Comparison of cephalometric measurements of the Twin Block and A6 appliances in the treatment of Class II malocclusion: a retrospective comparative cohort study

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Background: Skeletal Class II malocclusion is a common malocclusion that seriously affects patients' profile and occlusal function. The key to treatment is to use functional appliances guide the mandible forward. This study aimed to evaluate the clinical efficacy of traditional functional appliance Twin Block (TB) and invisible functional appliance (A6).

Methods: In the retrospective cohort study, 46 patients with Class II Division 1 mandibular retrognathia (23 females, 23 males; mean age 13.66±4.25 years) from the Third Affiliated Hospital of Sun Yat-sen University were selected. They were divided into A6 group and TB group according to the type of appliance guided mandibular forward used in orthodontic treatment (n=23 each; average treatment time 9.82±3.52 months). Lateral cephalometric radiographs were taken before and at the end of each treatment, and paired *t*-test or paired rank-sum tests were performed when appropriate to detect any statistical significance at the level of α=0.05.

Results: The baseline characteristics of the two groups of patients were similar. Treatment with both appliances helped correct Class II malocclusion, improve the discrepancy between the maxilla and mandible, reduce the labial inclination of the maxillary anterior teeth, and relieve the deep overbite. A comparison of the treatment effects of the TB and A6 groups showed that the A6 had a better effect when moving Point A backward, and performed better in the abduction of the anterior teeth. TB group has more advantages than A6 group in moving forward point B and improving the nasolabial angle.

Conclusions: Both the A6 and TB can significantly improve Class II malocclusion. A6 showed an obvious advantage in moving Point A backward and adducting the anterior teeth, which better corrects a skeletal Class II malocclusion.

Keywords: Class II malocclusion; functional appliance; invisible appliance without brackets; lateral cephalometric radiographs; mandibular advancement

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Introduction

As people's living standards improve, they pay more attention to facial appearance and oral health. In China, especially in the south, facial appearance problems caused by Class II malocclusion have become the main reason for malocclusion correction. Epidemiological research shows that Class II malocclusion comes second only after Class I malocclusion (1-5). Class II malocclusion can be divided into skeletal and dental malocclusion. Dental Class II malocclusion can be improved simply by correcting the teeth, whereas a skeletal malocclusion is usually associated with overdevelopment of the maxilla or underdevelopment of the mandible, or both. It is currently clinically considered that skeletal Class II malocclusion is mainly caused by mandibular retrognathia (6). To date, the main treatment methods for mandibular advancement were the Twin Block (TB) functional appliance, Frankel II appliance, Activator-Headgear, Herbst, Bionator, muscle function trainer, and others Through the functional advancement of the mandible, they promote the development of the mandible, thereby coordinating the position of the maxilla and mandible and creating a good skeletal basis for secondary dental correction. These functional appliances not only have large volume and poor aesthetics, but also affect pronunciation, cannot solve sagittal and transverse problems at the same time, so two-stage correction is needed. TB is one of them, which has been widely used all over the world (7-11).

Invisible orthodontic technology is booming and is expected to become the future development direction of orthodontics. The previous orthodontic treatment technology was immature, mainly to treat malocclusion caused by dental problems. In recent years, with the development of invisible orthodontic technology and the progress of materials science, invisible orthodontic companies at home and abroad have launched invisible functional appliances successively to solve the maladjustment of the maxilla and mandible, such as the MA and A6 series. These appliances not only move the mandible forward, but are cosmetically advantageous due to their invisibility. In addition to mandibular advancement, they can also align the teeth, expand the dental arch, improve an open bite and lower the anterior teeth. What is worth mentioning is that it can control the height of the posterior teeth while depressing the anterior teeth, so as to prevent the lower 1/3 height of the anterior mandibular from increasing. However, because the A6 functional appliance is removable, it was unknown whether it can still achieve the desired mandibular advancement effect when it is removed for eating or teeth brushing. Currently, there is scant research comparing the effects of invisible orthodontics and traditional functional appliances for mandibular advancement (12-14), and even less research on comparing the A6 and traditional functional appliances. To this end, we designed a retrospective comparative cohort study of the A6 and TB, in which adolescent patients with mandibular retrognathia were selected for a comparison of the effects of the TB and A6 appliances. We present the following article in accordance with the STROBE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-3762/rc).

Methods

Participants

Participants were selected from the Orthodontics Department of the Third Affiliated Hospital of Sun Yat-sen University. A retrospective comparative cohort study was conducted on 46 patients (23 males, 23 females; mean age, 13.69±4.25 years) who underwent and completed orthodontic treatment between July 2016 to August 2021 (*Table 1*). Participants were divided into TB or A6 groups according to according to the appliance used in the treatment.

The inclusion criteria of participants are as follows:

- ❖ Skeletal Class II Division 1 malocclusion;
- ❖ At least an end-to-end molar relationship;
- ❖ Overjet between 5 and 10 mm;
- ❖ SNB <78°, and ANB >5°;
- ❖ Can wear appliance for at least 17 h/day;
- ❖ No previous history of orthodontic treatment;
- ❖ Complete medical record.

The exclusion criteria were:

- ❖ Crowded teeth (≥4 mm);
- ❖ Anterior open bite;
- ❖ Craniomaxillofacial abnormalities;
- ❖ Tooth extraction treatment or congenital tooth loss (excluding the third molar);
- ❖ History of orthodontic treatment.

Ethical statement

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by ethics committee of the Third Affiliated Hospital of Sun Yat-sen University [No. (2021)02-402-01] and individual consent for this retrospective analysis was

Table 1 Age, sex distribution, and treatment duration of the final sample (M ± SD)

Treatment	n	Male	Female	Age (years)	Duration of treatment (months)
TB	23	12	11	15.25±4.93	9.40±4.23
A6	23	11	12	12.07±2.63	10.23±3.27

M ± SD, mean ± standard deviation; TB, Twin Block.

waived. The diagnosis and treatment of participants were performed under standard procedures. All participants were fully informed of orthodontic procedures, the benefits, potential risks, and outcomes of the treatment before orthodontic treatment.

Follow-up

All follow-up visits during treatment were conducted every 8 weeks to assess occlusal relationship and profile of the patient. X-ray films were taken before and after treatment to evaluate the treatment effect. Cephalometric analysis was performed on the X-ray films before and after treatment to evaluate the treatment effect. The cephalometric variables are described in *Table 2*.

Statistical analysis

All lateral cephalometric radiographs are taken by an experienced operator (Sirona Dental Systems GmbH D-64625 Bensheim, Germany), and the same operator used the cephalometric analysis software developed by Shanghai Angelalign to perform fixed-point analysis of the lateral cephalometric radiographs taken pretreatment (T0) and post-treatment (T1). The normal distribution of the data was determined by the Kolmogorov-Smirnov test, and the values of the two experimental groups before and after treatment were statistically evaluated using a parametric and non-parametric test respectively. Paired *t*-tests and Wilcoxon signed-rank tests were used for intragroup comparison, with two independent sample *t*-tests and Wilcoxon signed-rank tests used for intergroup comparison. The data were presented in the form of mean ± standard (M ± SD) and analyzed using SPSS software (version 22.0; IBM, Armonk, New York), $\alpha=0.05$, $P<0.05$.

Results

Population characteristics

A total of 46 patients were included in this study. The average duration of orthodontic treatment was 9.82±3.82 months. Among them, 23 participants were treated with TB appliance, while others were treated with A6 appliance. Demographic data of the participants are described in *Table 1*.

Clinical efficacy of orthodontic treatment

After the treatment, the ANB angle of the two groups was significantly reduced, and both the length of corpus mandibulae and the ramus height of the mandible increased. The maxillary anterior teeth were significantly adducted, and the mandibular anterior teeth were labially inclined. Both appliances showed excellent performance in terms of profile improvement.

In the TB group, the skeletal changes after treatment showed that SNB angle increased ($P<0.05$), and at the same time the vertical growth of the mandible (S-Ar-Go) increased ($P=0.031$). The A6 group showed improved soft tissue protrusion (Pog-NB) ($P<0.05$), and both appliances had significant effects on increasing the effective maxillary length (Co-A) and mandibulae length (Co-Gn, Go-Me) ($P<0.05$). After treatment, the ANB angle decreased, and the facial height (ANS-Me, N-Me, S-Go) increased in the two groups ($P<0.05$) (*Table 3*).

The changes in the alveolar bone pre- and post-treatment are shown in *Table 4*. After treatment with the A6 or TB, the overjet of the anterior teeth was significantly reduced ($P<0.05$), the maxillary anterior teeth were significantly adducted, and the mandibular anterior teeth were slightly inclined. The alveolar heights of the maxillary anterior teeth and maxillary posterior teeth were significantly increased.

The soft tissue post-treatment in the TB and A6 groups showed significant improvement in profile. After the treatment, the Ul-E-line was significantly reduced ($P<0.05$), indicating that the two appliances had a significant effect on improving the protrusion of the upper lip, the (Z-angle) was significantly increased ($P<0.05$), and there was a prominent improvement in the protrusion of the chin in both groups (*Table 5*).

Table 6 shows that the A6 had a more prominent

Table 2 Measurements and definitions of cephalometric analysis

Variable	Definition
SNA	Angle formed by sella (S), nasion (N) and subspinale (A), indicating the position of the jaw on the sagittal plane, towards the anterior base of the skull
SNB	Angle formed by sella (S), nasion (N) and supramental (B), indicating the position of the jaw on the sagittal plane, towards the anterior base of the skull
ANB	Angle formed by subspinale (A), nasion (N) and supramental (B). The ANB angle highlights the gap between the mandibular bone base and the maxillary bone base on the sagittal plane
GoGn-SN	Angle formed by S-N plane and mandibular plane, measuring the mandibular base tipping relative to the cranium
Co-A	Distance from condylion (Co) to subspinale (A); measurement of the effective length of midface
Co-Gn	The linear distance between condylion (Co) and gnathion (Gn), measuring the effective mandibular length
Go-Me	The distance between gonion (Go) and mental (Me), measuring length of corpus mandibulae
Go-Gn	The linear distance between gonion (Go) and gnathion (Gn), measuring length of corpus mandibulae
N-Me	Distance from nasion (N) to mental (Me), measuring overall anterior face height
ANS-Me	The distance between the anterior nasal spine (ANS) and mental (Me), measuring lower anterior face height
S-Go	The distance between sella (S) and gonion (Go), reflecting lower posterior face height
ANS-Me/N-Me (%)	Ratio of lower anterior face height to overall anterior face height
S-Go/N-Me (%)	Ratio of lower posterior face height to overall anterior face height
N-S-Ar	The angle composed of nasion (N), sella (S) and anticulare (Ar), also known as saddle angle, reflecting the position of condyle
S-Ar-Go	The angle formed by sella (S), anticulare (Ar) and gonion (Go), also known as articular angle, reflecting the growth trend of the mandible
Ar-Go-Me	The angle formed by anticulare (Ar), gonion (Go) and mental (Me), also known as gonial angle, reflecting the growth trend of the mandible
Sum	Sum of saddle angle (N-S-Ar), articular angle (S-Ar-Go) and gonial angle (Ar-Go-Me), reflecting the clockwise or counterclockwise growth direction of the mandible
NA-Pog	The linear distance from the pogonion (Pog) to the connecting line between the nasion(N) and subspinale (A), reflecting the protrusion of the chin relative to the maxilla
Pog-NB	The linear distance from the pogonion (Pog) to the connecting line between nasion (N) and supramental (B), reflecting the protrusion of the chin relative to the mandible
U1-SN	The angle formed by the long axis of the upper incisor (U1) and the plane formed by sella (S) and nasion (N), reflecting the lip inclination of the upper anterior teeth relative to the anterior cranial base plane
U1-PP	The angle between the long axis of the upper central incisor (U1) and palatal plane (PP), reflecting the labial inclination of upper anterior teeth relative to the palatal plane
U1-NA (degree)	The angle formed by the long axis of the upper central incisor (U1) and the connecting line between nasion(N) and subspinale (A), reflecting the protrusion of upper central incisor
U1-PP (mm)	The linear distance from the upper central incisor (U1) to the palatal plane (PP), reflecting alveolar bone height of upper anterior teeth
U6-PP (mm)	The linear distance from the upper first molar (U6) to the palatal plane (PP), reflecting alveolar bone height of maxillary posterior teeth
IMPA	Angle between the long axis of the lower central incisor (L1) and the mandibular plane (MP), reflecting the labial inclination of mandibular anterior teeth
L1-NB (degree)	The angle formed by the long axis of the lower central incisor (L1) and the connecting line between nasion (N) and supramental (B)

Table 2 *(continued)*

Table 2 *(continued)*

Variable	Definition
L1-MP (mm)	The linear distance from the lower central incisor (L1) to the mandibular plane (MP), reflecting alveolar bone height of mandibular anterior teeth
L6-MP (mm)	The linear distance between the lower first molar (L6) and the mandibular plane (MP), reflecting alveolar bone height of mandibular posterior teeth
U1-L1	The intersection angle of the long axis of the upper and lower central incisors
Overjet	Horizontal distance between the upper anterior teeth and the lower anterior teeth
Overbite	Vertical distance of upper anterior teeth over lower anterior teeth
UL-E-Line	The distance from the convex point of the upper lip (UL) to the E-line, reflecting the protrusion of the upper lip
LL-E-Line	The distance from the convex point of the lower lip (LL) to the E-line, reflecting the protrusion of the lower lip
Z-angle	The posterior inferior corner formed by the contour line of Chin lip soft tissue surface and Frankfort Horizontal plane, reflecting the protrusion or contraction of the mandible
H -angle	The intersection angle of the line between the pogonion of soft tissue (Pos) and the upper lip (UL), also known as H line, and the line between nasion (N) and supramental (B), representing the positional relationship between the soft tissue chin and lip
Nasolabial angle	The anterior intersection angle of the line between the subnasal (Sn) and the columella (Cm) and the line between the subnasal (Sn) and the processus of the upper lip (UL), representing the positional relationship between the upper lip and the bottom of the nose

Table 3 Descriptive information and paired *t*-test results of pre- and post-treatment skeletal variables (M ± SD)

Variables	TB group			A6 group		
	T0	T1	P value	T0	T1	P value
SNA	80.60±3.24	80.91±3.20	0.094	82.98±4.07	82.39±3.29	0.148
SNB	75.60±3.39	77.17±3.36	0.000*	77.67±3.55	78.20±3.25	0.088
ANB	5.00±2.05	3.73±2.38	0.000*	5.11±2.03	4.19±2.36	0.027*
GoGn-SN	32.51±4.15	32.33±4.38	0.518	30.07±5.52	31.11±5.66	0.081
Co-A	77.59±2.62	78.82±3.24	0.017*	77.53±4.34	79.04±3.76	0.018*
Co-Gn	102.07±5.26	107.04±5.70	0.000*	98.66±5.97	103.53±6.28	0.000*
Go-Me	67.88±3.75	69.73±3.69	0.003*	65.28±5.83	67.15±5.42	0.005*
Go-Gn	80.70±4.83	84.15±4.24	0.059	74.95±10.06	76.67±8.56	0.014*
N-Me	110.95±6.63	115.22±5.85	0.000*	104.56±6.65	109.86±6.79	0.000*
ANS-Me	62.31±4.32	64.96±4.08	0.000*	57.44±4.27	60.56±4.70	0.000*
S-Go	74.69±5.59	78.16±5.60	0.000*	71.67±7.81	75.15±8.14	0.000*
ANS-Me/N-Me (%)	53.53±1.84	54.46±1.80	0.000*	52.40±1.53	53.10±1.72	0.001*
S-Go/N-Me (%)	65.77±3.22	66.23±3.32	0.006*	64.00±4.81	66.75±4.40	0.831
N-S-Ar	125.72±5.00	125.28±5.07	0.278	127.65±4.89	124.53±4.44	0.744
S-Ar-Go	153.93±8.87	152.25±9.80	0.031*	148.96±7.51	148.76±5.61	0.746
Ar-Go-Me	113.87±6.56	115.76±7.16	0.001*	111.60±8.01	118.92±8.21	0.020*
Sum	393.52±4.60	393.29±4.90	0.422	391.21±6.20	392.20±6.35	0.084
NA-Pog	9.25±5.08	7.16±5.44	0.000*	9.05±5.51	7.59±6.05	0.011*
Pog-NB	1.57±1.15	1.47±0.98	0.368	1.66±1.03	1.44±0.87	0.013*

α=0.05 two-tailed test, *P<0.05. M ± SD, mean ± standard deviation; TB, Twin Block; T0, pretreatment; T1, post-treatment.

Table 4 Descriptive information and paired *t*-test results of pre- and post-treatment dentoalveolar variables (M ± SD)

Variables	TB group			A6 group		
	T0	T1	P value	T0	T1	P value
U1-SN	108.14±8.46	104.91±8.95	0.011*	111.41±7.04	105.34±6.92	0.000*
U1-PP	118.27±6.87	114.81±6.98	0.012*	120.90±6.55	115.12±6.50	0.000*
U1-NA (°)	27.54±8.08	24.41±9.07	0.027*	28.43±6.69	22.96±6.93	0.000*
U1-PP (mm)	27.13±1.87	28.23±1.98	0.000*	25.06±2.29	26.00±2.32	0.003*
U6-PP (mm)	21.03±1.87	21.92±1.61	0.001*	19.29±1.76	19.91±2.08	0.013*
IMPA	98.35±5.97	100.22±5.80	0.177	99.96±5.80	102.88±6.74	0.002*
L1-NB (°)	27.47±5.48	31.18±6.22	0.014*	28.84±5.58	33.28±6.24	0.000*
L1-MP (mm)	39.92±2.75	39.16±2.45	0.039*	37.07±3.57	36.76±3.96	0.453
L6-MP (mm)	29.41±2.02	30.56±2.26	0.000*	27.35±3.02	28.69±3.43	0.000*
U1-L1	119.98±9.48	121.51±8.04	0.520	117.42±7.74	119.58±9.02	0.029*
Overjet	7.94±2.55	4.44±1.95	0.000*	7.77±2.33	3.50±2.52	0.000*
Overbite	5.82±1.62	2.55±2.04	0.000*	5.50±0.99	2.08±1.91	0.000*

α=0.05 two-tailed test, *P<0.05. M ± SD, mean ± standard deviation; TB, Twin Block; T0, pretreatment; T1, post-treatment.

Table 5 Descriptive information and paired *t*-test results of pre- and post-treatment soft tissue variables (M ± SD)

Variables	TB group			A6 group		
	T0	T1	P value	T0	T1	P value
UL-E-Line (mm)	3.11±2.41	1.49±1.94	0.000*	2.75±2.07	1.31±1.95	0.002*
LL-E-Line (mm)	2.85±2.56	3.10±2.99	0.721	2.39±2.85	2.77±2.71	0.360
Z-angle	67.92±5.67	71.62±5.13	0.000*	67.76±5.03	71.25±5.34	0.000*
H-angle	17.84±5.21	14.21±4.34	0.000*	17.78±4.21	15.74±4.03	0.030*
Nasolabial angle	103.69±11.17	107.02±12.18	0.022*	104.39±9.43	107.75±10.74	0.056

α=0.05 two-tailed test, *P<0.05. M ± SD, mean ± standard deviation; T0, pretreatment; T1, post-treatment.

treatment effect than TB in the process of moving Point A backward, adducting the maxillary anterior teeth. In contrast, TB performed better in moving Point B forward.

Discussion

Both the A6 and TB appliances use the principle of a mechanically inclined plane to forcibly change the position of the mandible, triggering adaptive changes in muscles, nerves, and joints (15). The difference is that the TB does not play a role in expanding the arch, aligning the teeth, or controlling the torque of the anterior teeth in the process of guiding the mandibular advancement. Therefore, for patients who use the TB to guide the mandible forward, it must be combined with standard appliances for a two-stage correction (*Figure 1*). The A6 functional appliance designed by Shanghai Angelalign, which combines the TB and a bracketless invisible appliance, can not only guide the mandibular advancement, but also gradually expand the maxillary arch, lower the maxillary and mandibular anterior teeth, and slightly align the anterior teeth (*Figures 2,3*). Finally, the height of the occlusal bite pad is gradually reduced to establish a good occlusal relationship of the posterior teeth, thereby stabilizing the jaw position and achieving the correct occlusal relationship.

The main purpose of this study was to analyze and compare the changes in maxillofacial soft and hard tissues during the mandibular advancement process with the A6

Table 6 Comparison of treatment changes between the TB and A6 groups (M ± SD)

Variables	TB	A6	P value
SNA	0.30±0.85	–0.59±1.88	0.002*
SNB	1.57±1.22	0.53±1.43	0.009*
ANB	–1.27±1.14	–0.92±1.86	0.421
GoGn-SN	–0.19±1.38	1.04±2.72	0.093
Co-A	1.23±2.35	1.51±2.83	0.818
Co-Gn	4.98±3.87	4.87±3.89	0.822
Go-Me	1.85±2.74	1.87±2.92	0.881
Go-Gn	1.45±3.57	1.72±3.11	0.651
N-Me	4.26±4.01	5.29±5.01	0.831
ANS-Me	2.65±2.41	3.12±3.00	0.630
S-Go	3.47±2.73	3.48±3.02	0.952
ANS-Me/N-Me (%)	0.93±0.86	0.70±0.79	0.258
S-Go/N-Me (%)	0.47±1.37	–0.25±2.86	0.157
N-S-Ar	–0.44±1.69	–0.13±1.81	0.563
S-Ar-Go	–1.67±3.58	–0.20±2.96	0.116
Ar-Go-Me	1.88±2.52	1.32±2.52	0.684
Sum	–0.23±1.41	0.99±2.64	0.106
NA-Pog	–2.09±2.37	–1.46±2.54	0.410
Pog-NB	–0.09±0.51	–0.21±0.45	0.465
U1-SN	–3.24±5.76	–6.07±3.66	0.044*
U1-PP	–3.45±6.22	–5.78±3.71	0.068
U1-NA (°)	–3.13±6.49	–5.48±2.45	0.166
U1-PP (mm)	1.10±0.85	0.94±1.32	0.517
U6-PP (mm)	0.89±1.16	0.62±1.11	0.383
IMPA	1.87±6.57	2.91±4.05	0.438
L1-NB (°)	3.70±6.80	4.44±3.59	0.750
L1-MP (mm)	–0.76±1.69	–0.31±1.94	0.410
L6-MP (mm)	1.15±1.32	1.33±1.19	0.640
U1-L1	1.53±11.44	2.16±4.43	0.410
Overjet	–3.50±2.47	–4.27±3.48	0.464
Overbite	–3.27±2.69	–3.42±2.31	0.853
UL-E-Line	–1.63±1.48	–1.44±1.80	0.598
LL-E-Line	0.24±3.28	0.38±1.80	0.886
Z-angle	3.70±3.83	3.49±3.45	0.724
H-angle	–3.63±3.75	–2.04±3.78	0.183
Nasolabial angle	3.33±6.63	3.36±7.98	0.949

α=0.05 two-tailed test, *P<0.05. TB, Twin Block; M ± SD, mean ± standard deviation.

and TB appliances. A retrospective study was conducted to evaluate the effects of the two appliances in terms of dentoskeletal, alveolar bone, and soft tissue reconstruction.

Dentoskeletal changes

As far as vertical changes of the jaws are concerned, the length of mandibular ramus increased in both groups: TB group (from 74.69±5.59 to 78.16±5.60; P<0.001) and A6 group (from 71.67±7.811 to 75.15±8.14; P<0.001). As for whether the growth of the mandibular ramus was the result of normal growth and development or an effect of appliance, a prior study reported that the growth of the mandibular ramus is the largest at QCVM II (male 8.21±0.72 mm, female 6.47±0.42 mm), and the smallest at QCVM IV (male 0.84±0.19 mm, female 0.80±0.18 mm) (16). Because the cervical spine was not clearly staged and there was not a control group in this study, it cannot be concluded that the growth of mandibular ramus was due to the effect of the appliance. After treatment, the gonial angle (Ar-Go-Me) increased: in the TB group from 113.87±6.56 to 115.76±7.16 (P=0.001) and in the A6 group from 111.60±8.01 to 118.92±8.21 (P=0.02), indicating that both appliances tend to promote mandibular clockwise rotation. At the same time, the increase in anterior facial height [ANS-Me, N-Me, ANS-Me/N-Me (%)] (P<0.05) was consistent with previous research results, indicating that these two types of appliances can increase anterior facial height and lower 1/3 of the face (10,12). Therefore, mandibular advancement treatment should be cautiously applied in high-angle patients. In this study, the articular angle (S-Ar-Go) decreased, with the TB group going from 153.93±8.87 to 152.25±9.80 (P=0.031), indicating that the vertical growth trend of the jaw in the TB group decreased.

In terms of the sagittal changes of the maxillary and the mandible, the effective maxillary length (Co-A), effective mandibular length (Co-Gn), and corpus mandibulae length (Go-Me) increased significantly in the two groups (P<0.05), which is consistent with the study results of Elfeky *et al.* (17) and Ajami *et al.* (18). Both appliances had significant effects on increasing effective maxillary length (Co-A) and corpus mandibulae length (Go-Me) (P<0.05). However, whether the increase in the length of the mandible was caused by the relocation of the mandible or growth and development, combined with the subsequent changes in alveolar bone structure and the saddle angle (N-S-Ar), we believe that it was related to growth and development.

In this study, we observed that the ANB angle of the two

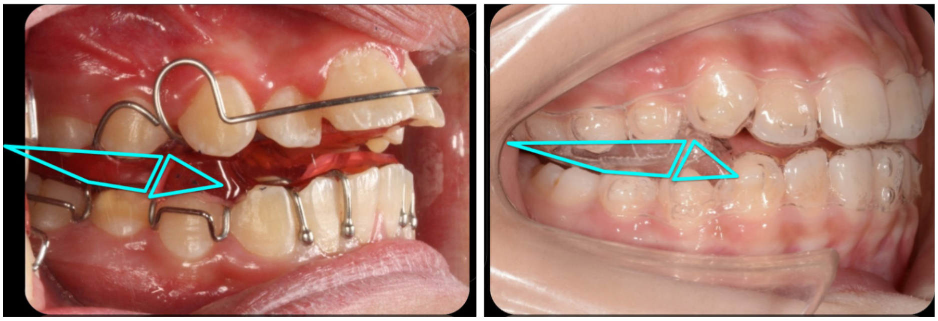

Figure 1 Traditional Twin Block *vs.* A6 'invisible' appliance without brackets. Photo courtesy of Angelalign.

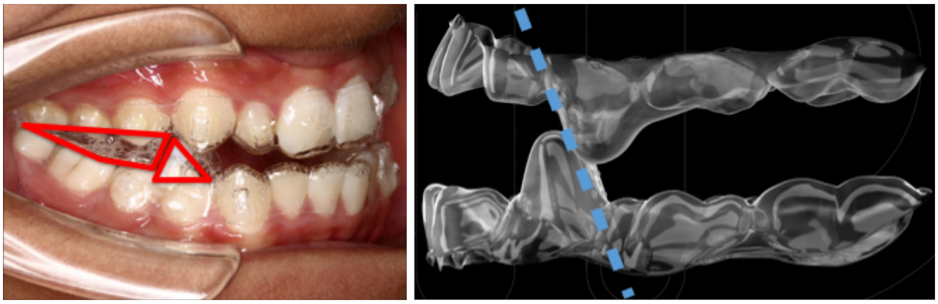

Figure 2 Guided mandibular protrusion technique with the A6 appliance. Photo courtesy of Angelalign.

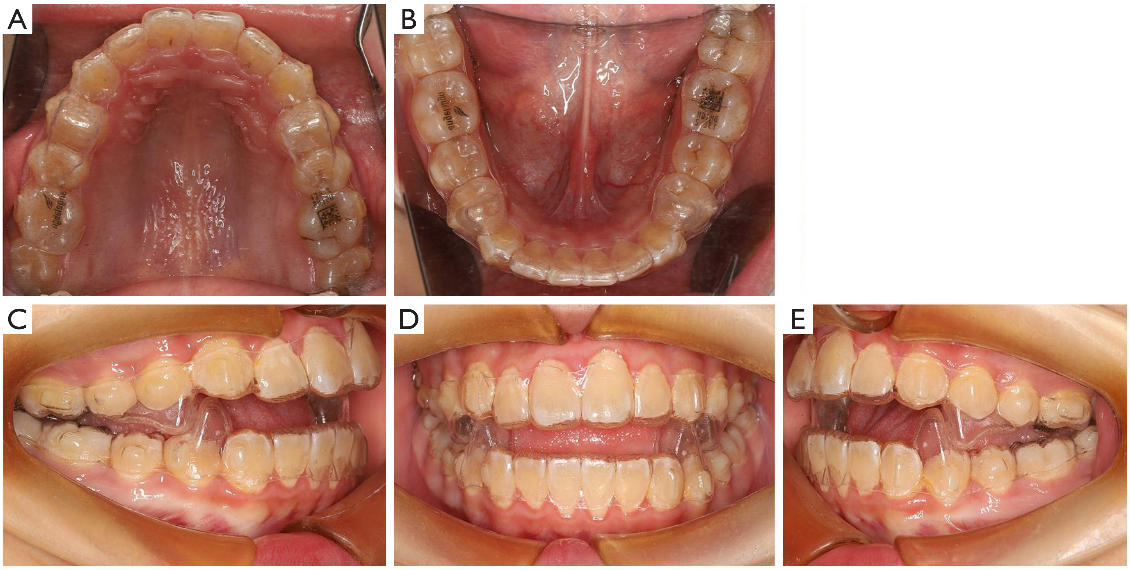

Figure 3 Occlusal state when wearing A6 appliance.

groups decreased after treatment, the change in the SNB angle in the TB group was statistically significant, but the SNA angle of the two groups did not change significantly after treatment (P>0.05), which is the same as most research results, indicating that the two appliances can adjust the sagittal development of mandible (19-21). However, we observed some differences in some parameters between the two groups. For example, statistical analysis of the SNB angle changes in the A6 group was not significant, which may have been caused by an insufficient sample size. NA-Pog and Pog-NB statistical analyses (P<0.05) confirmed this view.

Alveolar bone changes

The upper alveolar height increased in both groups, with the U1-PP (mm) for the TB group going from 27.13±1.87 to 28.23±1.98 (P<0.001) and the A6 group from 25.06±2.29 to 26.00±2.32 (P<0.003); U6-PP (mm) for the TB group going from 21.03±1.87 to 21.92±1.61 (P=0.001) and the A6 group from 19.29±1.76 to 19.91±2.08 (P=0.013). These results were consistent with the study of Baysal *et al.* (10,22). We believe that the increase in maxillary alveolar bone height shown in the results may be a collection of actions of growth and the increase in posterior teeth because of the role of the occlusal pad in the process of correction, which finally resulted in the increased alveolar bone height. TB did not lower the anterior teeth, but the alveolar bone height of the mandibular anterior teeth decreased significantly in this study (P<0.05), which may be due to a certain degree of absorption of labial alveolar bone of the mandibular anterior teeth during the anterior lip inclination process.

The changes in the angle of the anterior teeth, with the U1-SN angle changing from 108.14°±8.46° to 104.91°±8.95° (P=0.011) and the L1-NB angle from 27.47°±5.48° to 31.18°±6.22° (P=0.014) in the TB group; the U1-SN angle changing from 118.41°±7.04° to 105.34°±6.92° (P<0.001) and the L1-NB angle from 28.84°±5.58° to 33.28°±6.24° (P<0.001) in the A6 group, indicating that in both groups the appliance had the effect of adducting the maxillary anterior teeth and changing the labial inclination of lower incisor, which was similar to the results of Khoja *et al.* (23,24).

Overbite and overjet were significantly decreased in the TB group and A6 group, with the overjet improving from 7.94±2.55 to 4.44±1.95 (P<0.001) and overbite from 5.82±1.62 to 2.55±2.04 (P<0.001) in the TB group, and from 7.77±2.33 to 3.50±2.52 (P<0.001) and from 5.50±0.99 to 2.08±1.91 (P<0.001), respectively, in the A6 group. The reduction of overjet may be the result of adduction of the maxillary anterior teeth, mandibular advancement, and mandibular anterior teeth labial inclination. The decrease of overbite in the A6 group was due to the addition of resin attachments to lower the anterior teeth and improve the anterior overbite. The TB does not have this function. The reduction of overbite after correction may be related to the forward movement of Point B and the increased labial inclination of the mandibular anterior teeth.

Soft tissue changes

As for the change in the soft tissue profile brought by functional appliances to Class II Division 1 patients, most studies believe that the TB improves the patient's profile by adducting the anterior teeth and simultaneously moving Point B and the chin forward (25-29). But some studies have reported contrary views (30-32). In this study the results showed that both the A6 and TB had significant effects in improving the profile, consistent with those reported by Shahamfar *et al.* (33) and others (11). The significant reduction in the Ul-E-line may be caused by the change in upper lip position due to adduction of the anterior teeth, and the reduction in the H-angle is also related to the improvement of maxillary protrusion. The increased Z-angle may be related to the soft tissue changes caused by mandibular advancement.

We observed that the Nasolabial angle increased significantly in the TB group (P<0.05), which may be related to the change in upper lip position caused by the reduction of the anterior teeth, which is consistent with the study results of Ahmadian-Babaki *et al.* (8,34). Because of the dearth of literature on the A6, it was not analyzed in this respect.

Finally, the data on the changes in the A6 and TB groups post-treatment were compared. The statistical analysis showed that promotion of the backward movement of point A and adduction of anterior teeth in the A6 group was statistically significant compared with the TB group. It may be that A6 can control the torque of the anterior teeth at the same time during mandibular advancement, so it has more advantages than the TB for adducting the anterior teeth, as well as promoting the backward movement of Point A. TB group has more advantages in moving forward point B than A6 group, which may be related to the excessive lip inclination of lower anterior teeth in A6 group. As for the changes in the ANB angle and the alveolar bone height of the maxillary and mandibular anterior teeth, there was no significant difference, which may be caused by insufficient sample size.

Reflection and limitations of study design

Due to the large age difference between the study patients, especially the TB patients, this study did not carry out a clear cervical stage or set up a control group to exclude the effect of growth and development on the reconstruction of maxillofacial soft tissue. In addition, in terms of selecting observation tools, cone beam CT uses three-dimensional reconstruction, and the positioning of each measurement point after treatment is more accurate (35). However, considering both the people-oriented philosophy and easy access to clinical data, lateral cephalometric radiographs pre- and post-treatment were used for evaluation.

Conclusions

- ❖ Treatment with either appliance can correct Class II malocclusion, retract the upper anterior teeth, tilt the lower anterior teeth, coordinate the differences between the maxilla and mandible, and the patients' profiles were significantly improved in both groups.
- ❖ A6 has more advantages in adduction of anterior teeth and backward movement of point A, while TB has more advantages in forward movement of point B.

Both kinds of appliances can lead to an increase in the proportion of lower 1/3 of the face, so patients with high-angle should be cautious.

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Footnote

Reporting Checklist: We present the following article in accordance with the STROBE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-3762/rc

Data Sharing Statement: Available at https://atm.amegroups.com/article/view/10.21037/atm-22-3762/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-3762/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by ethics committee of the Third Affiliated Hospital of Sun Yat-sen University [No. (2021)02-402-01] and individual consent for this retrospective analysis was waived.

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