

Comparison of skeletal and dentoalveolar effects of two different mandibular advancement methods: Conventional technique vs aesthetic approach

Purpose

The aim of this study was to compare the effects of two different mandibular advancement methods on skeletal, dentoalveolar, and soft tissue structures through cephalometric measurements.

Materials and Methods

Twenty-four Class II division 1 patients (10 males, 14 female) treated with twin block (TB) or aesthetic approach (EA: Essix plates + Class II elastics) from the archive of our faculty were included in the study. There were 12 individuals in the EA group (mean age: 12.2 ± 1.0) and 12 individuals in the TB group (mean age: 11.8 ± 1.1 years). The skeletal, dentoalveolar, and soft tissue effects of the appliances were evaluated by performing 28 measurements, 14 linear and 14 angular, on the pre and post-treatment cephalometric radiographs. AudaxCeph 5.0 software (Ljubljana, Slovenia) was used for the analysis. A paired sample t-test was employed to assess the changes after one year of utilizing the appliance for each group. Intergroup comparison was performed by using student t test.

Results

The mandibular base was observed to move forward significantly in both groups ($p < 0.05$). However, the forward movement of the mandibular base was greater in the TB group than in the EA group ($p < 0.05$). There was no difference in lower incisor protrusion between the two treatment methods. The EA device was found to cause a significant increase in vertical direction parameters ($p < 0.05$).

Conclusion

Both methods resulted in Class II malocclusion correction as well as an acceptable occlusion plus profile. The effects of EA were primarily dentoalveolar. In patients with high aesthetic expectations, EA could be an alternative for TB.

Keywords: Class II malocclusion, mandibular retrognathia, mandibular advancement, twin-block, clear aligners

Introduction

Class II division 1 malocclusion is a common anomaly in various populations (1,2). This skeletal problem is usually caused by a small or retrusive mandible (3). In growing patients, functional orthopedic devices such as monoblock or twin-block are used to treat mandibular retrognathia. These devices provide muscle activation by moving the mandible forward. The concept of stimulating bone growth via muscle activation is known as functional matrix theory (4,5). It is still debatable whether functional appliances increase mandibular growth or not (6). Some authors have suggested that these devices promote mandibular growth, while others reported that they have no effect on total mandibular length (7,8). However, there is widespread agreement that functional orthopedic devices cause upper incisor retrusion and lower incisor protrusion (9–11).

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Received: 20 May 2021

Revised: 18 September 2021

Accepted: 12 November 2021

DOI: 10.26650/eor.2022939871

The twin-block is a device that is frequently used by orthodontists to correct retrusive mandible (12). This is because a twin-block can provide both mandibular advancement and maxillary expansion simultaneously. Furthermore, allowing the patient to speak is the most important reason why this appliance is preferred. However, its bulky structure may reduce patient compliance. Accordingly, some researchers have designed new appliances to overcome the twin-blocks disadvantage. Tripathi *et al.* (13), for example, created an “esthetic twin-block” fabricated on biocryl sheet to improve patient compliance. This new design device was visually pleasing, but still bulky. The Invisalign company’s mandibular advancement appliance is another option for correcting mandibular retrognathia. This appliance treats class II malocclusion by moving the mandible forward with the help of the upper and lower precision wings (14). However, this appliance is relatively bulky, and the major drawback of this device is its high cost. As a result, the authors of this study designed an easy-to-use, esthetically pleasing, and low-cost appliance for patients. The appliance is comprised of three major components: lower and upper Essix plates, plus class II elastics. The goal of this approach was to reduce the bulkiness in conventional appliances, lower the cost, and increase patient compliance.

The purpose of this study is to compare the skeletal, dentoalveolar, and soft tissue effects of the novel aesthetic approach (EA) and twin block using cephalometric analysis. The null hypothesis of the study suggested that there is no difference between the skeletal and dentoalveolar effects of the two mandibular advancement methods.

Materials and methods

Ethical statement

The research protocol of this retrospective study was approved by Afyonkarahisar Health Sciences University Clinical Research Ethics Committee (ID: 2021/89). The study was conducted in the orthodontics department of our faculty using pre- and post-treatment cephalometric radiographs of class II growing patients who underwent mandibular advancement with two different methods (EA and TB). Written informed consent forms were obtained from parents or legal guardians of the patients.

Sample size estimation

The power analysis, performed via the GPOWER software, revealed that each group required at least 11 patients ($n > 11$, $\alpha = 0.05$, and $1 - \beta = 0.90$) (13,15). There were twelve patients in the EA group (mean age 12.2 ± 1.0) and twelve patients in the TB group (mean age 11.8 ± 1.1). The following criteria were used to determine inclusion: MP3cap skeletal maturation phase, 4.5 mm overjet minimum, retrognathic mandible, optimal mandibular plane angle, ANB angles greater than 4° , and good patient compliance. Patients with a history of orthodontic treatment, anterior open bite, severe proclination of the maxillary incisors, and systemic disease affecting growth or low-quality radiographs were excluded. Except for one case in the EA group, none of the cases had an initial unilateral or bilateral crossbite. In both groups, slow expansion screws (Leone, Italy) were activated $\frac{1}{4}$ turn in 4 days to correct maxillary transversal deficiency developing following mandibular

advancement. The mean number of screw activations was 31.2 ± 2.0 in the TB group and 28.0 ± 1.5 in the EA group.

Twinblock design

In our department, TB is routinely made in a standard design by the same technician (Figure 1). The upper removable part includes slow expansion screw, labial bow, delta, and Adam’s clasps, while the lower removable part includes labial bow and Adam’s clasps. In addition, one-third of the vestibular surface of the lower incisors is covered with acrylic. TB was used for a total of one year, the first six months for the entire day (except meals), and the second six months only at night.



Figure 1. The design of twin-block.

Mandibular advancement with Essix plates

The EA appliance fabrication process involved the following steps (Figure 2): To improve the retention of the upper part, composite attachments were placed on the right and left premolars. Upper and lower arch impressions were taken from



Figure 2. The EA appliance design. A: frontal view, B: right lateral view, C: left lateral view, D: upper occlusal view, E: lower occlusal view.

each patient using alginate. Plaster models were obtained. Using a vacuum machine, 0.80-inch Essix plates (Dentsply Sirona, USA) were formed. Vacuum-formed appliances were trimmed at the level of the cervical line. Metal tubes were bonded to the lower first molars with clear buttons placed on the upper canines. Class II elastics (150-200 gr per side) were used for one year, the first six months for the entire day (except meals), and the second six months only at night.

Cephalometric analysis

All measurements were performed by a single researcher using AudaxCeph version 5 software (Ljubljana, Slovenia). The analysis consisted of parameters evaluating skeletal, dental, and soft tissue changes. The parameters were selected from McNamara, Ricketts, Steiner, and Pancherz analyses (13,16–18). On the cephalometric radiographs, twenty-four anatomical landmarks were identified (Figure 3). For each patient, a total of 28 parameters were measured, including 10 skeletal, 13 dental, and 5 soft tissue.

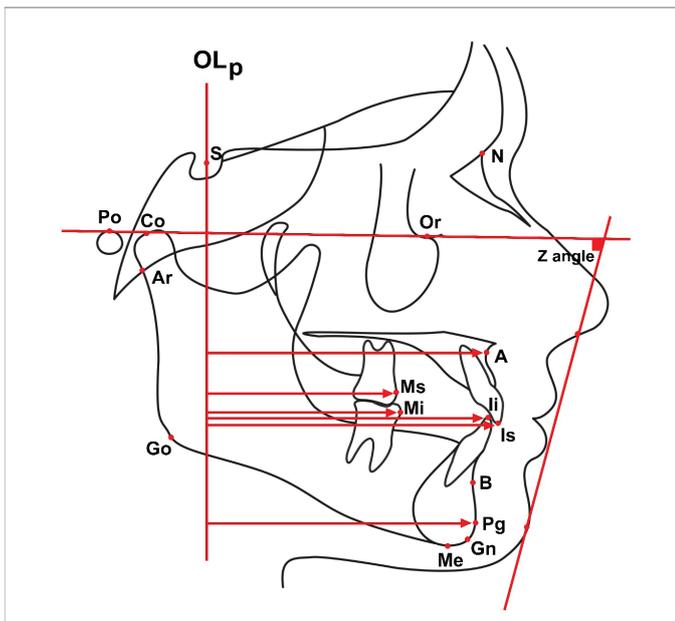


Figure 3. S: sella, N: Nasion, Co:condylion, Ar:articulare, A: A point, B: B point, Ms: molar superior, Mi: molar inferior, Is: incisor superior, Pg: pgonion, Gn: gnathion, Me: menton, Go: gonion, Ar: articulare, Co: condylion, Po: porion, Or: orbitale, A/OLp: linear position of the maxillary base, Pg/OLp: linear position of the mandibular base, Is/OLp: position of the maxillary central incisor; Ii/OLp: position of the mandibular central, Mi/OLp: position of the lower first molar, Ms/OLp: position of the upper first molar.

Statistical analysis

All statistical analyses were carried out using SPSS 22.0 package program (SPSS Inc, Chicago, Ill). Descriptive statistics such as mean values and standard deviations were calculated. The Shapiro Wilk normality test was used to determine the normality of parameters. The Student t-test was employed to compare the pre- and post-treatment results of the two groups. Skeletal, dental, and soft tissue changes that occurred after the use of TB and EA appliances were eval-

uated with paired sample t-test. The measurements of five randomly selected patients were reperformed two weeks later by the same researcher. The intracorrelation coefficient was calculated for each repeated measurement (Table 1). A p value $<.05$ was considered statistically significant.

Results

The results of skeletal, dental, and soft tissue effects of the appliances are reported in Table 1. The intracorrelation coefficient of all parameters was acceptable (Table 1). Post-treatment findings for the EA group revealed significant changes in maxillary base retraction, mandibular base advancement, increment gonial angle, upper incisors retrusion, overjet reduction, mesial movement of the lower molar, as well as retrusion of the lower and upper lip ($p<0.05$).

Post-treatment findings for the TB group revealed significant changes in mandibular base advancement, overjet reduction, mesial movement of the lower molar, upper lip protrusion, labiomental angle increment, and lower incisors protrusion ($p<0.05$).

Intergroup comparison showed that the extent of mandibular base advancement, as well as increase in nasolabial and labiomental angles was significantly higher in the TB group ($p<0.05$). More retrusion in the maxillary base and significant increase in the gonial angle were observed in the EA group ($p<0.05$). There was no significant difference between the two methods in terms of lower incisor protrusion ($p>0.05$). A high intracorrelation coefficient was found in repeated measurements in the intra-examiner variability assessment.

Discussion

While patients today desire a beautiful smile or profile at the end of treatment, they do not want to compromise on aesthetics during the procedure. This circumstance has prompted orthodontists to develop novel appliance designs that can be used as an alternative to traditional methods (13,19). The priority in these new appliances is aesthetic appearance and ease of use.

The main issue with functional orthopedic devices, however, is patient compliance. This is because traditional mandibular advancement appliances used by class II division 1 patients are bulky and cause speech difficulties. Many patients hardly tolerate these devices, resulting in a failure rate of nearly 34% (20). The EA appliance was designed to eliminate these drawbacks and increase patient compliance. The aim of this study was to compare the effects of TB and EA appliances on skeletal, dental, and soft tissue.

There are many different points of view in the literature about when to start treatment for class II division 1 patients (21). Treatment in the pre-adolescent period is effective, but it often necessitates a longer retention period. Many studies have found that these devices are more effective in children entering their adolescent growth spurt (22). Thus, only patients in the MP3cap period were included in our study. However, some authors suggest that the effect of early treatment is no different than that of a single course of treatment performed during adolescence (23–25).

According to Clark, a twin block is an appliance designed for 24-hour wear (26). He claims that use of the appliance

Table 1: Comparison of skeletal, dental, and soft tissue changes.

Parameters	ICC	Treatment changes						
		Group 1 (T0-T1) N=12 EA			Group 2 (T0-T1) N=12 TB			Group 1 vs Group 2
		Mean±SD (T0)	Mean±SD (T1)	P	Mean±SD (T0)	Mean±SD (T1)	P	P
SNA (°)	0.948	83.40±3.94	82.38±4.19	0.019*	78.68±3.76	78.45±4.61	0.631	0.045*
SNB (°)	0.973	77.10±3.26	77.74±3.64	0.018*	72.12±2.97	73.88±3.62	0.000*	0.019*
ANB (°)	0.913	6.30±1.80	4.62±2.15	0.000*	6.55±1.40	4.58±1.82	0.000*	0.958
A/OLp (mm)	0.874	65.98±2.70	67.48±3.29	0.117	66.61±4.43	65.04±5.10	0.220	0.193
Pg/OLp (mm)	0.826	54.58±4.45	58.97±8.54	0.438	54.95±8.02	52.62±6.54	0.117	0.062
N-A-Pg (°)	0.798	5.11±1.50	4.05±2.48	0.075	5.88±1.83	4.04±2.26	0.000*	0.990
SN/GoGn (°)	0.776	28.53±5.02	29.63±4.85	0.003*	35.39±6.57	35.41±6.44	0.956	0.025*
N-S-Ar (°)	0.868	125.80±4.84	124.63±6.81	0.313	127.87±6.22	128.05±5.62	0.849	0.203
Co-A (mm)	0.809	84.51±4.02	84.06±4.71	0.608	83.47±3.26	83.44±4.51	0.958	0.750
Co-Gn (mm)	0.778	104.02±4.05	106.41±6.54	0.092	101.12±3.44	105.10±4.12	0.000*	0.568
L1-NB (mm)	0.932	6.06±2.17	5.40±3.20	0.633	5.46±1.58	7.10±1.53	0.000*	0.458
L1-NB (°)	0.783	28.96±6.12	30.34±8.37	0.632	26.76±6.53	32.22±5.40	0.000*	0.114
IMPA (°)	0.933	102.93±10.80	103.29±6.33	0.899	99.24±6.18	102.90±7.0	0.015*	0.526
1-NA (mm)	0.956	5.97±1.71	5.50±2.28	0.145	5.94±2.19	5.41±1.74	0.238	0.922
1/NA (°)	0.950	24.33±4.92	21.20±4.78	0.007*	24.57±7.75	23.48±4.97	0.445	0.275
U1/SN (°)	0.888	107.74±2.95	103.60±3.52	0.003*	103.25±7.48	101.95±6.60	0.371	0.460
U1/L1 (°)	0.895	120.41±7.17	123.82±10.39	0.241	122.10±10.28	119.69±7.50	0.267	0.283
Overjet (mm)	0.944	6.84±1.70	3.38±1.27	0.000*	7.63±1.97	2.94±1.04	0.000*	0.373
Molar relation (mm)	0.871	1.58±2.60	-2.79±1.89	0.000*	2.50±1.17	-1.43±1.49	0.000*	0.069
Is/OLp (mm)	0.779	69.30±4.01	70.00±5.24	0.685	70.30±7.86	65.90±5.43	0.091	0.080
li/OLp (mm)	0.867	62.46±4.31	66.60±5.61	0.033*	62.66±7.55	62.96±5.30	0.890	0.125
Mi/OLp (mm)	0.839	37.05±4.94	42.33±5.49	0.023*	37.11±5.54	38.35±4.83	0.562	0.079
Ms/OLp (mm)	0.799	38.60±4.24	39.55±5.67	0.584	39.64±5.31	36.92±4.23	0.140	0.219
Upper lip to E line (mm)	0.891	0.02±1.93	-1.91±1.86	0.002*	-0.12±2.10	-2.74±1.77	0.001*	0.290
Lower lip to E line (mm)	0.765	1.68±2.29	0.30±2.07	0.044*	0.49±3.16	0.53±2.43	0.927	0.808
Nasolabial angle	0.903	109.99±7.02	108.68±8.10	0.635	102.17±6.96	101.35±7.49	0.753	0.035*
Labiomental angle	0.912	101.63±25.45	116.88±17.95	0.013*	115.72±26.20	133.01±11.07	0.023*	0.016*
Z angle	0.879	73.50±4.13	74.68±3.82	0.097	69.97±4.34	71.16±3.36	0.345	0.652

* Statistically significant changes ($p < 0.05$), SD: Standard deviation, ICC: Intraclass correlation coefficient. Linear and angular cephalometric points measured: SNA, sella–nasion–point A angle; SNB, sella–nasion–point B angle; ANB, point A–nasion–point B angle; A/OLp, linear position of the maxillary base; Pg/OLp, linear position of the mandibular base; N-A-Pg, angle between points of nasion, A, and pogonion; SN/GoGn, the angle between Sella-nasion and gonion-gnathion planes; Co-A, maxillary length; Co-Gn, mandibular real length; L1-NB, lower incisor-nasion/point B line (mm and angle); IMPA, angle between lower incisor long axis and mandibular plane. 1/NA, upper incisor–nasion/point A line (angle and mm); U1/SN, angle between upper incisor long axis and sella-nasion plane; U1/L1, interincisal angle; Is/OLp, position of the maxillary central incisor; li/OLp, position of the mandibular central; Mi/OLp, position of the lower first molar; Ms/OLp, position of the upper first molar; Z angle, porion point/orbital point (Frankfort plane)–line E (Ricketts line profile) angle.

part-time rather than full-time increases the probability of treatment failure. Class II elastics, on the other hand, should be worn for an average of 16 hours per day (27). In the current study, patients in both groups were instructed to wear the appliances full-time (except meals). As a result, device usage time was not allowed to influence the results. The forces produced by fixed functional appliances range between 150 and 200 g for each side (28). In the current study, participants in the EA group were subjected to a total force of 300–400 grams, which is similar to the value of fixed functional devices. Significant mandibular base advancement

was observed in both applications. However, mandibular base advancement was greater in the TB group (Pg / OLp: 4.39 ± 8.48 mm) than in the EA group (2.32 ± 10.0). In a systematic review, Janson *et al.* (29) reported that class II elastics were effective in correcting class II malocclusion, but the treatment effects were primarily dentoalveolar. In the present study, similar results were found. Significant lower incisor protrusion was observed in the TB group (IMPA: 3.66 ± 4.39), but there was no significant lower incisor protrusion (0.35 ± 9.04) in the EA group. Concerning lower incisor protrusion, nevertheless, there was no statistically significant

difference between the two methods. Giangotti *et al.* (30) also reported minimal incisor protrusion in A-P correction using Essix plates and class II elastics. As the plates cover all teeth, this could be related to the strengthening of the anchorage of the lower incisors (31). Significant retroclination of upper incisors was observed in the EA group, which could be attributed to a reduction in rigidity caused by the appliance being separated by an expansion screw. Upper incisor palatal tipping, on the other hand, is usually a desirable outcome in class II division 1 patients.

Lower molar tooth extrusion is one of the most common side effects of using long class II elastics (32). The use of twin-block causes significant intrusion in the lower molars (33). The increase in vertical dimension angles was greater in the EA group (SN / GoGn: 1.10 ± 0.94) than in the TB group (0.02 ± 1.52) ($p=0.025$). When the EA device is used in high angle cases, short class II elastics may be preferred or the elastics can be attached from the upper lateral to the lower second molar.

When the mandible was forced forward by the functional appliances, a reciprocal force was exerted distally on the maxilla, diverting growth (34). While the SNA angle in the EA group decreased ($p=0.019$), there was no statistically significant difference ($p=0.631$) in the TB group. These findings concur with some studies but contradict others (20,35,36).

The changes in soft tissue caused by the two appliances were relatively similar. However, improvement in the labio-mental sulcus was greater in the TB group ($p=0.023$). This was a reasonable result as the TB group had a greater forward movement of the mandibular base.

The bulky structure of the TB appliance was eliminated thanks to the EA device design. Speech problems caused by the TB appliance were clinically observed to disappear when the EA was used. Other advantages of EA included its ease of use, lack of a long and complex laboratory process, and low cost. However, the TB was clearly more durable than the EA appliance. Similarly, Saleh *et al.* (37) reported that vacuum-formed retainers are more acceptable in terms of appearance, self-confidence, and comfort.

The limitations of this study included a small sample size and undertaking it retrospectively. Another limitation of the study was the lack of a survey to assess ease of use and aesthetic expectations. Further studies are required to corroborate the present findings related to the EA approach.

Conclusion

Class II malocclusion was corrected using the EA device. A good occlusion and acceptable profile were achieved. The use of the TB appliance resulted in greater mandibular base advancement. There was no statistically significant difference in the amount of lower incisor protrusion caused by either application. In patients with high aesthetic expectations, EA may be preferred over TB. Note that use of the EA in high angle cases could be risky.

Türkçe Özet: İki farklı mandibular ilerletme yönteminin iskelet ve dentoalveolar etkilerinin karşılaştırılması: Geleneksel yöntem ve estetik yaklaşım. Amaç: Bu çalışmanın amacı iki farklı mandibular ilerletme yönteminin iskeletsel, dentoalveolar ve yumuşak doku etkilerinin sefalometrik röntgen ölçümleriyle karşılaştırılmasıdır. Gereç ve Yöntem: Çalışmaya fakültemiz arşivinden twin-block (TB) veya estetik yaklaşımla (EY: Essix plaklar+sınıf II elastikler) tedavi edilen yirmi dört Sınıf 2

bölüm 1 hasta (10 erkek, 14 kız) dahil edilmiştir. EY grubuna 12 birey (ortalama yaş: 12.2 ± 1.0) ve TB grubuna (ortalama yaş: 11.8 ± 1.1) 12 yer almaktaydı. Tedavi öncesi ve sonrası sefalometrik röntgenler üzerinde 14 linear, 14 angular olmak üzere toplam 28 ölçüm yapılarak apareylerin iskeletsel, dentoalveolar ve yumuşak doku etkileri değerlendirildi. Analizlerde AudaxCeph 5.0 yazılımı (Ljubljana, Slovenya) kullanıldı. Bir yıllık aygıt kullanımı sonucunda ortaya çıkan değişiklikler her bir grup için bağımlı örneklem t testi ile değerlendirildi. İki yöntemin etkilerinin karşılaştırılmasında ise student t-testi kullanıldı. Bulgular: Her iki yöntemde de mandibular kaidenin belirgin olarak öne hareket ettiği gözlemlendi ($p<0.05$). Ancak TB grubunda mandibulanın öne doğru hareketi EY grubundan daha fazlaydı ($p<0.05$). Alt keser protrüzyonu açısından iki yöntem arasında fark yoktu. EY aygıtının vertikal yön parametrelerinde belirgin artışa neden olduğu gözlemlendi ($p<0.05$). Sonuç: Her iki yöntem ile de Sınıf II maloklüzyon düzeltilerek kabul edilebilir bir oklüzyon ve profil elde edilmektedir. EY ile ortaya çıkan düzeltme daha çok dentoalveolardır. Ancak estetik beklentileri yüksek hastalarda TB'ye alternatif olarak EY tercih edilebilir. Anahtar Kelimeler: Sınıf II maloklüzyon, Mandibular retrognati, Mandibular ilerletme, Twin-block, Şeffaf Plaklar

Ethics Committee Approval: The research protocol of this retrospective study was approved by Afyonkarahisar Health Sciences University Clinical Research Ethics Committee. (ID: 2021/89).

Informed Consent: Participants provided informed consent.

Peer-review: Externally peer-reviewed.

Author contributions: HC participated in designing the study. HC, FS participated in generating the data for the study. HC, FS participated in gathering the data for the study. HC participated in the analysis of the data. HC wrote the majority of the original draft of the paper. HC participated in writing the paper. HC, FS have had access to all of the raw data of the study. HC, FS have reviewed the pertinent raw data on which the results and conclusions of this study are based. HC, FS have approved the final version of this paper. HC guarantees that all individuals who meet the Journal's authorship criteria are included as authors of this paper.

Conflict of Interest: The authors declared no conflict of interest.

Financial Disclosure: The authors declared that they have received no conflict of interest.

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