1 (1.1)	0.24
FMIA (°)	55.6 (5.3)	55.4 (7.4)	0.87
IMPA (°)	101.2 (5.9)	103.2 (7.4)	0.16
MP-OP (°)	18.6 (2.9)	17.1 (3.8)	0.05
OP-FH (°)	5.3 (3.6)	5.4 (2.8)	0.81
SN-OP (°)	16.7 (5.1)	15.3 (4.5)	0.17
Sum-of-angle (°)	396.1 (5.7)	393.1 (4.6)	**0.008**
Dento-Alveolar			
U1-FP (mm)	13.9 (2.4)	13.4 (3.3)	0.45
L1-FP (mm)	6.4 (2.6)	5.9 (2.8)	0.46
U1-PP (mm)	26.7 (2.2)	26.2 (2.4)	0.37
U6-PP (mm)	19.9 (2.0)	20.1 (1.7)	0.56
L1-MP (mm)	39.6 (2.9)	38.9 (2.5)	0.27
L6-MP (mm)	29.4 (2.4)	29.3 (2.3)	0.85
Mandibular dimensions			
Co_Gn (mm)	101.5 (6.0)	100.8 (4.5)	0.71
Go_Me (mm)	62.6 (3.9)	62.5 (4.3)	0.95
Go_Po (mm)	68.3 (4.2)	68.5 (4.2)	0.84
Go_Co (mm)	50.7 (5.2)	50.7 (4.1)	0.98
Cranial Based dimensions			
N_Ba (mm)	98.1 (4.5)	98.9 (3.9)	0.42
S_Ar (mm)	33.2 (3.9)	34.1 (2.5)	0.19

Bold indicates $p < 0.05$.

TABLE 4. Multivariate regression analysis of treatment outcome against explanatory variables.

	β	95% CI	p
Model 1			
Age	−0.10	−0.194 to −0.003	0.04
Na-Go-Me	−0.03	−0.055 to −0.006	0.01
Model 2			
Na-Go-Me	−0.03	−0.058 to −0.010	<**0.001**

CI: confidence interval.
Model 1: The dependent variable is GRG with PRG as reference. The independent variables include age, gender, CS, ∠SN-MP, ∠Na-Go-Me, ∠MP-OP, and Sum of angle.
Model 2: The dependent variable is adjGRG with adjPRG as reference. The independent variables include age, gender, CS, ∠SN-MP, ∠Na-Go-Me, ∠MP-OP, Sum of angle, ∠Ar-Go-Me, PFH/AFH.

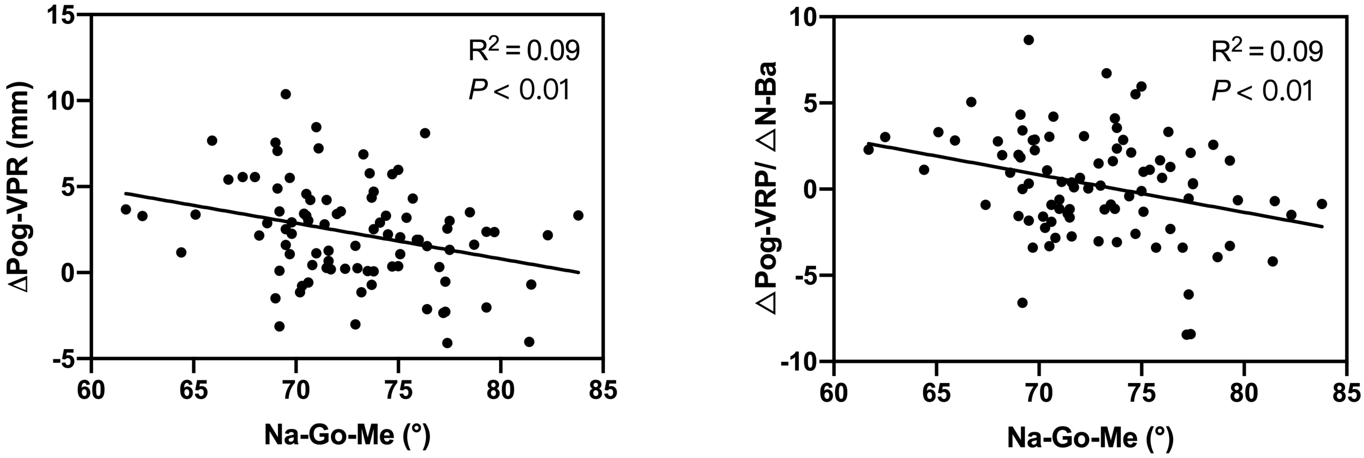

FIGURE 2. Linear correlation of Pog-VRP and adjPog-VRP against ∠Na-Go-Me.

block treatment.

Ideally, a reference group from the same population with class II skeletal relationship at growing stage would have been highly recommended to discriminate the "true" outcome produced by functional appliance. However, the ethical concerns make it difficult to delay the treatment for patients with such conditions [31]. As such, the present study further divided ΔPog-VRP by ΔN-Ba in an attempt to minimize any growth difference among the individuals. ΔN-Ba was chosen because of previous evidence that the distance from nasion to basion was not influenced by the available treatment [24]. Notably, the growth of cranial base was found to be closely associated with that of the mandibular [32]. Therefore, the adjusted ΔPog-VRP could be interpreted as the twin-block induced effects.

Several limitations had to be addressed for the current study. The retrospective nature of the data collection could increase the possibility of bias. Long-term design study with larger sample size is highly warranted to investigate the stability of functional appliance treatment in subjects with different skeletal pattern. The predictive parameters found in the present study should be validated in future prospective studies. Moreover, self-reported compliance of twin block use is subjective and prone to bias. In addition, the treatment response was dichotomized based on the median value of ΔPog-VRP in the current study. Such cut-off value cannot be generalized to other cohorts, and needs further validation.

5. Conclusions

Within the limitation of the study, we provide evidence that patients with a low divergent skeletal pattern are likely to experience more improvement in the advancement of chin position following twin-block treatment. The N-Go-Me angle is found to be the statistically significant predictor for favorable treatment outcome, regardless of the potential in facial growth.

ABBREVIATIONS

VRP, vertical reference plane; CS, cervical stage; GRG, good response group; PGR, poor response group; AUFH, anterior lower facial height; ALFH, anterior lower facial height; VRP, vertical reference plane; FH, Frankfort horizontal plane; FP, facial plane; EP, esthetic plane; OP, occlusal plane; PP, palatal plane; FMIA, Frankfurt mandibular incisor angle; IMPA, incisor mandibular plane angle.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are not publicly available due to the compliance with patient privacy regulations, but are available from the corresponding author on reasonable request upon permission from the ethic committee of Stomatology School & Hospital, Wenzhou medical University.

AUTHOR CONTRIBUTIONS

RH, YW and HZ—conceived the study. JD and YZ—collected and analyzed the data. QS and FL—collected that data. JD, YW and HZ—drafted the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the ethic committee of Stomatology School & Hospital, Wenzhou Medical University (No. WYKQ2020003) and conducted in accordance with the Declaration of Helsinki. Due to retrospective nature and anonymity of the data used in this study, the need for informed consent from each individual was waived by the ethic committee of Stomatology School & Hospital, Wenzhou Medical University.

ACKNOWLEDGMENT

Not applicable.

FUNDING

This study was supported by funding from Wenzhou Science and Technology Bureau (Y20190100 & 2020Y0536), and Natural Science Foundation of Zhejiang Province (LQ20H140002).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Lin M, Xie C, Yang H, Wu C, Ren A. Prevalence of malocclusion in Chinese schoolchildren from 1991 to 2018: a systematic review and meta-analysis. International Journal of Paediatric Dentistry. 2020; 30: 144–155.

[2] Moro A, Mattos CFP, Borges SW, Flores-Mir C, Topolski F. Stability of Class II corrections with removable and fixed functional appliances: a literature review. Journal of the World Federation of Orthodontists. 2020; 9: 56–67.

[3] Toth LR, McNamara Jr JA. Treatment effects produced by the twin-block appliance and the FR-2 appliance of Frankel compared with an untreated Class II sample. American Journal of Orthodontics and Dentofacial Orthopedics. 1999; 116: 597–609.

[4] Marsico E, Gatto E, Burrascano M, Matarese G, Cordasco G. Effectiveness of orthodontic treatment with functional appliances on mandibular growth in the short term. American Journal of Orthodontics and Dentofacial Orthopedics. 2011; 139: 24–36.

[5] Ruf S, Baltromejus S, Pancherz H. Effective condylar growth and chin position changes in activator treatment: a cephalometric roentgenographic study. The Angle Orthodontist. 2001; 71: 4–11.

[6] Serbesis-Tsarudis C, Pancherz H. "Effective" TMJ and chin position changes in Class II treatment: orthodontics versus orthopedics. The Angle Orthodontist. 2008; 78: 813–818.

[7] Rodrigues de Almeida M, Castanha Henriques JF, Rodrigues de Almeida R, Ursi W. Treatment effects produced by Frankel appliance in patients with class II, division 1 malocclusion. The Angle Orthodontist. 2002; 72: 418–425.

[8] 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. American Journal of Orthodontics and Dentofacial Orthopedics. 2003; 124: 234–243.

[9] Clark WJ. The twin block technique. A functional orthopedic appliance system. American Journal of Orthodontics and Dentofacial Orthopedics. 1988; 93: 1–18.

[10] Ehsani S, Nebbe B, Normando D, Lagravere MO, Flores-Mir C. Short-term treatment effects produced by the Twin-block appliance: a systematic review and meta-analysis. European Journal of Orthodontics. 2015; 37: 170–176.

[11] Li L, Liu H, Cheng H, Han Y, Wang C, Chen Y, *et al*. CBCT evaluation of the upper airway morphological changes in growing patients of class II division 1 malocclusion with mandibular retrusion using twin block appliance: a comparative research. PLOS ONE. 2014; 9: e94378.

[12] Güler ÖÇ, Malkoç S. Comparison of facial soft tissue changes after treatment with 3 different functional appliances. American Journal of Orthodontics and Dentofacial Orthopedics. 2020; 158: 518–526.

[13] DeVincenzo JP. Changes in mandibular length before, during, and after successful orthopedic correction of Class II malocclusions, using a functional appliance. American Journal of Orthodontics and Dentofacial Orthopedics. 1991; 99: 241–257.

[14] Franchi L, Baccetti T. Prediction of individual mandibular changes induced by functional jaw orthopedics followed by fixed appliances in class II patients. The Angle Orthodontist. 2006; 76: 950–954.

[15] Baccetti T, Franchi L, Stahl F. Comparison of 2 comprehensive Class II treatment protocols including the bonded Herbst and headgear appliances: a double-blind study of consecutively treated patients at puberty. American Journal of Orthodontics and Dentofacial Orthopedics. 2009; 135: 698.e1–e10.

[16] Cretella Lombardo E, Franchi L, Gastaldi G, Giuntini V, Lione R, Cozza P, *et al*. Development of a prediction model for short-term success of functional treatment of class II malocclusion. International Journal of Environmental Research and Public Health. 2020; 17: 4473.

[17] Caldwell S, Cook P. Predicting the outcome of twin block functional appliance treatment: a prospective study. The European Journal of Orthodontics. 1999; 21: 533–539.

[18] Ahn SJ, Kim JT, Nahm DS. Cephalometric markers to consider in the treatment of class II division 1 malocclusion with the bionator. American Journal of Orthodontics and Dentofacial Orthopedics. 2001; 119: 578–586.

[19] Patel HP, Moseley HC, Noar JH. Cephalometric determinants of successful functional appliance therapy. The Angle Orthodontist. 2002; 72: 410–417.

[20] Fleming PS, Qureshi U, Pandis N, DiBiase A, Lee RT. An investigation of cephalometric and morphological predictors of successful twin block therapy. Australian Orthodontic Journal. 2012; 28: 190–196.

[21] Lau JW, Hägg U. Cephalometric morphology of Chinese with class II division 1 malocclusion. British Dental Journal. 1999; 186: 188–190.

[22] McNamara Jr JA, Franchi L. The cervical vertebral maturation method: a user's guide. The Angle Orthodontist. 2018; 88: 133–143.

[23] Mills CM, McCulloch KJ. Treatment effects of the twin block appliance: a cephalometric study. American Journal of Orthodontics and Dentofacial Orthopedics. 1998; 114: 15–24.

[24] Jakobsson SO, Paulin G. The influence of activator treatment on skeletal growth in angle class II: 1 cases. A roentgenocephalometric study. The European Journal of Orthodontics. 1990; 12: 174–184.

[25] Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior Research Methods. 2007; 39: 175–191.

[26] Cozza P, Baccetti T, Franchi L, De Toffol L, McNamara Jr JA. Mandibular changes produced by functional appliances in class II malocclusion: a systematic review. American Journal of Orthodontics and Dentofacial Orthopedics. 2006; 129: 599.e1–e12.

[27] Morris DO, Illing HM, Lee RT. A prospective evaluation of Bass, Bionator and Twin Block appliances. Part II—the soft tissues. The European Journal of Orthodontics. 1998; 20: 663–684.
[28] Björk A. Variations in the growth pattern of the human mandible: longitudinal radiographic study by the implant method. Journal of dental Research. 1963; 42: 400–411.
[29] Jacobson A, Jacobson RL. Radiographic cephalometry, from basics to 3D imaging. 2nd edn. Quintessence Publishing: New Malden, UK. 2006.
[30] Kim JE, Mah SJ, Kim TW, Kim SJ, Park KH, Kang YG. Predictors of favorable soft tissue profile outcomes following Class II Twin-block treatment. The Korean Journal of Orthodontics. 2018; 48: 11–22.
[31] Baccetti T, Franchi L, McNamara JA. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. Seminars in Orthodontics. 2005; 11: 119–129.
[32] Lewis AB, Roche AF, Wagner B. Pubertal spurts in cranial base and mandible. Comparisons within individuals. The Angle Orthodontist. 1985; 55: 17–30.

How to cite this article: Jingya Dong, Yan Zhang, Qingjuan Shi, Feiou Lin, Rongdang Hu, Yi Wang, *et al*. Prediction on the chin advancement of the twin block functional appliance in growing Chinese patients using the cephalometric markers: a retrospective study. Journal of Clinical Pediatric Dentistry. 2024; 48(5): 110-118. doi: 10.22514/jocpd.2024.110.