Original Article

Evaluation of efficacy of utility arch with inter-maxillary elastics for treating skeletal deep bite with retroclined upper incisors in the mixed dentition: a clinical randomized controlled trial

Danya Hassan Alsawaf[a]; Nada Rajah[b]

ABSTRACT

Objectives: To investigate the effectiveness of utility arch (UA) with inter-maxillary elastics compared with fixed anterior bite plane (FABP) for treating deep bite in brachy-facial children.

Materials and Methods: This was a single-center, randomized controlled trial. Participants were children aged between 9 and 12 years with deep bite and a hypodivergent skeletal pattern. The sample was divided into the following two groups: (1) a UA group that was composed of patients with UAs with posterior inter-maxillary elastics and (2) an FABP group as a control. Outcomes were skeletal and dentoalveolar variables on cephalometric X-rays.

Results: A total of 28 patients (13 boys, 15 girls) with a mean age of 10.66 years were enrolled. The treatment duration was 8.16 months in the UA group and 7.22 months in the FABP group. After treatment, the angle between the anterior cranial base and the mandible in the vertical plane increased significantly ($P = .000$) in both groups (about 1.97 degrees in the UA group and 2.75 degrees in the FABP group). Overbite decreased significantly in both groups (−2.1 m in the UA group and −3.64 m in the FABP group), but it decreased less significantly in the UA group than in the FABP group. The upper incisors flared significantly after treatment with both appliances (6.6 degrees in the UA group and 5.9 degrees in the FABP group).

Conclusions: Treatment of deep bite in children with a horizontal growth pattern by each of the appliances used in this study is effective. The mandible showed minor, significant backward rotation after treatment. The overbite decreased less in the UA group than in the FABP group. (*Angle Orthod.* 2023;93:296–305.)

KEY WORDS: Deep bite; Overbite; Orthodontic treatment; Children; Mixed dentition

INTRODUCTION

Deep bite is considered one of the most deleterious malocclusion traits for the masticatory apparatus and dental units.[1] Graber and Vanarsdall defined "deep bite" as a condition of excessive overbite in which the vertical measurement between the maxillary and mandibular incisal margins is excessive when the mandible is brought into habitual or centric occlusion.[2] When increased overbite is combined with palatally tipped upper incisors, it is called "deckbiss" (cover bite).[3] Deep bite can be skeletal or dentoalveolar in origin. Skeletal deep bite is defined as convergence of the upper and lower jaw bases, which is caused by either backward inclination of the maxilla or forward rotation of the mandible or both.[1] Skeletal deep bite with a hypodivergent growth pattern often accompanies Class II division 2 malocclusion. Many features are clear in this malocclusion, such as concave lip profile, pronounced chin, and short lower facial height.[4]

Extrusion of the posterior teeth, intrusion of the incisors, and proclination of the incisors are modalities for deep bite correction.[5] Extrusion of the posterior teeth is the most common modality indicated in horizontal growth pattern patients. Many appliances have been used for this purpose, such as bite planes,

[a] MSc Student, Department of Orthodontics and Dentofacial Orthopedics, Faculty of Dentistry, Damascus University, Damascus, Syria.

[b] Assistant Professor, Department of Orthodontics and Dentofacial Orthopedics, Faculty of Dentistry, Damascus University, Damascus, Syria.

Corresponding author: Dr Danya Hassan Alsawaf, MSc Student, Department of Orthodontics and Dentofacial Orthopedics, Faculty of Dentistry, Damascus University, Al-Mazzeh Street, Damascus, Syria
(e-mail: dsawaf1993@gmail.com)

Accepted: November 2022. Submitted: July 2022.
Published Online: February 3, 2023

 DOI: 10.2319/072722-520.1

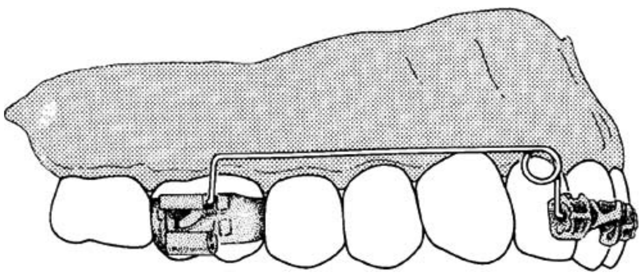

Figure 1. UA design.

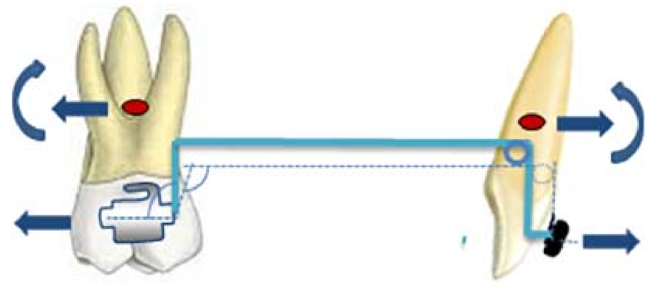

Figure 2. UA activation.

myofunctional appliances, and cervical headgear.[6,7] The classic treatment for deep bite in growing patients consists of a bite plane.[8,9] The fixed anterior bite plane (FABP) is often used to treat deep bite, especially when combined with Class II.[8,10–13] The utility arch (UA) may also be indicated for deep bite treatment. It was used for incisor protrusion, incisor intrusion, and posterior extrusion.[14] In general, when deep bite is combined with retroclined upper incisors, treatment is indicated as soon as possible as it considered a risk factor for temporomandibular disorders.[15]

In the literature, there is no previous randomized controlled trial that studied deep bite correction in the mixed dentition according to a recent systematic review.[16] The objective of this study was to assess the effectiveness of a UA with inter-maxillary elastics by evaluating the skeletal and dental changes induced during treatment of skeletal deep bite, mandibular in origin, combined with retroclined upper incisors (cover bite) in the mixed dentition.

MATERIALS AND METHODS

Trial Design

The Consolidated Standards of Reporting Trials (CONSORT) checklist was used as a guideline for conducting and reporting this trial.[17] This study was a clinical randomized controlled trial. This study was approved by the local ethics committee of the University of Damascus Dental School, Syria (UDDS-638-18062019/SRC-3870). This study was registered with the German Clinical Trials Register (https://www.drks.de/drks_web/navigate.do?navigationId=trial.HTML&TRIAL_ID=DRKS00028870).

Participants

Children were recruited between December 2019 and January 2022 in the Department of Orthodontics, Damascus University.

Inclusion Criteria

- Children with skeletal deep bite that resulted from forward rotation of the mandible (NSGoMe $<$ 30).[18]
- Children aged between 9 and 12 years before the cervical stage 3 (CS3) according to McNamara et al.[19]
- Horizontal growth pattern according to Bjork (BJORK $<$ 390).[18]
- Skeletal Class I or mild to moderate Class II (ANB from 2 to 6).
- Retroclined upper incisors (U1:SN $<$ 98).
- Overbite more than 40% ($>$ 3.5 mm).[20]

Exclusion Criteria

- Children who received previous orthodontic treatment.
- Children with dental deep bite with normal upper and lower jaw bases.
- Children with skeletal deep bite that resulted from maxillary origin (SN:Spp $>$ 12).

Intervention Group

Edgewise 0.022-inch bands were cemented on the permanent maxillary first molars, and brackets were bonded to the incisors. Leveling and alignment of the upper incisors was performed with the following nickel-titanium arch wire sequence: 0.014 inches, 0.016 inches, and 0.016 $\times$ 0.016 inches. Then, a UA of 0.016 $\times$ 0.022-inch blue elgiloy was inserted. The UA design is shown in Figure 1. It was activated with a straight plier by making the angle between the posterior vertical step and the buccal segment obtuse (Figure 2).[21] After the incisors reached their normal torque, the UA was fixed in a passive position, and bands with a lingual arch were cemented to the mandibular permanent first molars. Resin-modified glass ionomer cement (RMGIC) was bonded to the palatal surfaces of the upper incisors as bite planes (Figure 3). The posterior vertical space ranged from 1 to 2 mm. Vertical posterior inter-maxillary elastics (1/8-inch medium 4.5 oz) were applied from the upper first molar to the lower first molar (Figure 4). Once the posterior segments achieved occlusal contact, the RMGIC plane was modified and raised to create a posterior separation, and patients were asked to

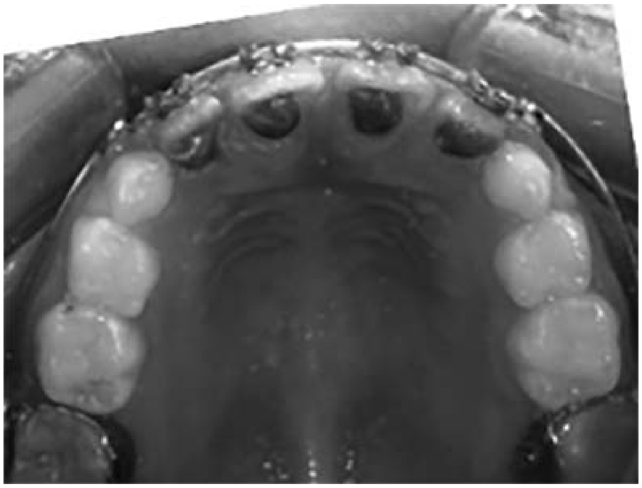

Figure 3. RMGIC on palatal surfaces of incisors.

continue using the elastics. When the overbite reached the normal value (40%), the bands and brackets were debonded, and the retention appliance was delivered.

Control Group

A fixed, acrylic flat anterior bite plane soldered to the permanent first molars bands with a labial bow (stainless steel [SS] 0.7 mm) and palatal Z springs (SS 0.5 mm) was applied. The thickness of the bite plane was determined to exceed the freeway space, creating a vertical posterior separation ranging between 2 to 4 mm, according to Hellsing et al.[8] Fixation of the appliance was achieved after activation of the Z springs by using glass ionomer cement as adhesive cement (Figure 5). Patients had visits every 3 weeks. At each visit, the appliance was removed, the incisor angulation was assessed, and reactivation was achieved when necessary. The springs were activated by a straight plier by pulling the wire 2-mm facially in the same horizontal plane (Figure 6). When the incisors reached the normal angulation in the bucco-lingual plane, the activation stopped. The treatment

Figure 4. The posterior inter-maxillary elastic.

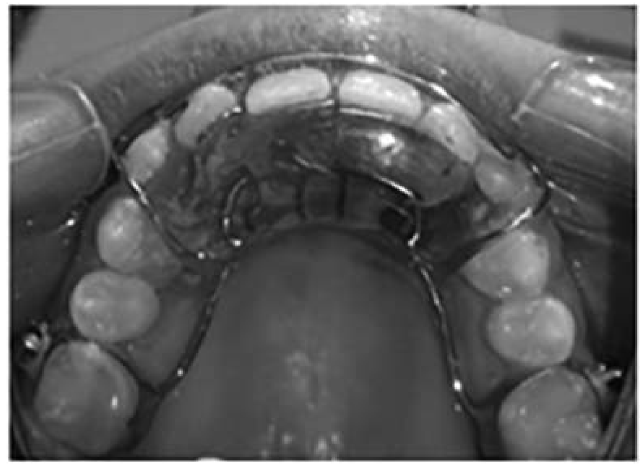

Figure 5. The FABP.

finished when overbite reached the normal value (40%) and the appliance was replaced by another for retention.

Primary Outcomes

The primary outcome measures were changes in SN:GoMe and overbite.

Secondary Outcomes

Secondary outcomes were vertical and sagittal angular and linear measurements. The variables are shown in Table 1. The outcomes were assessed on lateral cephalometric radiographs taken at time 0 (T0) and time 1 (T1). The cephalometric radiographs were traced using WebCeph (WebCeph, AssembleCircle

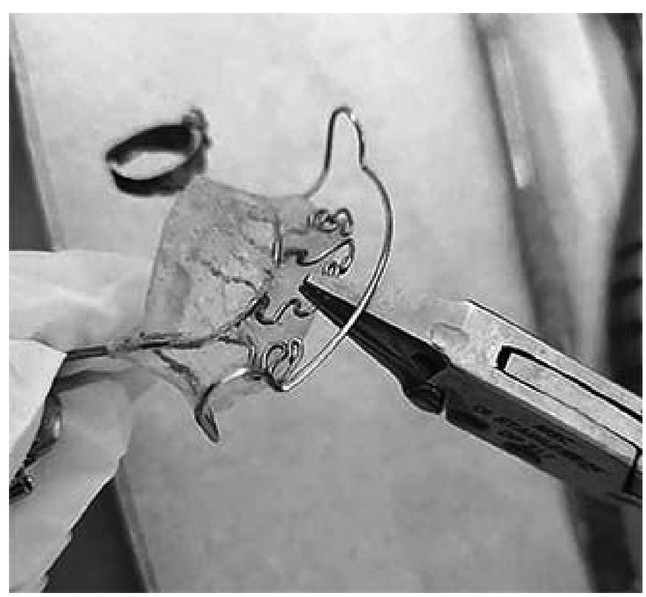

Figure 6. The activation of Z springs.

Table 1. Skeletal and Dentoalveolar Variables

Abbreviation	Definition
SNA	Angle between anterior cranial base and maxilla in sagittal plane
SNB	Angle between anterior cranial base and mandible in sagittal plane
ANB	Angle between maxilla and mandible in sagittal plane
SNAr	Saddle angle
SArGo	Articular angle
ArGoMe	Gonial angle
BJORK sum	Sum of the three previous angles
SN:Spp	Angle between anterior cranial base and maxilla in vertical plane
SN:GoMe	Angle between anterior cranial base and mandible in vertical plane
MM	Angle between maxilla and mandible in vertical plane
S-Go	Posterior facial height
N-Me	Anterior facial height
Jarabak	Facial height percentage
Overjet	Horizontal distance between the buccal surface of upper incisor and lower incisor in sagittal plane
Overbite	Vertical overlap of upper incisor to lower incisor
U1-Spp	Distance between the crown's tip of upper incisor and maxillary plane
U6-Spp	Distance between the buccal groove of upper molar and maxillary plane
L1-MP	Distance between the crown's tip of lower incisor and mandible plane
L6-MP	Distance between the mesio-buccal groove of lower molar and mandible plane
U1:SN	Angle between upper incisor and anterior cranial base
L1:Go Me	Angle between lower incisor and mandible plane

Corp, Korea) (www.webceph.com) (Figures 7 and 8). The treatment time was also recorded.

Sample Size Calculation

Sample size was calculated using G-Power version 3.0.10 (Universitate Keil, Keil, Germany). Because no previous study compared overbite correction between UAss and bite planes, data from a study assessing the effectiveness of FABP were used.[22] The means and standard deviations of the primary outcome (SN:GoMe) before and after treatment were 32.5 $\pm$ 4.3 and 34.1 $\pm$ 4.4, respectively, and the mean of the difference was 1.6 $\pm$ 2.25. The effect size was calculated to be 0.71. If $\alpha = 5\%$ and β is 95% with a paired *t*-test, 14 patients were required in each group (Figure 9). To compensate for any possible attrition, a 5% attrition percentage (one patient in each group) was added. The total sample size was 30.

Randomization, Allocation Concealment, and Blinding

Simple randomization was conducted by one of the academic staff members who was not involved in this research. Computer-generated random numbers were used with an allocation ratio of 1:1. The allocation sequence was concealed using sequentially numbered, opaque, sealed envelopes. Blinding of personnel and participants were not applicable. Therefore, blinding was applied only for the outcome assessor.

Statistical Methods

The statistical analysis was conducted using IBM (Armonk, N.Y.) SPSS Statistic Data Editor version 24. The Shapiro-Wilk normality test was conducted. When data were normally distributed, paired-sample and two-sample *t*-tests were applied. When a non-normal distribution was detected, nonparametric tests were applied (Wilcoxon matched pair signed rank, Mann-Whitney *U*-test). Statistical analysis was performed by one author who was blinded to all measurements.

Error of the Method

A total of 16 cephalometric radiographs were randomly chosen after a 1-month interval. The intraclass correlation coefficient (ICC) test was used to determine the random error,[23] and a paired *t*-test was used to determine any systematic error.

RESULTS

A total of 30 patients were enrolled in this trial. One patient in the UA group did not receive the allocated intervention because of noncompliance, and one patient in the FABP group was lost to follow-up for personal reasons. A total of 28 patients (14 in each group) with a mean age of 10.66 $\pm$ 1.1 years were analyzed. Patient allocation and follow-up are shown in Figure 10. The basic characteristics of the sample are presented in Table 2. The treatment duration was 8.16 $\pm$ 2.42 months in the UA group and 7.22 $\pm$ 2.63 months in the FABP group; however, the difference in duration between groups was not significant ($P = .335$) (Table 3).

A paired-sample *t*-test was conducted to assess the systematic error. It showed that there was no significant difference between the two measurements ($P >$ .05) (Supplemental Table 1). For evaluating the random error, the ICC was calculated. It ranged from .913 to .997, meaning high reproducibility for the measurements made on cephalometric radiographs (Supplemental Table 2).

The normality test (Shapiro-Wilk) was used to assess the distribution of data. All the data at T0 and T1 in both groups were normally distributed (Table 4).

All the skeletal and dentoalveolar outcomes measures showed insignificant differences between the groups at T0 (Tables 5 and 6). After treatment, SN:GoMe increased significantly ($P <$ .001) in both

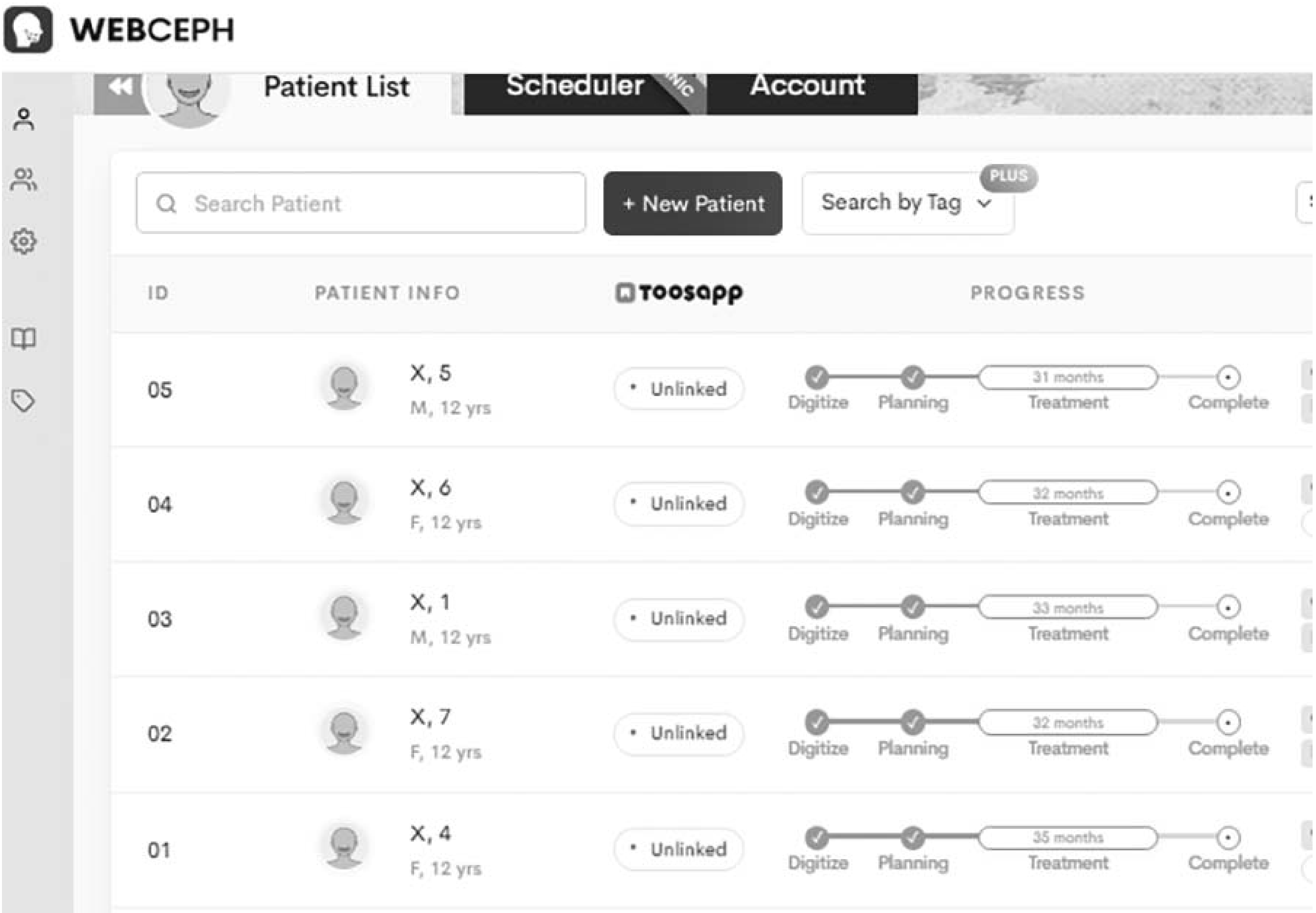

Figure 7. WebCeph records.

groups (about 1.97 degrees in UA group and 2.75 degrees in FABP group). However, the difference between groups was not significant. The angle between the maxilla and mandible in the vertical plane increased significantly in both groups (1.55 degrees ±

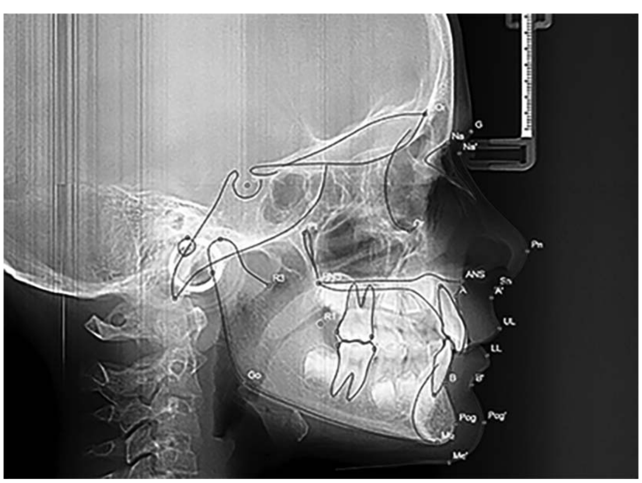

Figure 8. Landmarks detection and tracing.

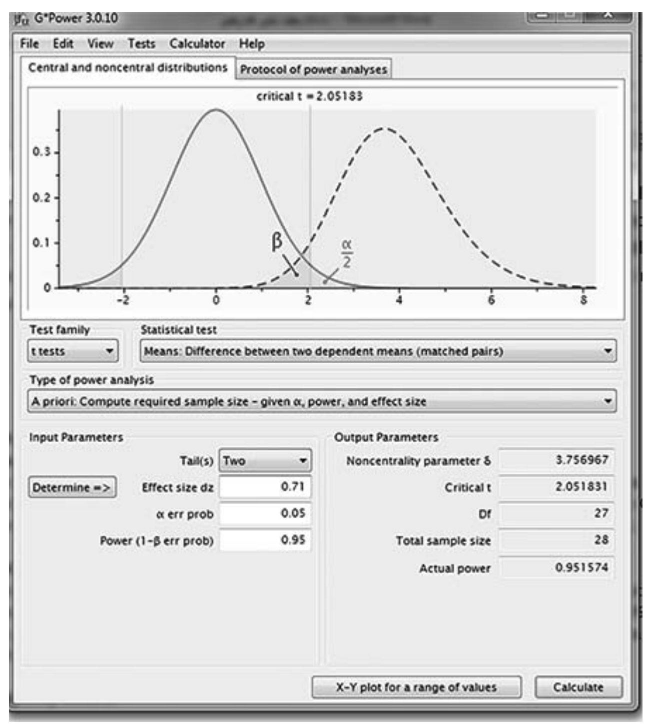

Figure 9. Sample size calculation.

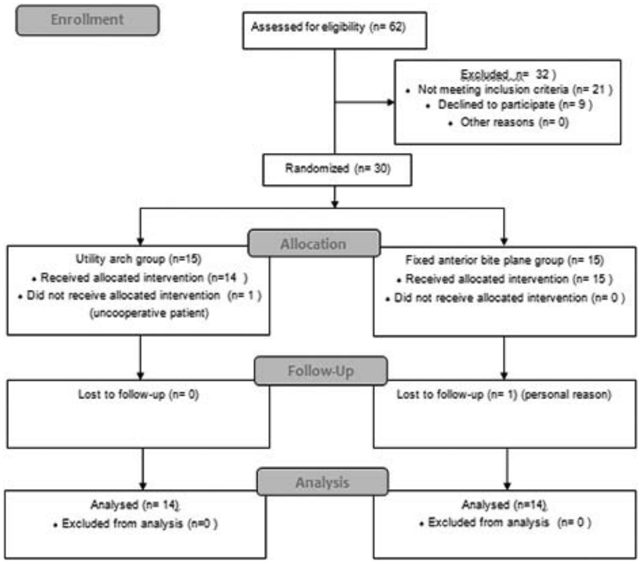

Figure 10. CONSORT flow diagram.

1.82 degrees in the UA group, $P = .007$; 2.81 degrees $\pm$ 1.74 degrees in the FABP group, $P < .001$), but the difference between groups was negligible and not significant. The BJORK sum increased significantly in both groups (0.79 degrees $\pm$ 1.24 degrees in the UA group, 1.37 degrees $\pm$ 1.12 degrees in the FABP group). In the UA group, the N-Me and ANS-ME heights increased significantly, whereas the Jarabak outcome decreased significantly (–0.80 $\pm$ 1.08). The anterior and posterior facial heights increased significantly in the FABP group; however, the Jarabak percentage did not decrease significantly (Table 7).

In the sagittal plane, SNA and ANB decreased significantly after treatment in the UA group, whereas there were nonsignificant (NS) differences in the FABP group (Table 7).

Regarding the dentoalveolar outcomes, the overjet increases were not significant in either group. Overbite decreased significantly less in the UA group than in the FABP group. The U1-Spp did not show any significant difference in the UA group, whereas it showed a significant decrease in the FABP group. The U6-Spp, L1-MP, and L6-MP did not differ significantly. The upper incisors protruded significantly in both groups, whereas the lower incisors protruded significantly in the UA group but not significantly in the FABP group (Table 8).

DISCUSSION

This was the first randomized clinical trial comparing two techniques for treating deep overbite in children with a horizontal growth pattern.[16] The combination of a UA and vertical posterior inter-maxillary elastics was evaluated for the first time in this study. However, the use of posterior vertical elastics was previously reported for extrusion to treat deep bite.[24] Because the inter-maxillary elastic was applied buccally, it would cause lingual tipping of the molars. The UA was fixed in a passive position on the upper molars after incisor protrusion was achieved, and the buccal segment retained molar torque. However, for the lower molars, a lingual arch was cemented on the first permanent molars to avoid any lingual tipping. The UA was applied after leveling and aligning the incisors, correcting their torque and protruding them, thus causing facial movement of the incisor crowns and palatal movement of the roots. This may have resulted in the significant decrease of the SNA angle and, consequently, the ANB angle in the UA group because of the effect of root movement on the position of A point.[25] In the FABP group, SNA did not show any significant changes as the upper incisors were protruded using palatal Z springs with more crown tipping and less root torque. After protrusion of incisors, the mandible did not seem to move forward in the sagittal plane in either group. To the contrary, point B retruded in both groups, but not significantly, because of an opening rotation of the mandible.

Table 3. Treatment Time

Treatment Time, Months	UA Group	FABP Group	Difference Between Groups	
Mean	8.1629	7.2229	Mean difference	0.94
Standard deviation	2.42306	2.63211	Standard error difference	0.956
			P value	.335
			Significance	NS

Table 2. Characteristics of the Sample

		Age, Years		Difference Between Groups (Two-Sample *t*-Test)		Sex				Difference Between Groups, χ^2	
	N	Mean	Standard Deviation			No. of Boys	Percentage of Boys	No. of Girls	Percentage of Girls		
UA group	14	10.65	0.97	Mean	0.01357	8	57	6	43		
FABP group	14	10.67	1.25	Standard error difference	0.42592	7	50	7	50		
Total	28	10.66	1.10	*P* value	.975	15	53	13	47	*P* value	.705
				Significance	NS					Significance	NS

Table 4. Normality Test Results (Shapiro-Wilk)

	T0						T1					
	UA Group			FABP Group			UA Group			FABP Group		
Variable	Statistic	*P* Value	Significance	Statistic	*P* Value	Significance	Statistic	*P* Value	Significance	Statistic	*P* Value	Significance
SNA	.935	.354	NS	.948	.534	NS	.969	.862	NS	.905	.135	NS
SNB	.959	.712	NS	.913	.176	NS	.959	.706	NS	.894	.092	NS
ANB	.960	.727	NS	.896	.099	NS	.945	.489	NS	.967	.832	NS
SN:Spp	.958	.698	NS	.946	.501	NS	.955	.644	NS	.945	.492	NS
SN:GoMe	.889	.077	NS	.911	.165	NS	.912	.167	NS	.980	.976	NS
MM	.929	.294	NS	.968	.855	NS	.922	.232	NS	.911	.162	NS
SNAr	.946	.496	NS	.905	.134	NS	.918	.202	NS	.961	.736	NS
SArGo	.961	.739	NS	.935	.362	NS	.979	.969	NS	.969	.869	NS
ArGoMe	.945	.492	NS	.943	.456	NS	.894	.094	NS	.986	.995	NS
BJORK sum	.933	.341	NS	.884	.067	NS	.984	.991	NS	.953	.609	NS
S-Go	.964	.788	NS	.882	.062	NS	.914	.183	NS	.967	.832	NS
N-Me	.936	.373	NS	.895	.095	NS	.946	.501	NS	.946	.505	NS
Jarabak	.934	.349	NS	.893	.091	NS	.937	.376	NS	.937	.382	NS
Overjet	.937	.378	NS	.937	.386	NS	.912	.170	NS	.928	.287	NS
Overbite	.919	.213	NS	.957	.675	NS	.920	.219	NS	.923	.241	NS
U1-Spp	.924	.251	NS	.922	.232	NS	.975	.939	NS	.886	.071	NS
U6-Spp	.943	.454	NS	.960	.721	NS	.969	.868	NS	.889	.079	NS
L1-MP	.957	.679	NS	.921	.225	NS	.945	.481	NS	.893	.089	NS
L6-MP	.883	.064	NS	.892	.085	NS	.960	.717	NS	.957	.672	NS
U1:SN	.951	.584	NS	.961	.745	NS	.946	.500	NS	.933	.332	NS
L1:Go Me	.936	.366	NS	.942	.439	NS	.978	.962	NS	.960	.730	NS

Table 5. Skeletal Characteristics at T0

T0	UA Group			FABP Group			Difference Between Groups (Two-Sample *t*-Test)			
Variable	N	Mean	Standard Deviation	N	Mean	Standard Deviation	Mean Difference	Standard Error Difference	*P* Value	Significance
SNA	14	79.9271	3.61461	14	80.1000	2.72918	−0.17286	1.21049	.888	NS
SNB	14	75.2443	2.96545	14	76.2121	3.22098	−0.96786	1.17012	.416	NS
ANB	14	4.6829	1.74454	14	3.8864	2.04136	0.79643	0.71766	.277	NS
SN-Spp	14	9.6457	1.24654	14	9.0886	1.56208	0.55714	0.53412	.307	NS
SN:GoMe	14	29.2000	0.57032	14	28.8529	1.16851	0.34714	0.34751	.330	NS
MM	14	19.5543	1.12034	14	19.7643	2.04635	−0.21000	0.62351	.740	NS
SNAr	14	124.7843	4.67361	14	124.3943	3.68320	0.39000	1.59034	.808	NS
SArGo	14	144.9150	5.74281	14	143.7750	4.45871	1.14000	1.94312	.562	NS
ArGoMe	14	119.0614	2.79303	14	119.8207	3.44833	−0.75929	1.18599	.528	NS
BJORK sum	14	388.7607	1.27051	14	387.9900	2.39259	0.77071	0.72401	.300	NS
S-Go	14	66.7843	4.00768	14	66.8357	5.09330	−0.05143	1.73212	.977	NS
N-Me	14	99.7779	5.81403	14	99.7750	6.96393	0.00286	2.42457	.999	NS
Jarabak	14	66.9860	2.85647	14	66.9754	2.71707	0.01058	1.05363	.992	NS

Table 6. Dentoalveolar Characteristics at T0

T0	UA Group			FABP Group			Difference Between Groups (Two-Sample *t*-Test)			
Variable	N	Mean	Standard Deviation	N	Mean	Standard Deviation	Mean Difference	Standard Error Difference	*P* Value	Significance
Overjet	14	4.3621	1.32861	14	4.7114	1.34243	−0.34929	0.50478	.495	NS
Overbite	14	4.9586	1.18425	14	5.4829	1.59868	−0.52429	0.53172	.333	NS
U1-Spp	14	23.9557	1.38417	14	24.5893	2.16151	−0.63357	0.68598	.364	NS
U6-Spp	14	16.8236	1.80051	14	17.0979	1.94123	−0.27429	0.70762	.701	NS
L1-MP	14	33.4093	1.79093	14	33.5386	2.60101	−0.12929	0.84400	.879	NS
L6-MP	14	23.3864	1.71376	14	23.0857	2.00632	0.30071	0.70520	.673	NS
U1:SN	14	91.8493	4.91451	14	94.2979	5.61870	−2.44857	1.99503	.231	NS
L1:Go Me	14	92.4093	5.50449	14	90.7529	5.06934	1.65643	1.99996	.415	NS

Table 7. Differences in Skeletal Outcomes Between the Groups (Two-Sample *t*-Test)

	UA Group (T1-T0)				FABP Group (T1-T0)						95% Confidence Interval of the Difference			
Variable	Mean Difference	Standard Deviation	*P* Value	Significance	Mean Difference	Standard Deviation	*P* Value	Significance	Mean Difference Between Groups	Standard Error Difference	Lower	Upper	*P* Value	Significance
SNA	−0.78643	1.24392	.034	*	0.32286	1.56544	.454	NS	−1.10929	0.53438	−2.20773	−0.01084	.048	*
SNB	−0.20929	0.49476	.137	NS	0.22929	1.50653	.579	NS	−0.43857	0.42379	−1.33803	0.46089	.316	NS
ANB	−0.58000	0.93834	.038	*	0.09357	0.92969	.713	NS	−0.67357	0.35303	−1.39923	0.05209	.067	NS
SN-Spp	0.42286	0.73547	.051	NS	−0.05143	0.77562	.808	NS	0.47429	0.28567	−0.11292	1.06149	.109	NS
SN:GoMe	1.97286	1.51036	.000	***	2.75857	1.60014	.000	***	−0.78571	0.58807	−1.99452	0.42309	.193	NS
MM	1.55000	1.82377	.007	**	2.81000	1.74800	.000	***	−1.26000	0.67515	−2.64779	0.12779	.073	NS
SNAr	−0.53071	1.75612	.279	NS	1.00500	4.11426	.377	NS	−1.53571	1.19556	−3.99322	0.92179	.210	NS
SArGo	1.63071	2.82666	.050	NS	1.02071	4.81871	.442	NS	0.61000	1.49308	−2.45907	3.67907	.686	NS
ArGoMe	−0.31000	2.61734	.665	NS	−0.57071	1.93004	.289	NS	0.26071	0.86913	−1.52581	2.04724	.767	NS
BJORK sum	0.79000	1.24723	.034	*	1.37143	1.12084	.001	**	−0.58143	0.44816	−1.50264	0.33978	.206	NS
S-Go	0.43500	1.90781	.409	NS	1.17643	2.00462	.047	*	−0.74143	0.73961	−2.26171	0.77886	.325	NS
N-Me	1.84929	2.92403	.034	*	2.87929	3.54365	.009	**	−1.03000	1.22787	−3.55393	1.49393	.409	NS
Jarabak	−0.80292	1.08622	.016	*	−0.70224	2.11374	.236	NS	−0.10068	0.63515	−1.42812	1.22676	.876	NS

*$P > .05$; **$P > .01$; ***$P > .001$.

Ve İskeletsel evaluated the effect of an FABP for deep bite treatment in the mixed dentition. According to that study, SNB increased significantly and ANB decreased after treatment because of the anterior position of mandible.[22] That contrasts with the current study, possibly because of the difference in appliance design using an inclined bite plane. In another study that assessed the effect of a removable anterior bite plane with a jackscrew, ANB decreased significantly.[26]

Vertically, the mandible showed a small opening rotation after treatment by both appliances, which resulted in an increase in SN:GoMe, MM, and BJORK. Applying RMGIC on the palatal surfaces of the upper incisors with posterior vertical inter-maxillary elastics resulted in extrusion of the posterior teeth in the UA group. However, although the amount of extrusion was not significant, it appeared that the growth direction of the mandible was affected. In the FABP group, passive extrusion occurred because of the posterior vertical space. Although the mandible rotated open, the gonial angle did not show any significant difference in either group. Therefore, rotation of the mandible occurred with no changes in gonial angle dimensions. Points Go and Me moved downward and backward, which affected the anterior and posterior facial heights, but the N-Me and S-Go measures increased because of a positional difference more than a dimensional difference. The facial height percentage according to Jarabak decreased significantly in the UA group but not significantly in the FABP group. However, there was no significant difference between the groups.

Forsberg and Hellsing first studied the FABP to treat Class II deep bite in children and adolescents. They found that this appliance affected mandibular growth and caused opening rotation, which is in agreement with the current study.[8,10] According to another previous study, SNGoGn increased after treatment with an FABP as a result of the opening rotation of the mandible.[22] In the study by Ansari et al., SNGoGn did not show any significant change, and the Jarabak

Table 8. Differences in Dentoalveolar Outcomes Between the Groups (Two-Sample *t*-Test)

	UA Group (T1-T0)				FABP Group (T1-T0)						95% Confidence Interval of the Difference			
Variable	Mean Difference	Standard Deviation	*P* Value	Significance	Mean Difference	Standard Deviation	*P* Value	Significance	Mean Difference Between Groups	Standard Error Difference	Lower	Upper	*P* Value	Significance
Overjet	0.36214	1.11931	.248	NS	1.12500	2.19088	.077	NS	−0.76286	0.65753	−2.11443	0.58871	.257	NS
Overbite	−2.10143	0.92874	.000	***	−3.64571	1.87999	.000	***	1.54429	0.56042	0.37127	2.71730	.013	**
U1-Spp	−0.28571	0.89303	.253	NS	−1.45643	1.80451	.010	*	1.17071	0.53810	0.06463	2.27680	.039	*
U6-Spp	0.51643	1.22524	.139	NS	0.25071	1.46339	.533	NS	0.26571	0.51009	−0.78279	1.31422	.607	NS
L1-MP	0.38214	0.83251	.110	NS	−0.31643	1.56355	.462	NS	0.69857	0.47342	−0.27456	1.67170	.152	NS
L6-MP	0.63571	1.36928	.255	NS	0.56071	1.12277	.401	NS	0.17500	0.47325	−0.79778	1.14778	.715	NS
U1:SN	6.60143	4.32112	.000	***	5.97357	5.42365	.001	**	0.62786	1.85334	−3.18174	4.43745	.738	NS
L1:Go Me	3.39214	3.05518	.001	**	2.00857	5.19676	.172	NS	1.38357	1.61113	−1.92816	4.69530	.398	NS

*$P > .05$; **$P > .01$; ***$P > .001$.

percentage increased significantly.[26] Another study showed that the mandible rotated open after using the anterior bite plane in children with Class II deep bite.[13]

Regarding the dentoalveolar outcomes, the overjet did not show any significant differences, whereas the overbite decreased significantly less in the UA than in the FABP group. This may be explained by the relative intrusion that occurred in the upper incisors in the FABP group, which was greater than in the UA group. Occlusion of the lower incisors on the acrylic bite plane with activated palatal Z springs might have caused an intrusive force in addition to the protrusive force on the upper incisors, resulting in a significant decrease in U1-Spp. A small, but NS, amount of intrusion also occurred in the lower incisors because of the fixed bite plane. Another previous study found that overbite decreased significantly after treatment with an FABP.[13,22] The U6-Spp and L6-MP increased in both groups because of the extrusive force; however, this increase was not significant. The upper incisors protruded significantly in both groups. Because of the separation between the upper and lower arches in both groups, the lower incisors were released from the restriction caused by the retroclined upper incisors, thus enabling lower incisor protrusion to occur in the UA group.

Limitations

Although the appliances used in the study were fixed, the inter-maxillary elastics were dependent on patient cooperation. The application of the UA caused ulcers in some patients, and it was removed until healing occurred.

CONCLUSIONS

- The mandible showed a small but significant opening rotation after treatment by both appliances.
- The overbite decreased less in the UA group than in the FABP group.
- The maxillary incisors protruded after treatment in both groups.

SUPPLEMENTAL DATA

Supplemental Tables 1 and 2 are available online.

REFERENCES

1. Sreedhar C, Baratam S. Deep overbite—a review. *Ann Essence Dent*. 2009;1(1):8–25.
2. Graber TM, Vanarsdall RL Jr. *Orthodontics: Current Principles and Techniques* (2nd ed.). St. Louis, MO: Mosby–Year Book; 1994.
3. Youssef M. Craniofacial growth pattern in cover-bite malocclusions and its therapeutic influencing. *J Orofac Orthop*. 2001;62(6):422–435.
4. Hultgren BW, Isaacson RJ, Erdman AG, Worms FW, Rekow ED. Growth contributions to Class II corrections based on models of mandibular morphology. *Am J Orthod*. 1980;78(3): 310–320.
5. Daokar S, Agrawal G. Deep bite its etiology, diagnosis and management: a review. *J Orthod Endod*. 2016;2:4.
6. de Almeida-Pedrin RR, de Almeida MR, de Almeida RR, Pinzan A, Ferreira FPC. Treatment effects of headgear biteplane and bionator appliances. *Am J Orthod Dentofacial Orthop*. 2007;132(2):191–198.
7. Hans MG, Kishiyama C, Parker SH, Wolf GR, Noachtar R. Cephalometric evaluation of two treatment strategies for deep overbite correction. *Angle Orthod*. 1994;64(4):265–274.
8. Hellsing E, Hellsing G, Eliasson S. Effects of fixed anterior biteplane therapy—a radiographic study. *Am J Orthod Dentofacial Orthop*. 1996;110(1):61–68.
9. Franchi L, Baccetti T, Giuntini V, Masucci C, Vangelisti A, Defraia E. Outcomes of two-phase orthodontic treatment of deepbite malocclusions. *Angle Orthod*. 2011;81(6):945–952.
10. Forsberg C-M, Hellsing E. The effect of a lingual arch appliance with anterior bite plane in deep overbite correction. *Eur J Orthod*. 1984;6(1):107–115.
11. Deregibus A, Debernardi CL, Persin L, Tugarin V, Markova M. Effectiveness of a fixed anterior bite plane in Class II deep-bite patients. *Int J Orthod*. 2014;25(1):15–20.
12. Zaboulian J, Ghassemi B. Fixed functional therapy with an anterior bite plane. *Int J Orthod*. 2014;25(4):9–12.
13. Senussi IB, Abdelgader I. Evaluation of changes on maxillofacial skeleton of Class II patients with deep bite treated with anterior bite plane as a functional appliance. *J Adv Res Dent Oral Health*. 2019;4(1):1–9.
14. Woods MG. Sagittal mandibular changes with overbite correction in subjects with different mandibular growth directions: late mixed-dentition treatment effects. *Am J Orthod Dentofacial Orthop*. 2008;133(3):388–394.
15. Egermark I, Magnusson T, Carlsson GE. A 20-year follow-up of signs and symptoms of temporomandibular disorders and malocclusions in subjects with and without orthodontic treatment in childhood. *Angle Orthod*. 2003;73(2):109–115.
16. Millett DT, Cunningham SJ, O’Brien KD, Benson PE, de Oliveira CM. Orthodontic treatment for deep bite and retroclined upper front teeth in children. *Cochrane Database Syst Rev.* 2018;2(2):CD005972.
17. Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *J Pharmacol Pharmacother*. 2010;1(2): 100–107.
18. Al-Salti. M. *Craniofacial Morphology of Subjects With Neutral Occlusion in Syria* [master’s thesis]. Damascus, Syria: Damascus University; 2000.
19. McNamara JA, Franchi L. The cervical vertebral maturation method: a user’s guide. *Angle Orthod*. 2018;88:133–143.
20. Wang MK, Buschang PH, Behrents R. Mandibular rotation and remodeling changes during early childhood. *Angle Orthod*. 2009;79(2):271–275.
21. McNamara J. Utility arches. *J Clin Orthod*. 1986;20(7):452–456.
22. ve İskeletsel BTD. Evaluation of the effects of fixed anterior biteplane treatment on the dental and skeletal structures and

masticatory muscles in patients with deep bite. *Evaluation*. 2010;34(1–2):10–22.
23. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med*. 2016;15(2):155–163.
24. Jariyavithayakul P, Charoemratrote C. Skeletal and dental changes after lower posterior tooth extrusion in Class II division 1 deep bite short-faced growing patients. *APOS Trends Orthod*. 2019;9(3):165–171.
25. Chen Q, Zhang C, Zhou Y. The effects of incisor inclination changes on the position of point A in Class II division 2 malocclusion using three-dimensional evaluation: a long-term prospective study. *Int J Clin Exp Med*. 2014;7(10):3454.
26. Ansari G, Showkatbakhsh R, Malekshah S, Dashti M, Simaei L. The effect of anterior bite plate on deep bite correction during early mixed dentition. *Avicenna J Dent Res*. 2018;10(2):63–66.