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Treatment and posttreatment outcomes induced by the Mandibular Advancement Repositioning Appliance; A controlled clinical study

Luis Tomas Huanca Ghislanzoni[a]; Douglas Edward Toll[b]; Efisio Defraia[c]; Tiziano Baccetti[d]; Lorenzo Franchi[d]

ABSTRACT

Objective: To evaluate the treatment and posttreatment dentoskeletal effects induced by the Mandibular Advancement Repositioning Appliance (MARA) in the treatment of Class II malocclusion.

Materials and Methods: The treated sample consisted of 23 consecutively treated patients at prepubertal or pubertal stages, as assessed by the cervical vertebral maturation method. A control group of untreated Class II subjects was generated from published normative growth data. Lateral cephalograms were digitized and superimposed via cephalometric software at three different times: T1, pretreatment; T2, post-MARA treatment; and T3, at least 1 year after T2. The T1–T2, T2–T3, and T1–T3 changes in the treated group were compared to those in the control group with independent-sample Student's *t*-tests.

Results: Skeletal and dentoalveolar effects of MARA were assessed after the active phase of the treatment (T1–T2). Mandibular elongation in length (Co-Gn, +2.2 mm) was evident together with lower incisor proclination (IMPA, +5.8 mm). A relapse tendency for IMPA was noticed after removing the appliance (IMPA, −2.1° during T2–T3). Significant skeletal effects (Co-Gn, +2.0 mm) and headgear effects on the maxilla (SNA, −1.2°) were significant in the long term (T1–T3).

Conclusions: The MARA appliance provides an effective correction of Class II malocclusion, which is maintained at a posttreatment observation with a moderate skeletal effect. (*Angle Orthod.* 2011;81:684–691.)

KEY WORDS: Fixed functional appliances; Class II malocclusion; Cephalometrics

INTRODUCTION

The Mandibular Advancement Repositioning Appliance (MARA), a noncompliance device for Class II treatment, was first proposed by Eckhart and Toll in 1998.[1] Since then it has received scarce attention in the literature[2–5] in spite of the increasing interest in Class II noncompliance treatment options[6–11] such as the Herbst, the Forsus, and the Jasper Jumper.

When cooperation may be a problem[12] or in late-adolescence treatment, a recommendable choice can include noncompliance appliances.[13] Bulkiness and complications represent a problem in the clinical management of the Herbst appliance in 60% of patients.[14] The MARA is an alternative to the Herbst, with the major advantage being that it treats a Class II malocclusion in combination with comprehensive fixed appliances. This may represent a favorable clinical feature in shortening treatment duration. The MARA differs from other noncompliance Class II devices such as the Forsus[8,9] or Jasper Jumper[7,9,10] because it is rigid and has no continuous upper arch–lower arch connection.

Gonner et al.[2] evaluated the clinical effectiveness of the appliance in the posttreatment period with no controls, while Pangrazio-Kulbersh et al.[3] used a

[a] PhD student, Department of Orthodontics, University of Florence, Florence, Italy.

[b] Private practice, Bad Soden, Germany.

[c] Associate Professor, Department of Orthodontics, University of Florence, Florence, Italy.

[d] Assistant Professor, Department of Orthodontics, University of Florence, Florence, Italy; Thomas M. Graber Visiting Scholar, Department of Orthodontics and Pediatric Dentistry, School of Dentistry, The University of Michigan, Ann Arbor, Mich.

Corresponding author: Dr Tiziano Baccetti, Department of Orthodontics, Università degli Studi di Firenze, Via Ponte di Mezzo 48 Firenze, Italy 50127 Italy
(e-mail: tbaccetti@unifi.it)

matched untreated Class II control group for comparisons with the treated group, with no follow-up. Only recently Siara-Olds et al.[4] evaluated the posttreatment effects of MARA with respect to untreated controls. In this study the authors annualized the treatment outcomes in order to compare their findings with those of other treatment modalities. According to the present literature, the MARA is able to produce effective Class II correction by reducing overjet, Wits, and ANB angle. Gonner et al.[2] showed a few dental side effects (lower incisor proclination adversely related to age of treatment). Pangrazio-Kulbersh et al.[3] reported similar findings together with a distalizing effect on the upper first molar with a smaller "headgear effect" (growth restriction of the maxilla), as compared to the Herbst appliance. Mandibular first molars and incisors experienced significant sagittal advancement. Siara-Olds et al.[4] reported long-term stability of dentoalveolar changes of comprehensive MARA and fixed appliance therapy, while no significant annualized changes of skeletal growth were reported. Unfortunately, the annualization used in studies on growing patients is questionable.

The aim of this controlled clinical study was to evaluate the treatment and posttreatment dentoskeletal effects induced by MARA in the treatment of Class II malocclusion.

MATERIALS AND METHODS

Subjects

Approval for this study was received from the Ethical Committee at the University of Florence, Italy. From a parent sample of 62 Class II division 1 subjects treated consecutively with the MARA appliance, 23 subjects were selected according to the following inclusion criteria: ANB greater than or equal to 4°, full Class II or end-to-end molar relationships, and follow-up observation at least 1 year after the end of comprehensive treatment with MARA and fixed appliances. All patients received active treatment with MARA before (15 subjects) or during (8 subjects) their pubertal growth spurt, as assessed by the cervical vertebral maturation (CVM) method.[15] The assessment of the cervical vertebral stages for each subject was performed by one investigator and verified by a second one (T.B.). Any disagreements were resolved to the satisfaction of both observers.

The mean age of the treated group at time 1 (T1, maximum 6 months before the start of treatment) was 10.2 ± 1.5 years; at time 2 (T2, immediately after MARA treatment) it was 12.3 ± 1.5 years; and at time 3 (T3, at least 1 year after comprehensive treatment) it was 14.8 ± 2.3 years. Mean T1–T2 interval was 2.1 ± 1.0 years, mean T2–T3 interval was 2.4 ± 1.7 years, and mean T1–T3 interv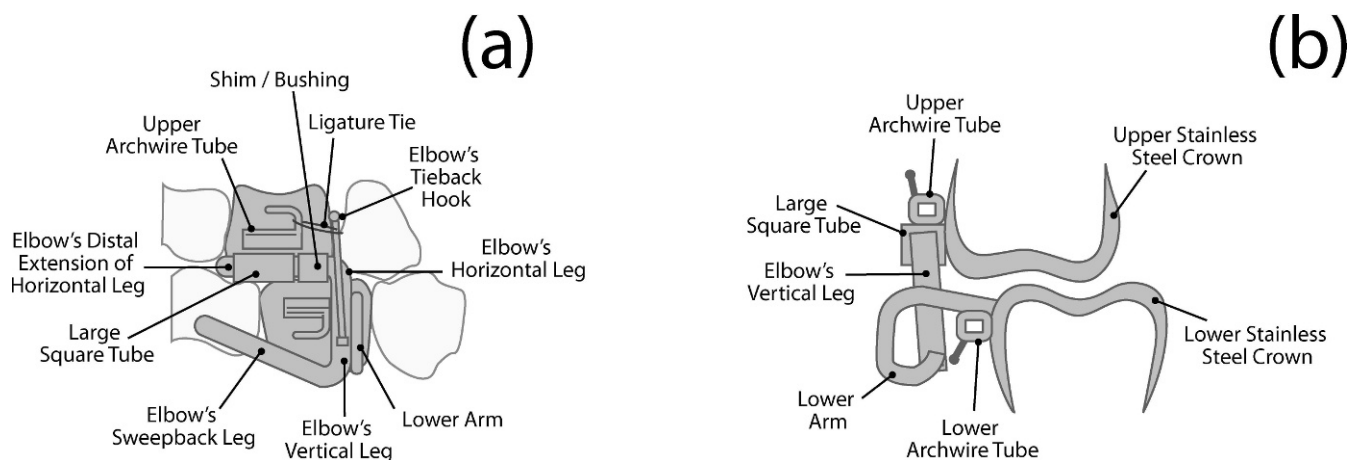al was 4.6 ± 2.0 years. The median value for the CVM stages at T1 was 2 (range, 1–3); it was 3 (range, 2–5) at T2; and it was 5 (range, 3–6) at T3.

The control "group" comprised data calculated on longitudinal series of 17 untreated Class II subjects selected from the University of Michigan and Denver Child Growth Studies.[16] The longitudinal series consisted of Class II subjects who matched the treated subjects for Class II dentoskeletal features at T1, sex distribution, age, and skeletal maturation (CVM stages) at T1, T2, and T3. The use of historical controls was due to the lack of ethical reasons to leave Class II patients untreated at the developmental period (puberty), which is known to represent the optimal time for orthopedic modifications.[6,15]

Treatment Protocol

All patients were consecutively treated by the same operator with MARA (AOA, Sturtevant, Wis) and fixed appliances followed by removable retention in a private practice setting. No subjects underwent extraction of teeth as part of the treatment protocol, nor did any undergo maxillary expansion concurrent with the use of the MARA appliance. The MARA inclined plane (elbow's sweepback leg; Figure 1) works as an obstacle to be avoided during closure, inducing the lower jaw to move forward. This is supposed to favor a neuromuscular reeducation during correction of the Class II dentoskeletal relationship. During treatment with the MARA it is also possible to use other appliances (like fixed appliances or rapid palatal expander) to better address specific patient needs and to shorten treatment duration. The developers[1] of the appliance recommend a 12-month treatment time to achieve a bite-jumping or orthopedic effect. Stabilization of the lower molars is assisted by the fitting of a lingual arch, which is constructed at a 2-mm to 3-mm distance from the lingual surface of the lower incisors in order to prevent proclination of these teeth. This appliance does not require the placement of attachments on teeth other than the first molars.

A stepwise advancement protocol with 2–3-mm enhancement steps[17–19] was used up until the point that a slight overcorrection of the Class II dental relationship was achieved. Fixed appliances were initiated together with the MARA or after a few months of active treatment. The T1–T2 interval provided information about the active treatment with the MARA appliance. The T2–T3 interval gave data about posttreatment changes that included a phase of finishing treatment with fixed appliances. The T1–T3 interval provided information about the overall effects induced by MARA during treatment and posttreatment intervals.

Figure 1. The Mandibular Advancement Repositioning Appliance (MARA) and its components: (a) sagittal view, (b) frontal section.

Cephalometric Analysis

Lateral cephalograms were traced and measured using a digitizing software (Viewbox, ver. 3.0; DHAL software, Kifissia, Greece).[20] There was no difference in cephalometric magnification between the cephalograms of the two groups (8%).

A customized analysis required the digitization of 65 landmarks and four fiducial markers.[14] The analysis contained measurements from the analyses of Steiner,[21] Jacobson,[22] Ricketts,[23] and McNamara.[24] It generated 34 variables (12 angular and 22 linear) for each tracing. Tracing involved anatomic stable structures such as the inner contour of the symphysis, the alveolar nerve canal, and the inner contour of the palatal bone. A preliminary tracing was made on T1 cephalograms for each patient and fiducial points were placed (two in the maxilla and two in the mandible). Fiducial markers were then transferred to the T2 and T3 tracings based on superimposition, via software, over anatomical stable structures,[25] as described by Stahl et al.[16] This superimposition allowed for the description of the movement of the maxillary dentition relative to the maxilla and of mandibular dentition relative to the mandible.

Method Error

All cephalograms were traced and superimposed by the same operator and were checked by a second operator to verify anatomic outlines, landmark placement, and tracing superimpositions. Any disagreements were resolved to the satisfaction of both observers.

Ten randomly selected cephalograms were re-digitized by the same operator, and the variables were recalculated to determine the method error with the Intraclass Correlation Coefficient (ICC). The ICCs ranged from 0.90 to 0.99 for linear measurements and

from 0.92 to 0.98 for angular measurements. All recalculated measures were within 1 mm/1 d° from the original, and the average discrepancy was 0.4 mm/0.4°.

Statistical Analysis

Descriptive statistics were calculated for each cephalometric variable. Craniofacial changes in the treated group were compared with the growth changes occurring in the corresponding control group. T1–T2 (active MARA treatment), T2–T3 (posttreatment modifications), and T1–T3 (long-term effects) changes were analyzed.

A preliminary Shapiro-Wilks test was performed to assess whether or not data had a normal distribution. All statistical comparisons were performed by an independent-sample Student's t-test. The significance level was set at $P < .05$. Considering mandibular elongation (Co-Gn) a sensitive variable for Class II correction, the power of the statistics was calculated as 0.82 with reference to the literature.[6] The tests were carried out using a commercial statistical package (SPSS for Windows, release 12.0, SPSS Inc, Chicago, Ill).

RESULTS

In the present study the mean duration of the MARA treatment was 1.2 ± 0.5 years. Results of the statistical comparisons between MARA patients and Class II control subjects on the changes for all cephalometric variables during the T1–T2 observation interval are reported in Table 1. All cephalometric variables contributing to Class II correction showed significantly favorable changes (ANB angle, −1.4°; Wits, −2.1 mm; overjet, −2.8 mm). A "headgear effect" was observed in the maxilla (A to Nasion perpendicular, −0.8 mm), while total mandibular length (Co-Gn) and ramus height (Co-Go) increased significantly more in cases than in controls (+2.2 mm

Table 1. Statistical Comparison of Pretreatment T1–T2 Changes: Mandibular Advancement Repositioning Appliance (MARA) Active Phase[a]

Variables	MARA T1–T2		CTRLs T1–T2		Statistics		
	Mean	SD	Mean	SD	Net Difference	t	P
Cranial base							
NSBa, °	−0.6	1.9	−0.1	1.7	−0.6	0.941	.532
Maxillary skeletal							
SNA, °	−0.1	1.5	0.2	1.1	−0.3	0.774	.388
Pt A to nasion perp, mm	−0.8	1.5	0.1	0.8	−0.8	2.539	.015
Co-Pt A, mm	2.4	2.5	3.3	1.5	−0.9	1.481	.146
Mandibular skeletal							
SNB, °	1.6	1.7	0.4	1.1	1.2	2.842	.006
Pg to nasion perp, mm	1.6	3.8	0.9	1.6	0.7	0.814	.420
Co-Gn, mm	7.2	3.5	4.9	1.4	2.2	2.926	.005
Maxillary/mandibular							
ANB, °	−1.7	1.4	−0.3	0.7	−1.4	4.290	.000
Wits, mm	−1.9	3.1	0.3	1.1	−2.1	3.208	.003
Maxillary/mandibular difference, mm	4.8	2.9	2.0	1.2	2.8	4.279	.000
Vertical skeletal							
FH to palatal plane, °	0.6	2.3	−0.5	1.4	1.1	1.992	.056
FH to mandibular plane, °	−0.3	2.3	−0.5	1.3	0.2	0.363	.718
N-ANS, mm	2.3	2.3	2.7	1.2	−0.4	0.740	.464
ANS-Me, mm	2.9	2.3	1.9	1.2	1.0	1.849	.071
Co-Go, mm	5.4	2.9	3.1	2.0	2.3	3.131	.003
ArGoiMe, °	−0.2	2.7	−0.5	1.5	0.4	0.466	.644
CoGoiMe, °	−0.3	1.9	−0.1	1.3	−0.1	0.417	.679
Interdental							
Overjet, mm	−2.7	2.6	0.1	0.8	−2.8	4.936	.000
Overbite, mm	−1.5	3.0	0.3	0.9	−1.8	2.756	.008
Interincisal angle, °	−6.8	15.2	0.9	3.7	−7.6	2.361	.023
Molar relationship, mm	3.0	2.4	0.4	0.7	2.7	4.988	.000
Maxillary dentoalveolar							
U1 to Pt A vertical, mm	0.6	2.5	0.4	0.8	0.2	0.365	.717
U1 to FH, °	1.5	12.3	−0.1	2.9	1.7	0.607	.547
U1 horizontal, mm	0.5	1.8	0.8	0.9	−0.3	0.715	.478
U1 vertical, mm	0.5	1.5	0.7	0.9	−0.2	0.548	.586
U6 horizontal, mm	1.2	1.8	1.1	1.0	0.1	0.817	.233
U6 vertical, mm	1.5	1.7	1.2	0.8	0.3	0.766	.448
Mandibular dentoalveolar							
L1 to Pt A-pogonion, mm	2.8	2.5	0.0	0.8	2.8	5.116	.000
L1 to mandibular plane, °	5.5	7.2	−0.3	2.5	5.8	3.65	.000
L1 horizontal, mm	1.1	1.9	0.1	0.7	1.0	2.369	.022
L1 vertical, mm	1.0	1.6	1.3	0.9	−0.3	0.784	.437
L6 horizontal, mm	2.1	1.8	1.1	0.9	1.0	2.383	.022
L6 vertical, mm	2.3	1.2	1.4	0.9	0.9	2.878	.006

[a] T1 indicates pretreatment; T2, post-MARA treatment; CTRL, control; and SD, standard deviation.

and +2.3 mm, respectively), thus enhancing a favorable differential growth pattern (Max/Mand differential, +2.8 mm). The lower incisors exhibited sagittal advancement and proclination (+5.8°) relative to the mandibular plane. The lower molars were also significantly advanced (+1.0 mm) and showed some extrusion (+0.9 mm). There were no adverse effects on the vertical dimension with any significant change on vertical measures.

T2–T3 interval changes and statistical comparison are reported in Table 2. Only minor posttreatment changes were noted as a slight, but significant, relapse (−2.2°) in the excessive proclination of the lower incisors. The "headgear effect" on the maxilla (SNA, −0.9°) continued during this phase.

T1–T3 changes describe overall treatment effects of comprehensive MARA and fixed appliance treatment and are shown in Table 3. The headgear effect (SNA, −1.2°; A to Nasion per, −1.4 mm) on the maxilla was associated with mandibular supplemental elongation (Co-Gn, +2.0 mm). ANB angle (−1.8°), Wits (−1.8 mm), overjet (−3.3 mm), and overbite

Table 2. Statistical Comparison of T2–T3 Changes: Fixed Appliance Finishing and Recovery Phase[a]

Variables	MARA T2–T3		CTRLs T2–T3		Statistics		
	Mean	SD	Mean	SD	Net Difference	t	P
Cranial base							
NSBa, °	0.7	1.9	0.0	1.5	0.7	1.387	.173
Maxillary skeletal							
SNA, °	−0.7	1.6	0.3	1.0	−0.9	2.542	.014
Pt A to nasion perp, mm	−0.4	1.8	0.2	0.8	−0.6	1.460	.151
Co-Pt A, mm	2.5	2.2	3.0	1.6	−0.5	0.881	.383
Mandibular skeletal							
SNB, °	0.0	1.5	0.5	1.0	−0.6	1.000	.190
Pg to nasion perp, mm	0.6	3.3	1.2	1.7	−0.6	0.775	.442
Co-Gn, mm	4.4	2.9	4.6	1.6	−0.3	0.290	.774
Maxillary/mandibular							
ANB, °	−0.6	1.2	−0.2	0.7	−0.4	0.290	.774
Wits, mm	0.8	2.3	0.4	0.9	0.4	0.777	.442
Maxillary/mandibular difference, mm	1.9	2.0	2.1	1.3	−0.2	0.402	.690
Vertical skeletal							
FH to palatal plane, °	−0.3	1.8	−0.5	1.3	0.2	0.432	.668
FH to mandibular plane, °	−0.9	2.2	−0.6	1.6	−0.3	0.529	.600
N-ANS, mm	2.1	2.1	2.1	1.1	0.0	0.040	.968
ANS-Me, mm	2.7	2.7	2.0	1.2	0.7	1.136	.262
Co-Go, mm	2.9	3.4	3.2	2.3	−0.3	0.304	.762
ArGoiMe, °	−1.1	3.3	−0.6	1.8	−0.5	0.638	.527
CoGoiMe, °	−1.2	2.7	−0.2	1.4	−1.0	1.577	.122
Interdental							
Overjet, mm	−0.4	1.4	0.1	0.7	−0.5	1.532	.133
Overbite, mm	0.3	1.3	−0.1	0.8	0.4	1.257	.216
Interincisal angle, °	3.5	7.7	0.6	3.3	2.9	1.660	.104
Molar relationship, mm	0.9	2.1	0.2	0.7	0.7	1.517	.137
Maxillary dentoalveolar							
U1 to Pt A vertical, mm	0.0	1.1	0.2	0.8	−0.3	0.705	.484
U1 to FH, °	−0.4	4.7	0.1	2.8	−0.4	0.438	.663
U1 horizontal, mm	0.5	1.6	0.5	0.8	−0.1	0.161	.873
U1 vertical, mm	0.9	1.4	0.4	0.8	0.4	1.487	.144
U6 horizontal, mm	0.8	2.3	1.0	0.9	−0.2	0.388	.700
U6 vertical, mm	1.3	2.0	1.2	0.7	0.1	0.226	.822
Mandibular dentoalveolar							
L1 to Pt A-pogonion, mm	−0.1	1.5	−0.1	0.7	0.0	0.058	.954
L1 to mandibular plane, °	−2.2	4.0	−0.1	2.6	−2.1	2.111	.041
L1 horizontal, mm	0.3	1.5	0.0	0.7	0.3	0.603	.390
L1 vertical, mm	1.3	1.9	1.3	0.8	0.0	0.047	.963
L6 horizontal, mm	1.0	2.1	0.9	0.8	0.1	0.213	.832
L6 vertical, mm	2.0	1.6	1.2	0.9	0.8	2.090	.042

[a] T2 indicates post–Mandibular Advancement Repositioning Appliance (MARA) treatment; T3, 1 year after T2; CTRL, control; and SD, standard deviation.

(−1.4 mm) showed significantly greater decreases in MARA patients when compared to Class II controls. A vertical effect was present, with a slight opening of the Frankfurt to palatal plane angle (+1.3°) and an increase of the lower third of the face (ANS-Me, + 1.8 mm) in the MARA group. The lower incisors were proclined (+3.7°), with a tendency for the mandibular first molar to extrude (+1.6 mm) in the MARA group vs controls.

DISCUSSION

The present controlled clinical study evaluated the effectiveness of MARA in Class II patients treated at circumpubertal ages compared with the use of untreated Class II controls and the inclusion of a posttreatment observation period.

Gonner et al.[2] followed a protocol similar to the one used in the present study, but without untreated Class

Table 3. Statistical Comparison of T1–T3 Changes: Long-Term Changes[a]

Variables	MARA T1–T3		CTRLs T1–T3		Statistics		
	Mean	SD	Mean	SD	Net Difference	t	P
Cranial base							
NSBa, °	0.0	2.0	−0.1	2.3	0.1	0.157	.876
Maxillary skeletal							
SNA, °	−0.8	1.6	0.5	1.5	−1.2	2.843	.007
Pt A to nasion perp, mm	−1.2	1.8	0.2	1.2	−1.4	3.104	.003
Co-Pt A, mm	4.9	2.8	6.3	2.3	−1.4	1.853	.070
Mandibular skeletal							
SNB, °	1.6	1.2	1.0	1.5	0.6	1.000	.141
Pg to nasion perp, mm	2.2	4.4	2.1	2.3	0.2	0.097	.924
Co-Gn, mm	11.5	3.5	9.5	2.2	2.0	2.320	.025
Maxillary/mandibular							
ANB, °	−2.3	1.6	−0.5	1.0	−1.8	4.575	.000
Wits, mm	−1.1	3.8	0.7	1.5	−1.8	2.113	.040
Maxillary/mandibular difference, mm	6.7	2.5	4.1	1.8	2.6	4.048	.000
Vertical skeletal							
FH to palatal plane, °	0.3	2.0	−1.0	2.0	1.3	2.204	.033
FH to mandibular plane, °	−1.2	3.1	−1.1	2.1	−0.1	0.128	.899
N-ANS, mm	4.4	2.8	4.8	1.7	−0.4	0.586	.561
ANS-Me, mm	5.6	3.0	3.8	1.7	1.8	2.504	.016
Co-Go, mm	8.3	3.6	6.3	3.2	2.0	1.985	.053
ArGoiMe, °	−1.3	3.6	−1.1	2.4	−0.2	0.222	.826
CoGoiMe, °	−1.4	2.8	−0.4	1.9	−1.1	1.417	.163
Interdental							
Overjet, mm	−3.1	2.9	0.2	1.1	−3.3	5.103	.000
Overbite, mm	−1.2	2.7	0.2	1.2	−1.4	2.272	.028
Interincisal angle, °	−3.2	13.6	1.5	5.0	−4.7	1.556	.127
Molar relationship, mm	3.9	2.2	0.6	1.0	3.4	6.549	.000
Maxillary dentoalveolar							
U1 to Pt A vertical, mm	0.6	2.5	0.6	1.2	0.0	0.067	.947
U1 to FH, °	1.2	10.6	0.0	4.1	1.2	0.506	.615
U1 horizontal, mm	1.0	2.3	1.4	1.2	−0.4	0.74	.464
U1 vertical, mm	1.3	1.8	1.1	1.3	0.2	0.432	.668
U6 horizontal, mm	2.0	1.6	2.1	1.4	−0.1	0.226	.823
U6 vertical, mm	2.8	1.3	2.5	1.1	0.4	0.845	.403
Mandibular dentoalveolar							
L1 to Pt A-pogonion, mm	2.7	2.4	−0.1	1.0	2.8	5.165	.000
L1 to mandibular plane, °	3.3	7.8	−0.4	3.6	3.7	2.066	.045
L1 horizontal, mm	1.4	2.1	0.0	1.0	1.3	2.887	.006
L1 vertical, mm	2.3	2.4	2.6	1.2	−0.3	0.536	.595
L6 horizontal, mm	3.1	2.4	2.0	1.2	1.1	1.966	.056
L6 vertical, mm	4.3	1.9	2.6	1.3	1.6	3.541	.001

[a] T1 indicates pretreatment; T3, 1 year after T2 (post–Mandibular Advancement Repositioning Appliance [MARA]); CTRL, control; and SD, standard deviation.

II controls or evaluation of skeletal maturity. They reported only a few cephalometric variables (ANB, IMPA, incisor position change, and overjet) that showed changes that were similar to those shown in the present study. The study by the group at the University of Detroit[3,4] compared MARA patients vs Herbst, Twin Block, and bionator patients and Class II untreated controls using a larger number of cephalometric variables. However, comparisons shown in these studies were possible only after annualization of measurements. No skeletal effect was evident for any of the appliances, apart from a maxillary growth restriction potential of the acrylic splint Herbst. Thus, Class II correction was mainly attributed to dentoalveolar effects. Since concurrent treatment with Class II devices and fixed appliances is rare, the ability to compare the effect of the combination of MARA and fixed appliances with the effects of other similar treatment alternatives is very limited.

The presence of tubes on the upper and lower molar bands of the MARA offers the rare opportunity for a one-stage treatment that combines an effective Class

II treatment device and comprehensive fixed appliances. Comparisons are possible with Forsus,[8,9] Jasper Jumper[7,9,10] (concurrent treatment), and Herbst (consecutive treatment)[6,11] appliances. No significant differences can be found with regard to the effectiveness of different Class II noncompliance treatment protocols. A general trend can be described according to the values of the different variables: Forsus and Jasper Jumper appliances present with a Class II correction potential that is mainly dentoalveolar, while the Herbst appliance has a defined, although moderate, skeletal effect both in the mandible and the maxilla. The MARA is similar to the Herbst in that it offers mild but significant skeletal effects (on the mandible Co-Gn, +2.0 mm, and on the maxilla A to Na perp, −1.4 mm after follow-up) with a reduced lower incisor proclination.

During the finishing and recovery phase (T2–T3) no relapse tendency was assessed with the exception of the lower incisors that tended to lose torque. Remodeling at point A went on during this phase, giving a continued slight headgear effect on the maxilla, as reported also by Siara-Olds et al.[4] The MARA treatment of most of the patients was active during or slightly before the pubertal peak. Thus, the T2–T3 period was mainly postpubertal, and this may have resulted in the stability of the outcomes. During this period the growth rate of the treated subjects was similar to that of the Class II controls, and it has been reported[15] that physiological postpubertal mandibular growth in untreated Class II subjects is similar to that of untreated Class I subjects.

The vertical dentoskeletal changes were generally not pronounced (within 2.0 mm or degrees when compared to those of the controls). A significant amount of lower first molar extrusion (1.6 mm) did not lead to skeletal bite opening because of the concurrent supplementary elongation of the mandibular ramus (Co-Go, 2.0 mm).

The overall T1–T3 change in the inclination of the lower incisor to the mandibular plane in the treated sample was +3.3°. This value is limited with respect to the range of average proclination (3–7°) reported in the literature.[6,9,26,27] This favorable effect may be attributed to the particular design of the MARA, which allows for concurrent treatment with fixed appliances. Furthermore, the use of full-size wires on the lower incisor may help in maintaining incisor inclination with respect to the mandibular plane.

CONCLUSIONS

• When compared to matched untreated Class II controls, the MARA produces favorable skeletal changes (mandibular elongation, maxillary growth restriction, ANB decrease), although modest in entity, and dentoalveolar changes (overjet and overbite decrease, molar relationship correction) are maintained at an average 1-year posttreatment observation.
• Lower incisor proclination is limited, probably as a result of fixed appliance treatment used concurrently with MARA.

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