A Retrospective Study on the Cephalometric Markers That Predict the Treatment Outcomes of Twin Block Functional Appliance

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Abstract

Background

Despite the widespread use of functional appliances, broad variations are reported on the treatment response. This retrospective study aims to investigate the pre-treatment cephalometric predictors on the treatment outcome of Twin block in growing patients with class II malocclusion

Methods

After screening, a total of 90 patients treated by Twin block were included in the study. The treatment outcome was the advancement of the chin position, assessed by the distance of skeletal pogonion to the vertical reference plane perpendicular to Frankfurt plane (△Pog-VRP). Moreover, △Pog-VRP is adjusted by facial growth evaluated by △N-Ba to minimize the growth discrepancy among individuals (adj△Pog-VRP). The pre-treatment cephalometric measurements were compared with independent *t*-test. Stepwise multivariate regression analysis was performed to determine the pre-treatment cephalometric predictors for the treatment outcome.

Results

Patients were equally divided into good response group (GRG/adjGRG, N = 45) and poor response group (PRG/adjPRG, N = 45) respectively based on the median value of △Pog-VRP/adj△Pog-VRP. Patients with greater chin advancement had a significantly reduced cephalometric measurements in the vertical dimensions including ∠Na-Go-Me, ∠MP-OP and sum of angels ($P < 0.05$). And such differences increased after adjustments in comparison between adjGRG and adjPRG. Importantly, ∠Na-Go-Me was found to be independent predicter on Pog advancement before (β=-0.26, 95%CI, -0.06 to -0.01, $P = 0.01$) and after adjustments (β=-0.29,95%CI -0.06, -0.01, P < 0.01).

Conclusion

With the limitation of the study, we provide evidence that patients with a smaller Na-Go-Me angle are more likely to experience a greater chin advancement following Twin block treatment.

Background

Class II malocclusion is one of the most prevalent orthodontic conditions worldwide, affecting around one third of the populations. Based on the newly combined data from 37 studies enrolling around 11,000 subjects, the prevalence of Class II malocclusion is estimated to be 9.91% (95% CI: 7.41%-13.79%) in Chinese school children, calling for proactive and effective interventions [1]. Indeed, several types of functional appliances that aim for the correction of class II division 1 malocclusion in actively growing patients have been applied for decades, including Twin Block, activator, herbst, bionator, etc [2]. Yet, 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]. While others claimed that the successful effects of functional appliances were mainly attributed to dento-alveolar components, rather than the skeletal effects [7, 8]. Despite the disputed arguments, functional appliances are still widely used as they bring a harmonious facial profile in growing individuals.

The 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 is therefore one of the mostly used functional appliances in clinic. Many studies have revealed 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].

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 [12]. Therefore, studies have been carried out to determine whether the pretreatment cephalometric markers could predict good response following functional appliance treatment. It is well demonstrated that a decreased gonial angle may serve as good predictors for greater increment in mandibular growth [13] and chin point advancement [14, 15]. Moreover, overbite, inclination of the lower incisor and lip, mandibular length, ramus height, anterior and posterior face height are suggested to be significantly associated with the treatment response, depending on the functional appliance used and outcome measurement [16–18]. On the contrary, some argued that no relationship exists between mandibular morphology, vertical skeletal pattern and favorable dentoalveolar/skeletal responses to Twin block therapy [19].

The majority of the studies that determine the cephalometric predictors were carried out in white Caucasians. Whether such association can 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, Chinese presented with a significantly more prognathic maxilla and less retrusive mandible in reference to Caucasian, as indicated by larger S-N-A and S-N-B angles respectively [20]. As such, this present study aims to investigate the association of pretreatment cephalometric markers with Twin block treatment outcomes in Chinese subjects at pubertal stage.

Methods

The inclusion criteria

This study was carried out on 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. The inclusion criteria were as follows: 1) Overjet > 7mm with angle class II division I malocclusion; 2) ANB > 4°; 3) Cervical stage (CS) 3–4 at the beginning of functional treatment (T1) and CS 4–5 at the end of therapy (T2); 4) Lateral cephalometric graphs with high quality were available at T1 and T2; 5) No adjunct orthodontic treatment either prior to 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.

Treatment protocol

All the patients were treated by two specialists (HZ & QS). The basic design of the Twin-block is as previously described with brief modification [21]. 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 24h 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 is within 9-12 months till class I molar relationship is achieved.

Cephalometric analysis

The lateral Cephalometric images were taken prior to and 3 months after the completion of functional appliance treatment. The reference points and lines are displayed in Fig. 1, including 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), gnathion (Gn), menton (Me), subnasale (Sn), labrale superius (Ls), labrale inferius (Li), Soft tissue pogonion (Pog’), upper incisor edge (U1), upper incisor apex (U1A), lower incisor edge (L1), lower incisor apex (L1A), porions (P), orbitale (Or), pterygoid point(Pt), Pterygomaxillary fissure (Ptm), Soft tissue gnathion (Gn’), Pronasale (Prn), Maxillary first molars (U6), Mandibular first molar (L6). A Vertical reference plane (VRP) was constructed perpendicular to the Frankfort horizontal plane through sella point.

All the tracing on the lateral cephalometric graphs were done by a single examiner (JD) with the use of cephalometric software Uceph (Sichuan University, China). One week after the first measurements, 20 cephalometric graphs were randomly retraced and reassessed for all the variables included in the study. It was found that 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. Disagreement were discussed till satisfaction were reached by both.

Data curation and statistical analysis

The descriptive numerical data were presented as mean (standard deviation, SD), and categorical data were shown as N (%). The outcome was the alteration in Pog-VRP following treatment. Those who had △Pog-VRP value above the median were categorized in to good response group (GRG), while the rest were divided into poor response group (PRG). In an attempt to minimize the growth and development differences among individuals, △Pog-VRP was further divided by the alteration in the cranial base length (N-Ba). Accordingly, subjects with adj△Pog-VRP (△Pog-VRP/△N-Ba)) above the median were grouped as adjGRG, while the rest were adjPRG.

Independent students' *t* test was used to compare the numerical results between the groups (GRG v.s PRG; adjGRG v.s adjPRG), while chi-square test was performed for the categorical results. Spearman correlation was performed to assess the association of Na-Go-Me angle with continuous variable △Pog-VRP and adj△Pog-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. All statistical analysis were performed with SPSS19 (IBM, USA). A two tailed $P < 0.05$ was set as statistically significant.

Results

Based on the advancement of Pog, 45 subjects whose △Pog-VRP was above the median (> 2.3 mm), were categorized into GRG, while the rest half were PRG (≤ 2.3 mm). The demographic information is indicated in Table. 1. In general, there is 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 (PGR, 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 △Pog-VRP was adjusted by the individual growth (△N-Ba), those with △Pog-VRP/△N-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, $P = 0.17$) and 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 are displayed in Table 2. Subjects from GRG had a significantly lower value of ∠Na-Go-Me (71.8° ± 4.4° v.s 73.8° ± 3.9°, $P = 0.03$), ∠MP-OP (17.0° ± 3.9° v.s. 18.7° ± 3.7°, $P = 0.04$), sum of angels (395.7° ± 5.1° v.s. 393.4° ± 5.4°, $P = 0.04$). All of these baseline values corresponds to the vertical dimensions. In addition, numerical but non-significant difference were observed in ∠SN-MP (32.8° ± 6.1° v.s. 35.0° ± 5.6°, $P = 0.07$) and ∠L1-MP (38.8° ± 2.7° v.s. 39.7° ± 2.7°, $P = 0.10$).

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			0.31			0.31
CS3	42(93.3)	44 (97.8)		42 (93.3)	44 (97.8)	
CS4	3 (7.7)	1 (2.2)		3 (7.7)	1(2.2)	

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

Baseline cephalometric variables	**PRG (N = 45)** Mean (SD)	**GRG (N = 45)** Mean (SD)	***P***
AP			
SN-NPo (°)	76.3 (3.8)	76.6 (3.2)	0.69
Ar-Go-N (°)	47.5 (4.0)	47.4 (3.3)	0.90
SNA (°)	81.9 (4.0)	82.2 (3.6)	0.79
SNB (°)	75.8 (3.6)	76.0 (3.2)	0.77
ANB (°)	6.2 (2.4)	6.2 (1.9)	0.99
Po-NB (°)	1.1 (0.9)	1.1 (0.9)	0.90
OJ (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 (°)	61.1 (4.0)	60.4(4.0)	0.49
N-ANS (°)	49.8 (2.5)	49.3(2.9)	0.41
N-Me (°)	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

Bold indicates $P < 0.05$

Baseline cephalometric variables	PRG (N = 45) Mean (SD)	GRG (N = 45) Mean (SD)	*P*
OB (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-angle (°)	395.7(5.1)	393.4(5.4)	**0.04**
Dento-Alveolar			
U1-FP (°)	13.8(2.9)	13.5(2.9)	0.63
L1-FP (°)	6.4(2.8)	5.9 (2.5)	0.43
U1-PP (°)	26.4(2.2)	26.5(2.4)	0.75
U6-PP (°)	19.9(1.8)	20.1(1.9)	0.51
L1-MP (°)	39.7(2.7)	38.8(2.7)	0.10
L6-MP (°)	29.6(2.2)	29.2(2.5)	0.40
Mandibular dimensions			
Co-Gn (°)	101.5 (5.6)	100.8(5.0)	0.50
Go-Me (°)	62.6 (4.5)	62.4 (3.7)	0.84
Go-Po (°)	68.4(4.5)	68.4(3.9)	0.96
Go-Co (°)	50.7(4.8)	50.8 (4.5)	0.90
Cranial Based 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
Bold indicates $P < 0.05$			

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° v.s. 35.4° ± 6.0°, $P = 0.02$), ∠Na-Go-Me (71.6° ± 4.1° v.s. 74.0° ± 4.0°, $P < 0.01$), and sum of angles (393.1° ± 4.6° v.s. 396.1° ± 5.7°, $P < 0.01$) were found in the subject from adjGRG, with reference to that of adjPRG. Moreover, subjects in adjGRG showed a higher ratio of PFH/AFH (66.4 ± 3.8% v.s. 64.4 ± 5.0%). A marginal significant difference was observed in ∠Ar-Go-Me (119.4° ± 5.6° v.s. 121.6° ± 6.0°, $P = 0.08$) and ∠MP-OP (17.1° ± 3.8° v.s. 18.6° ± 2.9°, $P = 0.05$).

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			
SN-NPo (°)	76.1 (3.9)	76.8 (3.0)	0.33
Ar-Go-N (°)	47.5 (3.9)	47.4 (3.5)	0.88
SNA (°)	81.8 (4.1)	82.3 (3.5)	0.56
SNB (°)	75.6 (3.8)	76.1 (3.0)	0.53
ANB (°)	6.2 (2.1)	6.2 (2.2)	0.97
Po-NB (°)	1.0 (0.8)	1.2 (0.9)	0.21
OJ (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)	**< 0.01**
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 (°)	61.3 (3.9)	60.2 (4.0)	0.20
N_ANS (°)	49.9 (2.9)	49.2 (2.5)	0.25
N_Me (°)	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

Bold indicates $P < 0.05$

Baseline cephalometric variables	adjPRG (N = 45)	adjGRG (N = 45)	*P*
OB (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)	**< 0.01**
Dento-Alveolar			
U1-FP (°)	13.9 (2.4)	13.4 (3.3)	0.45
L1-FP (°)	6.4 (2.6)	5.9 (2.8)	0.46
U1-PP (°)	26.7 (2.2)	26.2 (2.4)	0.37
U6-PP (°)	19.9 (2.0)	20.1 (1.7)	0.56
L1-MP (°)	39.6 (2.9)	38.9 (2.5)	0.27
L6-MP (°)	29.4 (2.4)	29.3 (2.3)	0.85
Mandibular dimensions			
Co_Gn (°)	101.5 (6.0)	100.8 (4.5)	0.71
Go_Me (°)	62.6 (3.9)	62.5 (4.3)	0.95
Go_Po (°)	68.3 (4.2)	68.5 (4.2)	0.84
Go_Co (°)	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			

Next, those variables with $P < 0.10$ in Tables 2 & 3, together with age, gender and CS were included in the regression analysis to determine the association with the treatment outcome. As shown in Table 4, age (β = -0.21,95%CI, -0.19 to -0.003, $P = 0.04$), and Na-Go-Me (β = -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 △N-Ba, we found that only Na-Go-Me (β = -0.2995%CI -0.06, -0.01, P <

0.01) was included in the final model (Model 2). Additionally, the significant linear correlation of Na-Go-Me with △Pog-VRP (R^2 = 0.09, P< 0.01) and △adjPog-VRP (R^2 = 0.09, P< 0.01) was depicted in the scatter plot (Fig. 2)

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	< 0.01
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.			

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 Na-Go-Me angle 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 favorable results if patients were properly selected based on 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. demonstrated that overbite and SNB angles were associated with a reduction in overjet [16]. Ahn et al. indicated that horizontal growth pattern, retrusive mandibular incisor, and retrusive lower lip were in favor of good response [17]. Patel et al. showed mandibular length and ramus height, anterior and posterior lower face height were predictors for great ANB reduction [18]. Moreover, it has been suggested that growing patients with Co-Go-Me angle smaller than 125.5° are expected to experience a greater increment in mandibular length indicated by Co-Gn [13]. Similar results were obtained in other studies, in which Co-Go-Me degrees were significantly associated with chin position advancement [14, 15]. The outcome of Twin block was assessed by the advancement of skeletal Pog point in the present study since chin position is more directly related to the balance and harmony of the facial profile. Whereas an increase in the size of mandibular does not fully reflect the advancement of the mandibular as it can be camouflaged by the growth in the vertical dimensions [22]. Moreover, the skeletal

Pog was chosen over soft tissue Pog because of the relatively large individual variation and low accuracy of soft tissue measurements [23].

The present study showed that the favorable group had a smaller ∠SN-MP, ∠Ar-Go-Me, ∠Na-Go-Me, ∠MP-OP and sum of angles, and an increased PFH/AFH. Interestingly, such differences in the above variables markedly increased when the cohort was regrouped in adjGRG and adjPRG. These findings suggest that a low divergent skeletal pattern is likely to have greater chin advancement following Twin block treatment. Notably, lower gonial angle (∠Na-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 could be divided into upper and lower gonial angle, provides information on the he relationship between the ramus and corpus of the mandible. A decreased gonial angle indicates a more horizontal growth pattern, which is accompanied by counterclock rotation of the mandibular and reduced anterior face height [24]. Specifically, the upper gonial angle indicates how oblique the ramus is, and lower gonial angle suggests the slants of mandibular body [25]. The gonial angel (∠Co-Go-Me) was demonstrated to predict the treatment outcome in previous studies [14, 15, 26]. However, the information on the upper and lower gonial angle was not specified in their analysis. Here, we provide further evidence that it was the lower gonial angle that mainly contributes to the decrease in the gonial angle, which lead to the favorable treatment response.

Ideally, a reference group from the same population with class II skeletal relationship at growing stage are 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 [27]. As such, the present study further divided △Pog-VRP by △N-Ba in an attempt to minimize any growth difference among the individuals. The reason why △N-Ba was chosen is based on previous evidence that the distance from Nasion to basion is not influenced by the functional treatment [28]. Moreover, the growth of cranial base is closely associated with that of the mandibular [29]. Therefore, the adjusted △Pog-VRP could be interpreted as the twin block induced effects.

Several limitations have to be addressed for the current study. The retrospective nature of the data collection could increase the possibility of bias. Moreover, long-term design study is highly warranted to investigate the stability of functional appliance treatment in subjects with different skeletal pattern. Finally, the predictive parameters found in the present study should be validated in future prospective studies.

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 Na-Go-Me angle is found to be the statistically significant predictor for favorable treatment outcome, regardless of the of the potential in facial growth.

List Of Abbreviations

VRP, vertical reference plane; CS, cervical stage; GRG, good response group; PGR, poor response group

Declarations

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.

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.

Competing interests

The authors declare that they have no competing interests.

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Authors 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.

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Consent for publication

Not applicable

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Figures

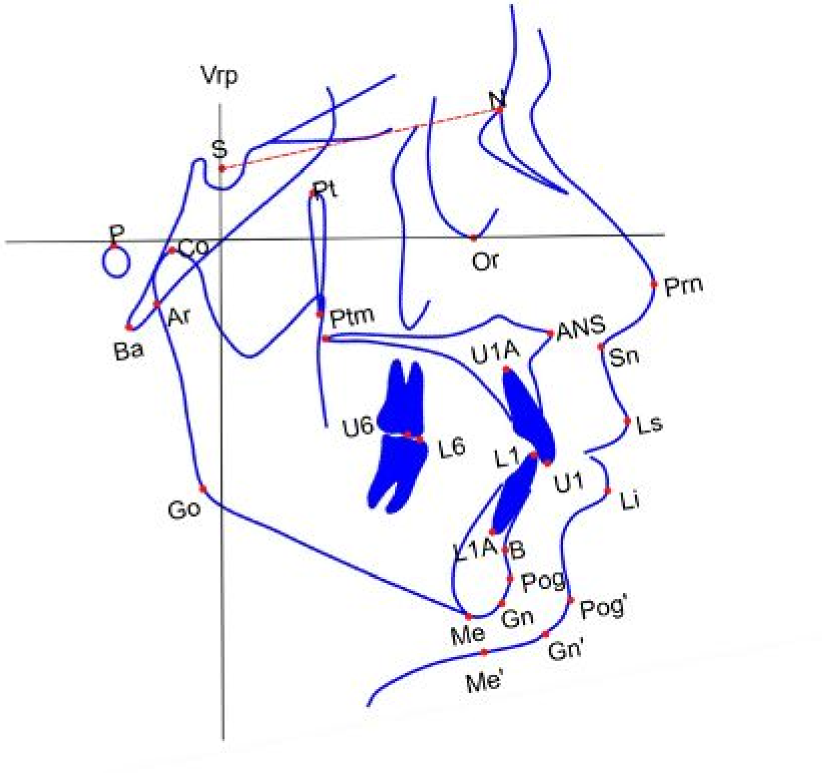

Figure 1

Cephalometric measurements used in this study.

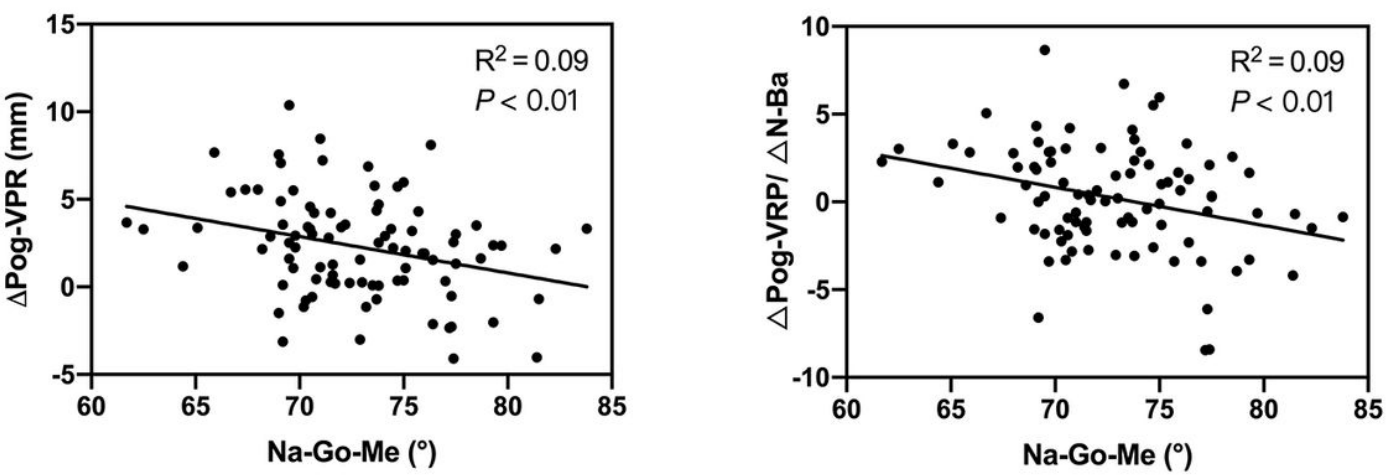

Figure 2

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