Submitted: 06 April, 2023 Accepted: 06 June, 2023 Online Published: 28 September, 2023 DOI:10.22514/jocpd.2023.070

Journal of Clinical Pediatric Dentistry

ORIGINAL RESEARCH

Comparison between clear aligners and twin-block in treating class II malocclusion in children: a retrospective study

Jianfang He[1,†], Longshuang Hu[2,†], Yan Yuan[3], Peipei Wang[4], Feifei Zheng[1], Han Jiang[2], Wen Li[1,*]

[1]Stomatology Hospital, School of Stomatology, Zhejiang University School of Medicine, Clinical Research Center for Oral Diseases of Zhejiang Province, Key Laboratory of Oral Biomedical Research of Zhejiang Province, Cancer Center of Zhejiang University, Engineering Research Center of Oral Biomaterials and Devices of Zhejiang Province, 310000 Hangzhou, Zhejiang, China
[2]Stomatology Hospital, School of Stomatology, Zhejiang University School of Medicine, 310000 Hangzhou, Zhejiang, China
[3]Department of stomatology, Hospital 302 attached to Guizhou aviation group, Anshun 561000, Guizhou, China
[4]Lishui Municipal Central Hospital, 323000 Lishui, Zhejiang, China

***Correspondence**
ewen74@zju.edu.cn
(Wen Li)

[†] These authors contributed equally.

Abstract

The study herein evaluated and compared the efficacy of Clear Aligners (CA) and Twin-Block (TB) appliances as the early orthodontic treatments of developing class II division 1 malocclusion. Twenty-four patients each for CA (11.73 ± 0.33 y) and TB (11.87 ± 0.34 y) groups were selected according to the inclusion and exclusion criteria. The cephalometric X-rays and intraoral photos were taken for the patients after nearly 12 months of treatment. Treatment impacts were evaluated by the molar correction and overjet reduction. The vertical and sagittal changes were analyzed through cephalometric measurements. Sella-nasion-point B angle (SNB), point A-nasion-point B angle (ANB), Wits Appraisal (AO-BO) and overjet were statistically significant regarding the sagittal changes analyzed before and after the treatments in both groups, respectively. So, no significant difference was noted in the sagittal changes between CA and TB groups. However, for the vertical changes, OP (occlusal plane) angle of CA group and OP angle, AFH (anterior facial height) and PFH (posterior facial height) of TB group were statistically significant. Moreover, the Z angle and cranial facial difficulty (C.F. difficulty) were also statistically significant in both groups. Class II children with retrognathic mandible are effectively treated by employing the CA, which has almost the same impact as of TB in sagittal and vertical changes. Resultantly, the patient profile is improved. The CA and TB treatments thus minimize the subsequent treatment difficulty by reducing the C.F. difficulty.

Keywords

Twin-block appliance; Clear aligner; Cephalometric measurement; Overjet; Class II malocclusion

1. Introduction

Class II division I malocclusion is usually characterized with mandibular retrusion. It is the commonly treated malocclusion in children [1, 2]. Mandibular retrusion is the skeletal dysplasia accompanied by functional factors [1]. Orthodontic treatment in mixed dentition is controversial [3, 4], however recent studies indicate some remedial benefits from the early treatment [2–4]. Two phases are involved in treating children with this malocclusion; one intervention during the late mixed dentition or early permanent dentition (phase I) followed by a second definitive course of appliance treatment in early adolescence (phase II) [5, 6]. Early correction (phase I) resolves early dysfunction, and minimizes the difficulty of later treatment (phase II).

Phase I treatment involves the traditional methods of moving jaw forward. Removable orthodontic devices such as twin-block (TB) or headgear-activator are employed to correct Class II malocclusion [7–9]. There are however some disadvantages. Firstly, wearing the appliance in mouth is uncomfortable, and many children cannot be insisted upon wearing this; secondly, in treating mandibular retrusion, the anterior teeth irregularity or occlusal interference may still exist causing relapse. Fixed functional appliances are thus employed to treat Class II malocclusion by number of professionals, such as Forsus and Herbst [10, 11]. However, fixed appliance requires fixed brackets to be used in conjunction, as is the case in older patients with permanent dentition. Moreover, if the brackets with installed instrument falls off, the appliance may fall apart causing certain risk.

The digital technology has rapidly developed in recent years [12–14]. Digital clear aligners (CA) such as Invisalign orthodontic system (Align Technology, Santa Clara, Calif.) [13] and Angelalign system (Angelalign Technology Co., Ltd, Shanghai, China) [15] have been introduced which can overcome the limitations of traditional appliances. Similar to the TB appliance, CA is composed of two pairs of inclined planes. They are positioned in the posterior area of aligners and come in contact when patient closes mouth. They thus determine the mandibular forward position. Some case reports indicate similar results by the aligners as of TB, however the studies sample size is too small [16] and lacks in-depth analysis. Therefore, the purpose of this retrospective study is to investigate the influencing factors in functional treatment of class II malocclusion in children by comparing CA and TB appliances.

2. Materials and methods

In this retrospective study, the lateral cephalograms of pre- and post- CA and TB treated patients were recorded at Stomatology Hospital, Zhejiang University School of Medicine.

2.1 Selection of study cases

Children of class II division 1 malocclusion were selected for this study. The inclusion criteria were as follows:

- Late mixed or early permanent dentition.
- The total treatment time of 12 months.
- Overjet >4 mm.
- No steep mandibular plane angle.
- No obvious transverse discrepancy.

The exclusion criteria included:

- Systemic diseases.
- Poor oral hygiene with periodontal disease.
- Signs or symptoms of temporomandibular disorders.
- Poor patient compliance (wearing less than 8 h/day).

Caruso method [12] was used to determine the sample size wherein minimum 5 subjects were required to attain sample power of 95% and alpha of 0.05. In this study, 24 pairs of radiographs were examined where 12 patients (11.73 $\pm$ 0.33 y) were treated with CA (Angelalign Technology Inc., China) and 12 patients (11.87 $\pm$ 0.34 y) with TB appliance.

2.2 Treatment design

2.2.1 Clear aligner treatment

The mandible moved forward to the neutral molar relationship for CA group. The wax bite positioning was used in this regard, and the intraoral tooth scanning was conducted *via* the 3D shape machine. After digital modeling, the CA system (Angelalign Technology Inc., China) (Fig. 1) was utilized to process and produce aligner appliances. CA materials were the copolyesters having no significant difference with metal orthodontic brackets regarding initial bacterial adhesion and biofilm formation [17]. Patients were instructed to wear CA appliances for full time except during eating, drinking or brushing teeth. The appliances were replaced with the new sets after 10 days. The patients were instructed to record the wearing times every day. The treatment lasted for 12 months. The aligner could also align the dentition in course of treating mandible retrusion.

2.2.2 Twin-block treatment

Anhydrite models were made after the occlusal positioning by wax piece and sent to the technician's room for processing the TB functional appliance. A labial arch was added to lower the anterior tooth area for preventing the lower anterior teeth inclination. TB group patients were required to wear appliances for more than 20 hours each day except for eating. After 6 months of wearing the TB appliance, the maxillary pad was removed in stages so that the mandibular molar elongates and establishes occlusal relationship. The patients were advised to record wearing time and treatment continued for nearly 12 months.

2.2.3 Measurement subjects

The cephalometric films and intraoral photos were taken before and after the treatment of nearly 12 months. Tweed-Merrifield analysis of cephalometric measurements was conducted (Fig. 2). There were 14 measurement items including sagittal, vertical and cranial facial difficulty (C.F. difficulty) analysis [18]. The definitions of these measurement items are listed in Table 1. The cephalometric measurements were traced by an expert having 12 years' experience, and was blind toward the groups. The expert tested the same cephalometric ray for three times to rule out intra-operator errors, and found no differences among the results.

2.3 Statistical analysis

The data were expressed as mean $\pm$ standard error (SE). SPSS 20.0 (SPSS, Chicago, IL, USA) was utilized for the statistical analysis. Statistical comparisons were made before and after treatments for the two groups using Student t tests. Chi-squared tests were conducted to compare the responses for two groups toward all questions. $p < 0.05$ was considered as the significant difference.

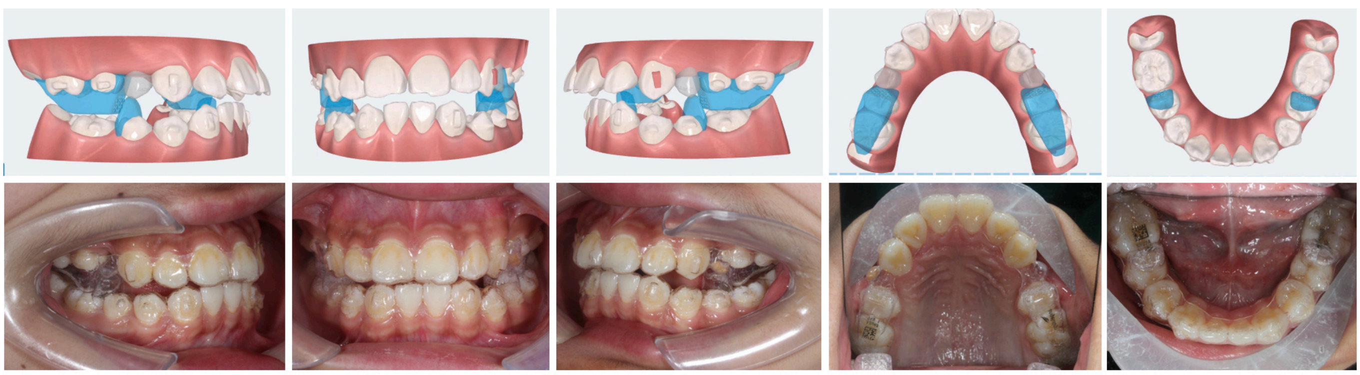

FIGURE 1. Digital modeling by the aligner system (Angelalign Technology Inc., China).

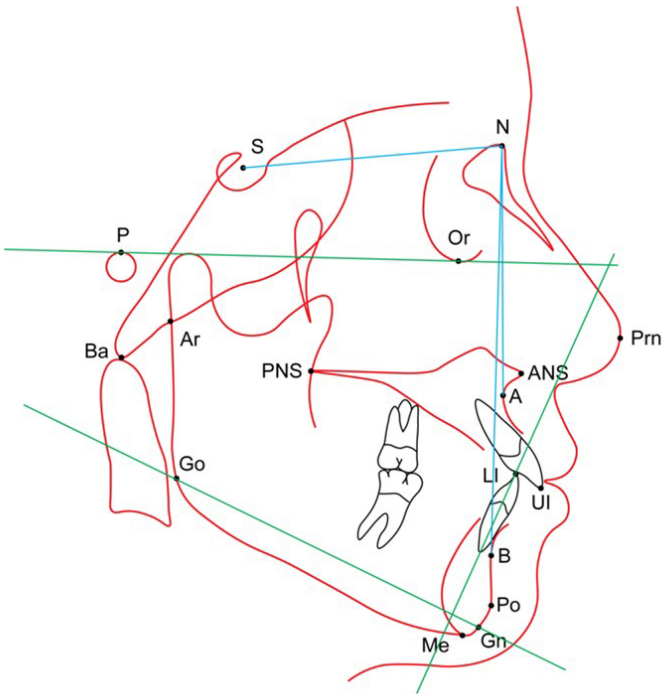

FIGURE 2. Tweed analysis (green line) of cephalometric measurements. S, sella; N, nasion; P, porion; Ba, basion; Or, orbitale; ANS, anterior nasal spine; PNS, posterior nasal spine; A, subspinale; UI, upper incisor; Ar, articulare; Go, gonion; B, supramental; LI, lower incisor; Po, pogonion; Me, menton; Gn, gnathion; Prn, pronasale.

TABLE 1. Definition of measurement items.

variable	Definition
FMIA (°)	Angle between Frankfort plane and mandibular incisor axis.
FMA (°)	Angle between Frankfort plane and mandibular plane.
IMPA (°)	Angle between mandibular incisor axis and mandibular plane.
SNA (°)	The SNA angle indicates the position of the jaw on the sagittal plane, towards the anterior base of the skull.
SNB (°)	The SNB angle indicates the position of the jaw on the sagittal plane, towards the anterior base of the skull.
ANB (°)	The ANB angle highlights the gap between the mandibular bone base and the maxillary bone base on the sagittal plane.
Wits appraisal (AO-BO) (mm)	A represents subspinale and B represents supramental. The points of contact of the perpendiculars onto the occlusal plane are labeled AO and BO respectively. AO-BO is the distance between AO and BO. (Positive, AO ahead of BO; negative, BO ahead of AO)
OP Angle (°)	The angle of intersection between occlusal plane and Frankfort plane.
Z-Angle (°)	The Z-line is the line connecting the most protruding point of the chin and lip, and the posterior lower angle formed by it with the orbital ear plane is the Z-angle.
AFH (mm)	Anterior facial height.
PFH (mm)	Posterior facial height.
Overjet (mm)	Overlap of the teeth in the horizontal dimension.
C.F. Difficulty	Cranial facial difficulty analysis.

FMIA, Frankfort-mandibular incisal angle; FMA, Frankfort mandibular plane angle; IMPA, Incisor mandibular plane angle; SNA, Sella-nasion-point A angle; SNB, Sella-nasion-point B angle; ANB, Point A-nasion-point B angle; OP Angle, Occlusal plane angle; AFH, Anterior facial height; PFH, Posterior facial height; C.F. Difficulty, Cranial facial difficulty analysis.

3. Results

3.1 Consistency check of two groups before treatment

Table 2 showed no significant sagittal difference (overjet, ANB) and treatment difficulties between CA and TB groups.

3.2 Treatment effects on sagittal changes in both groups

Overjet reduction differences were significant in CA (4.91 $\pm$ 0.61 mm) and TB (4.40 $\pm$ 0.43 mm) groups before and after the treatment ($p < 0.05$). SNB, ANB and AO-BO (AO is the projection from point A to the occlusal plane, Bo is the projection from point B to the occlusal plane) were also statistically significant in both groups before and after treatment. However, the sagittal changes were not significant between the CA and TB groups. The changes in cephalometric measurements are given in Table 3.

3.3 Vertical changes in two groups

For vertical changes, OP (occlusal plane) angle was statistically significant in CA group before and after the treatment ($p < 0.05$), but the Frankfort mandibular plane angle (FMA) was not ($p > 0.05$). In TB group, OP angle, AFH (anterior facial height), and PFH (posterior facial height) were statistically significant ($p < 0.05$), but not the FMA angle ($p > 0.05$).

Furthermore, both treatments increased the Z angle and decreased C.F. difficulty ($p < 0.05$).

4. Discussion

The sagittal disharmony of class II division I malocclusion is attributed to the mandibular retrusion which often present a big overjet [19]. This malocclusion affects facial beauty, increases anterior tooth injury risk, and impacts children's mental health [20, 21]. There have been controversies regarding the early treatment, however the treatments started in late mixed dentition verify that early treatment through TB appliance produces effective results, such as overjet reduction, correction of molar relationships, and reduction in malocclusion severity [2, 7, 9]. Our TB treatment results are in accordance with previous studies where most of this correction is because of dentoalveolar change.

Some shortcomings of TB treatment are uncomfortable wearing, impaired speech and others. New appliances considering the comfort and curative impact are appearing because of the developments in digital reconstruction technology and materials [14, 15]. Recently, CA has been employed more often in orthodontic treatments due to its benefits. Firstly, the CA appliance is more comfortable than the TB appliance and patients better comply; secondly, the CA appliance can better align the teeth while leading forward the mandible which is more recognizable and accepted by the patients and their parents.

There is less scientific literature available on CA usage for correcting class II malocclusions due to mandibular retrusion. In this study, it is found that CA can achieve almost the same results as TB. A previous study reports the effect of clear aligner (Align Technology™) on class II treatment, and demonstrates reduction in SNB and ANB angle, and decrease in overjet, being consistent with our sagittal results [12]. Wits measurement (AO-BO) also confirms CA role in leading jaw forward [22]. Studies suggest Invisalign aligners having good control on mandibular incisors while more compensatory lower incisors proclination in Twin-Block [23]. However, our results find that CA as well as TB treatments maintain initial inclination of lower anterior teeth, which is persistent with earlier studies [13]. This may be attributed to the full teeth coverage by CA.

Present study finds significant increase in AFH and PFH after TB treatment. Same results were not achieved for CA group. The reason can be linked to the jaw pad adjustment grinding of TB which may elongate the lower molars to increase AFH. PFH also increases due to condyle growth. AFH/PFH are not significant before and after the treatment in both groups, which is also consistent with FMA.

Our results have found that both CA and TB treatments improve the facial profile by increasing Z angle. Some studies support our results that CA treatment improves patient profile [13]. Besides, both treatments decrease cranial facial difficulty which would benefit the phase II treatment. This work has limitations of not including the cases of narrow maxillary arches and not considering a study on lateral discrepancy. The sample size is not large; However, it can be increased in future research.

5. Conclusions

The Angelalign® CA usage is effective in treating class II children with retrognathic mandible which has almost the same effects as of TB regarding sagittal and vertical changes, thus improving the patient profile. Both CA and TB treatments minimize the difficulty of subsequent treatments by reducing the C.F. difficulty.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

WL and JFH—designed the research study. LSH—performed research work. FFZ—analyzed the data. YY, HJ and PPW—provided help and advice on treatment design. JFH and LSH—wrote the manuscript. All authors contributed to the editorial changes in manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The patients' parents or guardians have signed a written informed consent to use their data including photos and images. The research plan was approved by the Ethics Committee of Dental Hospital affiliated to Zhejiang University after due

TABLE 2. Consistency check of two groups before treatment (mean ± SE).

Measurements	CA (n = 12)	TB (n = 12)	*t*	*p*
Age (y)	11.73 ± 0.33	11.87 ± 0.34	−0.240	0.815
Overjet (mm)	7.58 ± 0.81	8.22 ± 0.59	−0.665	0.520
ANB (°)	5.55 ± 0.42	6.74 ± 0.58	−1.558	0.148
C.F. Difficulty	52.34 ± 7.07	72.65 ± 12.41	−1.182	0.262

CA, Clear Aligner; TB, Twin-Block.

TABLE 3. Comparison of sagittal changes after treatment of CA and TB groups.

Measurements	CA (n = 12)				TB (n = 12)			
	Before (Mean ± SE)	After (Mean ± SE)	Δd (Mean ± SE)	*p*	Before (Mean ± SE)	After (Mean ± SE)	Δd (Mean ± SE)	*p*
FMIA (°)	56.15 ± 1.79	54.25 ± 2.27	−1.90 ± 0.96	n.s	54.29 ± 2.10	53.30 ± 2.12	−1.00 ± 0.84	n.s
FMA (°)	24.28 ± 1.14	24.29 ± 1.15	0.01 ± 0.46	n.s	25.55 ± 0.97	25.77 ± 1.11	0.22 ± 0.51	n.s
IMPA (°)	99.65 ± 1.70	101.38 ± 2.10	1.72 ± 0.85	n.s	100.16 ± 1.79	100.93 ± 1.87	0.78 ± 0.72	n.s
SNA (°)	81.19 ± 0.67	81.31 ± 0.66	0.11 ± 0.16	n.s	81.75 ± 1.17	81.50 ± 1.09	−0.25 ± 0.21	n.s
SNB (°)	75.65 ± 0.42	77.72 ± 0.80	2.08 ± 0.50	**	75.01 ± 1.21	76.55 ± 1.23	1.54 ± 0.10	**
ANB (°)	5.55 ± 0.42	3.58 ± 0.49	−1.97 ± 0.42	**	6.74 ± 0.58	4.95 ± 0.55	−1.78 ± 0.28	**
Wits appraisal (AO-BO) (mm)	4.86 ± 0.55	0.75 ± 0.66	−4.11 ± 0.77	**	4.99 ± 0.69	1.56 ± 0.91	−3.43 ± 0.56	**
OP Angle (°)	6.28 ± 0.68	8.29 ± 0.83	2.01 ± 0.90	*	8.57 ± 1.25	9.69 ± 1.29	1.12 ± 0.51	n.s
Z-Angle (°)	63.99 ± 1.11	69.12 ± 1.83	5.13 ± 1.33	**	62.70 ± 2.18	66.99 ± 2.11	4.29 ± 0.73	**
AFH (mm)	56.01 ± 1.14	57.18 ± 1.23	1.17 ± 1.03	n.s	54.80 ± 0.94	58.38 ± 0.94	3.58 ± 0.51	**
PFH (mm)	41.25 ± 0.92	42.26 ± 1.19	1.01 ± 0.96	n.s	38.98 ± 0.84	41.64 ± 1.03	2.66 ± 0.55	**
PFH/AFH (%)	73.80 ± 1.57	74.06 ± 1.99	0.26 ± 0.91	n.s	71.19 ± 1.26	71.43 ± 1.75	0.23 ± 0.80	n.s
Overjet (mm)	7.58 ± 0.81	2.67 ± 0.60	−4.91 ± 0.61	**	8.22 ± 0.59	3.82 ± 0.70	−4.40 ± 0.43	**
C.F. Difficulty	52.34 ± 7.07	31.23 ± 6.24	−21.11 ± 5.34	**	72.65 ± 12.41	46.22 ± 9.81	−26.43 ± 4.55	**

*SNA, Sella-nasion-point A angle; SNB, Sella-nasion-point B angle; ANB, Point A-nasion-point B angle; AO-BO, A represents subspinale and B represents supramental. The points of contact of the perpendiculars onto the occlusal plane are labeled AO and BO respectively. AO-BO is the distance between AO and BO. *p < 0.05, **p < 0.01, n.s, no statistically significant difference between groups.*

examination and authorization (Approval No.2023-056).

ACKNOWLEDGMENT

Funding from the Natural Science Foundation of Zhejiang Province is gratefully acknowledged.

FUNDING

This research was funded by Natural Science Foundation of Zhejiang Province (LY22H140003).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Jianfang He, Longshuang Hu, Yan Yuan, Peipei Wang, Feifei Zheng, Han Jiang, *et al*. Comparison between clear aligners and twin-block in treating class II malocclusion in children: a retrospective study. Journal of Clinical Pediatric Dentistry. 2023. doi: 10.22514/jocpd.2023.070.