Evaluation of MARA Appliance with Skeletal Anchorage in Early Treatment of Class II Malocclusion

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Abstract:

Objective: To investigate the effects of the fixed functional appliance Mandibular Anterior Repositioning Appliance (MARA) with skeletal anchorage on growing patients with skeletal Class II malocclusion. **Materials and Methods:** This study was conducted on 10 patients with a mean age of 10.3 years with skeletal Class II malocclusion. These patients were treated simultaneously with the MARA appliance with skeletal anchorage for 16.5 months on average. All the patients had the following criteria: skeletal Class II due to mandibular retrusion, overjet more than 4mm, no systemic diseases, no previous orthodontic treatment, or abnormal habits. Photographs and study casts were obtained before and after treatment. Lateral head films were taken before MARA appliance treatment and after MARA appliance removal. The collected data were analyzed using IBM SPSS software Version 22.0.**Results:** Restricted maxillary growth and significant mandibular growth were observed upon using the MARA appliance. Overjet was improved, and also maxillary molar distalization, and improvement of soft tissue profile were observed. **Conclusions**: The MARA appliance was effective in the treatment of Class II malocclusion by a combination of slight skeletal and dental changes. Restriction of maxillary growth and dentoalveolar changes in the maxillary and mandibular arches were responsible for the correction of the Class II malocclusion.

Introduction:

Class II malocclusion is considered one of the most commonly encountered problems in the orthodontic field.[1] This malocclusion was also found to represent 20.6% of the Egyptian population with ages between 11 and 14 years.[2] Patients with Class II malocclusions can show maxillary protrusion, mandibular retrusion, or both, together with abnormal dental relationships and profile discrepancy. Based on the work of McNamara, mandibular retrusion is considered the most common characteristic of this malocclusion rather than maxillary prognathism.[3]

The purpose of early treatment of Class II malocclusion is to improve the skeletal pattern and dentoalveolar and soft tissue profiles. There are several types of functional appliances for correction of Class II division 1 malocclusion due to mandibular deficiency by inducing mandibular growth and forward positioning of the mandible. The choice of the appliance varies according to the clinician's preference, type of defect, and growth pattern.[4]

Several studies evaluated the main skeletal characteristics of Class II malocclusion and most of them concluded that mandibular retrusion is the most dominant underlying skeletal feature. Many removable and fixed functional orthopedic interventions for correction of mandibular retrusion were studied in literature throughout the years. Removable functional appliances were the most commonly used treatment modalities for years. The advantages of removable functional appliances are simplicity in construction and early Class II correction by these appliances. However, patient compliance with these appliances has always been a major disadvantage because of their bulkiness and interference with the patient's speech and function.[5]

On the other hand, fixed functional appliances offer the clinical advantage of independence in patient compliance and the rapid correction of malocclusion through the application of a higher force level, especially for patients at a critical growth stage with a minimal amount of growth remaining.[6] A more recent fixed functional appliance that is gaining popularity is the Mandibular Anterior Repositioning Appliance (MARA) originally developed by Toll.[7]

Material and Methods:

After sample size calculation, 10 patients were selected from the clinic of the Orthodontic Department, Faculty of Dentistry, Mansoura University. The parents of each patient were informed about the study and signed written consent before starting the treatment. These patients were treated by MARA appliance with skeletal anchorage.

All patients had the following criteria:

- Age range from 9 -14 years.
- Skeletal Class II due to mandibular retrusion.
- Overjet more than 4mm.
- No cleft lip or palate.
- No systemic diseases.
- No previous orthodontic treatment or abnormal habits.
- No congenital craniofacial deformity.

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Records: The following records were taken before and after treatment:

1-Study casts.

2-Photographs:

Extraoral.

Intraoral.

3-Radiographs: Panoramic x-ray films were taken pre and post-treatment.

Lateral cephalometric x-ray films were taken pre and post-treatment.

Appliance Construction: Separators were placed mesial and distal to first permanent molars if their adjacent teeth were erupted for one week to allow fitting of stainless steel crowns. Proper sizes of stainless-steel crowns were fitted on the first permanent molars. Alginate impressions were taken to mandibular and maxillary arches with the molar crowns in place. Then, the molar crowns were removed from the patient's mouth and inserted in their place in alginate impressions. The impressions were sent to a laboratory to be poured on the same day. Other separators were placed in the same place as the old one to prevent space closure. The MARA appliance used in the study was based on Toll's design.[8] The appliance consisted of the following parts; Four stainless-steel crowns on the first permanent molars (The lower arm soldered to lower molar crowns, its purpose was to guide the mandible to occlude in a forward position posture), soldered maxillary and mandibular archwire tubes, maxillary elbow tubes for placement of elbows (The upper elbows were shimmed to provide the desired advancement), and lower lingual arch attached to lower stainless-steel crowns, which is recommended to prevent the lower molars from tipping mesially and lingually in response to the forces from the elbow. 0.9 mm wires were soldered to the anterior part of the-

Figure 1: MARA appliance anchored with mini-screws on a study cast

lower arms. The wires ran anteriorly and form a coil between the lower first premolars and canines at the level of the mucogingival junction where 1.6 mm in diameter and 8 mm in length orthodontic mini-screws (Morelli, Brazil) were placed Appliance delivery: Separators were removed and a try-in for the appliance was made. Important points were checked in the try-in procedure such as the proper fit, size, and length of the crown and the appliance was completely seated the way it should, and the crown was completely seated without applying any pressure on the soft tissue, Figure 1.

The stainless-steel crowns of MARA appliance were cemented on the first permanent molars with Glass ionomer cement (Medicem, Promedica, Neumunster, Germany). The heavy wires were proved away from the heads of the mini-screws to avoid their interference during the insertion of the lower stainless-steel crowns. After fully seated of the stainless-steel crowns, the coils at the mesial end of the wires were bonded to the head of mini-screws by a flowable composite to hold the wire with mini-screws and to avoid cheeks irritation, Figure 2.

Cephalometric reference points:

Nasion (N): The most anterior point of the frontonasal suture in the median plane.

Sella (S): The point representing the midpoint of the hypophysial fossa (sella turcica).

A point –Subspinale: The deepest point at midline concavity on the maxilla between the anterior nasal spine and prosthion.

B point –Supramentale: The point at the deepest midline concavity on the mandibular symphysis between infradentale and Pogonion.

Incisor superius (Is): Tip of the crown of the most anterior maxillary central incisor.

Columella (Col): The most anterior point on the Columella of the nose.

Glabella (G): The most prominent anterior point in the midsagittal plane of the forehead.

Subnasale (Sn): The point at the junction of the Columella and the upper lip.

Figure 2: Insertion of MARA appliance with mini-screw.

Labrale superius (Ls): The most anterior point on the convexity of the upper lip.

Labrale inferius (Li): The most anterior point on the convexity of the lower lip.

Soft tissue pogonion (Pg`): The most anterior point on the soft tissue chin in the midsagittal plane.

Cephalometric reference planes and line:

Sella-Nasion plane (SN): Reference line joining sella and nasion points.
Mandibular plane (MP): Plane joining Gonion and Gnathion points.
Steiner's S-line (S line): Line joining (Pg`) and midpoint of the curve "S" formed by the lower border of the nose.

Table 1: Skeletal, dentoalveolar, and soft tissue measurements

Measurements	Definition
Skeletal measurements	
SNA	Angle between points S, N and A
SNB	Angle between points S, N and B
ANB	Angle between points A, N and B.
Dentoalveolar measurements	
Is-NA	The angle formed between the long axis of the upper central incisor and the NA line
IMPA	The angle between the long axis of the mandibular central incisor and mandibular plane
Soft tissue measurements	
Nasolabial angle	The angle between Columella, Subnasale and Labrale superius
G`-Sn-Pg`	The angle between Glabella, Subnasale and soft tissue Pogonion
Ls-S line	The distance from the upper lip to Steiner's S line
Li-S line	The distance from the lower lip to Steiner's S line

The measurements in ,Figure 3, and Table 1 were obtained before and after treatment on cephalometric x-ray and analyzed by using IBM SPSS Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.

Results:

The means, standard deviations, and paired t-test changes results of the soft tissue, skeletal and dentoalveolar measurements before and after treatment are mentioned in, Table 2.
Skeletal measurements:There was a statistically significant decrease in the SNA$^{(o)}$ ($P > 0.05$), while the SNB$^{(o)}$ showed a significant statistical increase ($P \leq 0.05$), and the ANB$^{(o)}$ showed a significant statistical decrease ($P \leq 0.05$).
Dentoalveolar measurements:There was a significant statistical decrease in maxillary incisor angulation as represented by (Is-SN) angle ($P \leq 0.05$). On the other hand, the mandibular incisor angulation as represented by (IMPA) angle show significant increased.
Soft tissue measurements: In angular measurements, there was a significant increase in nasolabial angle ($P \leq 0.05$) while the soft tissue facial convexity measured by (G`-Sn-PG`) angle was significantly decreased ($P \leq 0.05$).

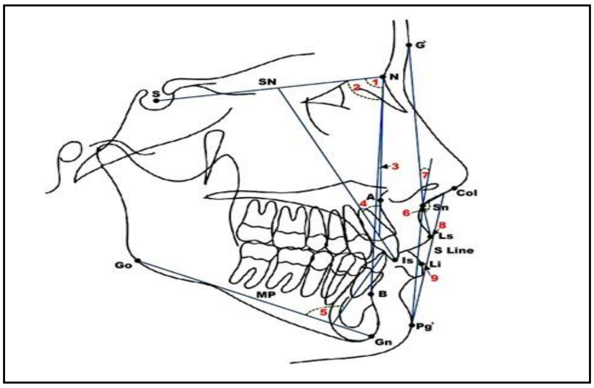

Figure 3: Cephalometric measurements: 1, SNA°; 2, SNB°; 3, ANB°; 4, Is-NA°; 5, IMPA°; 6, Nasolabial angle°; 7, G`-Sn-Pg`°; 8, Ls-S Line (mm); 9, Li-S Line (mm).

In linear measurements, there was a significant decrease in (Ls-S line) ($P \leq 0.05$), while the (Li-S line) significantly increased ($P \leq 0.05$).

Discussion:

Starting with the anteroposterior skeletal changes, results showed significant skeletal changes; significant reduction of the SNA angle by 0.6 degrees was noted. That decrease may be due to the functional appliances exerting upward and backward forces on the maxilla. This "headgear effect" was caused by tension in the facial muscles in an attempt to reposition the mandible back to its uppermost and posterior-most position. Given that the appliance contacts the upper arch, forces arising from the muscles and soft tissues were delivered by the appliance to the teeth and maxilla. This is in agreement with Siara-Olds et al.[9], Chiqueto et al.[10], and Aslan et al.[11]. In contrast, Pangrazio-Kulbersh et al.[12] evaluated the effects of the MARA and although the SNA values indicated maxillary retrusion, this change did not prove statistically significant compared to controls, despite a decrease the SNA by 0.4.

Asignificant increase in SNB due to the advancement of B point was observed. This could be due to direct orthopedic force to the bone that transmitted a forward and downward force vector to the condyle. The mandible in the forward position prompted tendons and muscle fibers to stretch and lengthen which in turn pulled on the muscular attachments at the surface of the bone and caused bone remodeling processes. This result is in agreement with Pangrazio-Kulbersh et al.[12] While these results were in disagreement with Siara-Olds et al.[9] who reported insignificant changes in SNB angle.

A significant decrease in ANB° angle by 1.4 degrees was observed, this change can be attributed to the reduction detected in SNA angle and increased SNB angle. This finding could be explained by posterior remodeling of the condyle. A similar finding of ANB decrease was found by Chiqueto et al.[10], Aslan et al.[11],

Pangrazio-Kulbersh et al.[12], and Al-Jewair et al.[13]. Regarding the anterior dental measurements, the results

Table 2: Changes in the cephalometric dental, skeletal and soft tissue measurement before and after treatment by MARA appliance

Measurements	Before treatment	After treatment	Difference	t-test	(P) value
	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)		
SNA(o)	82.7±2.6	82.1±2.6	0.6± 0.5	3.09	0.013*
SNB (o)	76.271±2.6	76.731±2.5	0.4 ± 0.1	11.5	<0.001*
ANB (o)	6.8±2.4	5.4±1.9	1.4± 0.5	8.83	<0.001*
Is-NA(o)	23.13±6.04	20.4±6.7	2.7 ± 0.9	9	<0.001*
IMPA(o)	95.1±8.4	96.5±8.3	1.4 ± 0.9	4.58	0.001*
Nasolabial angle	103.55±3.7	105.16±3.68	1.51 ± 0.58	4.15	0.001*
G_Sn-PG` (o)	23.97±3.66	23.39±3.73	0.68 ± 0.12	9.77	<0.001*
Ls-S line (mm)	1.64±0.47	0.92±0.53	0.72 ± 0.32	6.91	<0.001*
Li-S line (mm)	2.63±1.14	2.91±1.09	0.27 ± 0.08	10.02	<0.001*

incisors. These results were in agreement with Chiqueto et al.[10] and Al-Jewair et al.[13] who reported significant upper incisors retroclination, This may be explained by the backward movement of A point with a subsequent decrease in SNA angle.

Regarding the lower incisors, significantly less proclination was noted with an average of 1.4 degrees. This was in agreement with Aslan et al.[11] who reported limited proclination in Forsus with mini-screw. This labial tipping occurred because the fixed function appliance exerted forces of mesialization on mandibular incisors. In contrast, more proclination was obtained by Chiqueto et al.[10] who showed an increased in IMPA ° by 5 °. This shows that the use of mini-screw anchorage in the lower arch with MARA appliance was successful in minimizing the mandibular dentoalveolar side effects when compared to other Studies.

A significant increase in nasolabial angle was observed; this may be attributed to maxillary incisor retrusion which allowed soft tissue to move back. These treatment outcomes were in agreement with De Almeida et al.[14]

A significant decrease in the angle of facial convexity was noted, this might be due to the forward growth of the mandible. These results were in agreement with Siara-Olds et al.[9] Retrusion of the upper lip was also

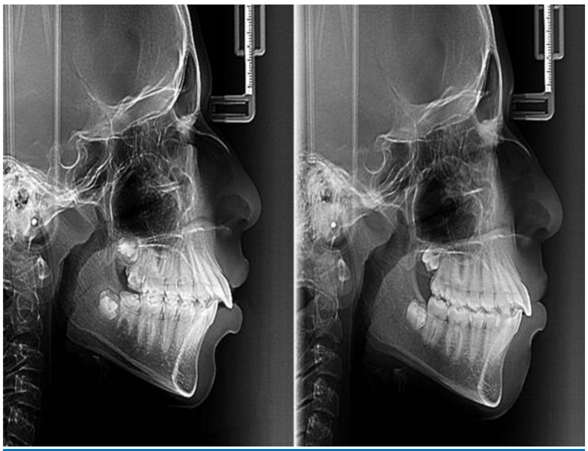

Figure 4: Lateral cephalometric x-rays of a patient before (left) and after (right) treatment

evident in relation to S- line. These results were in agreement with De Almeida et al.[14] Pancherz et al.[15] and Baysal et al.[16] who reported significant upper lip retrusion. This could be explained by the distalizing forces acting on the maxillary arch.

A significant lip Li-S line protrusion was observed, this might be due to the forward growth of the mandible which could affect the position of the soft tissue by forwarding it more anteriorly. This result was similar to Aslan et al.[11]

Figure 5: Extra-oral and Intra-oral photographs of a patient before (top) and after (bottom) treatment.

Conclusion:

This study showed that using a new treatment protocol of using MARA with mini-screw anchorage as a phase 1 treatment was successful in treating patients with Class II malocclusion. This protocol can be used with patients incompliant with removable functional appliance wear[5]. The results obtained were a combination of skeletal (significant headgear effect) and dentoalveolar effects (retroclination of maxillary incisors and less proclination of mandibular incisors) which enhanced the soft tissue profile, Figure 4 and Figure 5.

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