UNIVERSIDADE DE SÃO PAULO
FACULDADE DE ODONTOLOGIA DE BAURU

CAMILLA FIEDLER FONÇATTI

**Long-term stability of Class II division 1 treatment with the MARA
combined with fixed appliances**

**Avaliação da estabilidade em longo prazo da correção da Classe II
divisão 1 com aparelho MARA associado ao aparelho
ortodôntico fixo**

BAURU
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Tese constituída por artigos apresentada à Faculdade de Odontologia de Bauru da Universidade de São Paulo para obtenção do título de Doutor em Ciências no Programa de Ciências Odontológicas Aplicadas, na área de concentração Ortodontia.

Orientador: Prof.º Dr.º José Fernando Castanha Henriques.

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Martin Luther King

ABSTRACT

Long-term stability of Class II division 1 treatment with the MARA combined with fixed appliances.

Introduction: Successful treatment of class II Division 1 malocclusion is also implied to the long-term stability of treatment changes and many are the factors that can influence that. **Objective:** This research aimed to evaluate the long-term stability of the cephalometric changes obtained during Class II malocclusion correction with the MARA (Mandibular Anterior Repositioning Appliance) associated with fixed appliances. **Methods:** The treatment group comprised 12 patients who were evaluated at three stages: pretreatment (T1), posttreatment (T2) and long-term posttreatment (T3). The mean initial age of the patients was 12.35 years and the mean final age was 15.65 years. The mean age at the long-term posttreatment stage was 22.53 years and the mean long-term posttreatment period was 6.88 years. The control group comprised 12 subjects with normal occlusion and no orthodontic treatment with ages comparable to the treatment group at the posttreatment and long-term posttreatment stages. Intra-treatment group comparison between the three stages was performed with repeated measures analysis of variance (ANOVA), followed by Tukey tests. Intergroup comparison of posttreatment changes and normal growth changes of the treatment group were performed with t tests. **Results:** reduction of the maxillary protrusion and improvement of the maxillomandibular relationships remained stable during the long-term posttreatment period. Maxillary incisors inclination and overjet presented a tendency to relapse in relation to the control group **Conclusions:** Despite the different amount of growth potential, the reduction of the maxillary protrusion and maxillomandibular relationship improvement remained stable with no difference from normal occlusion behavior. Palatal inclination of the maxillary incisors and the overjet improvement showed a slight tendency towards relapse when compared to normal occlusion. Therefore, an increase of active retention time could be recommended to prevent that.

Key-words: Malocclusion, Angle Class II. Orthodontic Appliances, Functional. Orthodontics, Corrective. Relapse.

RESUMO

Avaliação da estabilidade em longo prazo da correção da Classe II divisão 1 com aparelho MARA associado ao aparelho ortodôntico fixo.

Introdução: o tratamento bem-sucedido da má oclusão de classe II Divisão 1 está implícito na estabilidade em longo prazo das correções e muitos são os fatores que podem influenciar esta estabilidade. **Objetivos:** observando que a terapia com o aparelho MARA (Mandibular Anterior Repositioning Appliance) associado ao aparelho ortodôntico fixo mostrou-se eficaz na correção da Classe II, este trabalho estabeleceu como objetivo avaliar cefalometricamente a estabilidade em longo prazo das correções obtidas durante este tratamento. **Materiais e métodos:** foram analisadas as alterações durante e após o tratamento através das telerradiografias em norma lateral de 12 pacientes (09 meninos e 03 meninas) nas fases: inicial (T1), final (T2) e pós-tratamento (T3), com idade média inicial de 12,35 anos e 15,65 anos ao final do tratamento. A idade média no estágio de pós tratamento em longo prazo foi de 22,53 e o tempo de acompanhamento pós tratamento foi em média 6,88 anos. As alterações foram comparadas a um Grupo Controle com oclusão normal, não tratados ortodonticamente, com idades compatíveis ao grupo experimental nos estágios final e pós tratamento em longo prazo. Os dados obtidos foram analisados através da análise de variância (ANOVA) para medidas repetidas e o teste de comparações múltiplas de Tukey. As alterações ocorridas no período de pós-tratamento foram comparadas com as alterações do Grupo Controle durante o período correspondente utilizando o teste *t* independente. **Resultados:** Observou-se uma redução da protrusão maxilar, assim como, uma melhora das relações maxilomandibulares, as quais, permaneceram estáveis durante o período de pós-tratamento. A inclinação dos incisivos superiores e o overjet apresentaram tendência à recidiva em relação ao grupo controle. **Conclusões:** A redução da protrusão maxilar e melhora da relação maxilomandibular mantiveram-se estáveis, sem diferença estatisticamente significativa do comportamento na oclusão normal. A retroinclinação dos incisivos superiores e a melhora do overjet mostraram uma ligeira tendência à recidiva quando comparada ao comportamento da oclusão normal. Portanto, um aumento do tempo de retenção ativo pode ser recomendado para evitar essa recidiva.

Palavras chave: Má oclusão de Angle Classe II. Aparelhos ortodônticos Funcionais. Ortodontia Corretiva. Recidiva.

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1 INTRODUCTION

1 INTRODUCTION

Proposed by Angle in 1899 (ANGLE, 1899), the classification of malocclusions, is still the most used in Orthodontics today. Simple and objective, the classification made the communication and standardization among professionals easier. According to the author, the first upper molar was always fixed on the craniofacial complex, while the lower first molars could be well positioned, in a Class I relationship, more anteriorly positioned featuring a Class III or more distalized resulting in a Class II relationship.

When the lower teeth are distalized compared to their normal position, accompanied by a marked disharmony of the facial lines and proclined upper incisors, it is called a Class II Division 1 malocclusion. In such cases, in addition to the dental component, it is also observed a mandibular retrusion, with its effective length reduced. On the other hand, the maxilla is generally protruded and atresic. Besides, modified function of the lips, some nasal obstruction and mouth breathing are also commonly observed (ANGLE, 1907).

Most recent studies corroborated with Angle findings (OPPENHEIM, 1928; NELSON; HIGLEY, 1948; CRAIG, 1951; MCNAMARA, 1981; KARLSEN, 1994; URSI; MC NAMARA JR, 1997; HENRIQUES et al., 1998), observing a retruded and smaller jaw, and a normal, well placed or with slight retrusion maxilla. In addition to the maxillomandibular and apical bases relationships, it is also highlighted the prevalence of a vertical facial pattern and a proclination of the upper and lower incisors, the upper incisors are usually normally placed, while the lower are protruded (FREITAS et al., 2005).

Therefore, based on the literature accessed, it was observed that Class II, Division 1 is a complex malocclusion, with skeletal, dentoalveolar or by the association of both source, that won't self-correct and implies a significant aesthetic commitment, which result in a great demand of these patients to search for orthodontic treatment. Approximately one third of patients seeking orthodontic treatment presents Class II, division 1 malocclusion, caused by various combinations of dental and skeletal factors (PROFFIT; FIELDS; MORAY, 1998). A successful

treatment comes from a careful investigation of these factors, resulting, in cases of growing patients, on the need of an association of orthodontic and orthopedic approaches (SARI et al., 2003).

The term "functional appliance" is used to describe a range of devices, usually removable, that aim to rearrange the muscles responsible for the function and positioning of the jaw in order to transmit forces to the dentofacial complex, which generate orthodontic and orthopedic movement. Functional appliances can be used to correct any form of malocclusion, but are more effective on Class II correction, especially in cases with mandibular retrognathism (BISHARA; ZIAJA, 1989).

The characteristics of Class II malocclusion in deciduous dentition remain during the growing period and may even be aggravated through time (BISHARA et al., 1997; NGAN; BYCZEK; SCHEICK, 1997; ALARASHI et al., 2003) that allows an early diagnosis and intervention. This conduct has several advantages, such as solve the patient's aesthetic complaint in advance, preventing bullying and psychological trauma (URSI; MC NAMARA JR, 1997; GURGEL; ALMEIDA; PINZAN, 2000; MIGUEL et al., 2005) and prevent against possible trauma to the anterior dentition, since these elements are most susceptible due to its excessive labial tipping (BISHARA et al., 1997; MIGUEL et al., 2005). Another indication of this approach is the elimination of harmful habits, like digital and pacifier suction, and lingual interposition (BISHARA; ZIAJA, 1989).

Functional appliances were developed as a way to intervene early, preventing the development of the factors that perpetuate and trigger the Class II malocclusion. Its mechanism of action is given by the restriction and redirection of the previous growth of the jaws and the speed of mandibular growth. Consequently, changes in the perioral tissues and muscles, which contribute to perpetuate this malocclusion, can be eliminated or minimized (BASS, 1983; YOKOTA; MURAKAMI; SHIMIZU, 1993; RONDEAU, 1994).

Many articles describe the efficiency of functional devices in Class II correction through mandibular growth stimulus. It is believed that the main factors responsible for this increase are condylar growth, due to condylar remodeling, anterior repositioning of the glenoid fossa due to its remodeling and, consequently, anterior repositioning of the condyle in the fossa. Condylar growth, detected through the

positioning of point Co, showed an upper and posterior direction, with a larger sagittal than vertical component, accompanied by an anterior and lower repositioning of the glenoid fossa (PANCHERZ; FISCHER, 2003; VOUDOURIS et al., 2003). Therefore, the intervention must start when it is the most effective and during the most effective period (PROFFIT; TULLOCH, 2002). To enhance the orthopedic effect, some authors recommend early intervention, during the late mixed dentition stage (BISHARA; ZIAJA, 1989), near or during the peak of growth.

Functional appliances vary greatly in terms of patient's adaptation. An ideal functional unit should be comfortable, allow freedom of mandibular movements, have comfortable space for the tongue, promote more skeletal than dental changes and should not hinder breath so that its use is appropriate for patients with mouth breathing or nasal obstruction (SARI et al., 2003).

Longitudinal follow up of young people who do not have suffered any kind of orthodontic intervention, noticed that the dentofacial growth in young people with Class II, Division 1 is similar to that presented by young people with normal occlusion after the pubertal growth. Thus, it can be concluded that the maxillomandibular discrepancy found in the final stage of puberty, will suffer no more significant changes (BACCETTI; STAHL; MCNAMARA JR, 2009).

Clinicians should be familiar with different devices in order to accomplish this choice individually for each patient, aware of the advantages and limitations that each intervention will have, as well as its long-term outcomes. Observing the lack of studies aiming to confirm the long-term stability of the effectiveness of the appliance MARA in the correction of Class II Division 1 malocclusion, it was established as the objective of the following articles to evaluate the long-term behavior of the skeletal and dental changes produces by this therapy.

2 ARTICLES

2 ARTICLES

The articles presented in this Thesis were written according to the American Journal of Orthodontics and Dentofacial Orthopedics instructions and guidelines for article submission (Annex B).

- **Article 1** - Long-term stability of the skeletal changes induced by the MARA appliance.
- **Article 2** - Long-term stability of the dental changes induced by the MARA appliance

ARTICLE 1

LONG-TERM STABILITY OF THE SKELETAL CHANGES INDUCED BY THE MARA APPLIANCE

ABSTRACT

Introduction: The efficiency of functional devices in Class II correction through mandibular repositioning is widely studied in literature and has shown excellent results when used in growing patients. **Objective:** This research aimed to evaluate the long-term stability of the skeletal changes obtained during Class II malocclusion correction with the MARA (Mandibular Anterior Repositioning Appliance) associated with fixed appliances. **Methods:** The treatment group comprised 12 patients who were evaluated at three stages: pretreatment (T1), posttreatment (T2) and long-term posttreatment (T3). The mean initial age of the patients was 12.35 years and the mean final age was 15.65 years. The mean age at the long-term posttreatment stage was 22.53 years and the mean long-term posttreatment period was 6.88 years. The control group comprised 12 subjects with normal occlusion and an initial mean age of 15.08 years and final mean age of 22.47 years comparable to the treatment group at the posttreatment and long-term posttreatment stages. Intra-treatment group comparison between the three stages was performed with repeated measures analysis of variance (ANOVA), followed by Tukey tests. Intergroup comparison of posttreatment changes and normal growth changes of the treatment group were performed with t tests. **Results:** Reduction of the maxillary protrusion and improvement of the maxillomandibular relationships remained stable during the long-term posttreatment period. **Conclusions:** Despite the different amount of growth potential, the reduction of the maxillary protrusion and maxillomandibular relationship improvement remained stable with no difference from normal occlusion behavior.

INTRODUCTION

Functional orthopedic appliances consist of a variety of fixed or removable devices designed to modify the sagittal and vertical position of the jaw, resulting in dental and skeletal changes.¹ Despite its historic and everyday use among

Orthodontists,² there are still many controversies as to its use, effects and effectiveness. One of the major causes attributed to failure of therapy with functional orthopedic appliances is the lack of patient cooperation on the use of the appliance, as well as the difficulty in controlling the amount and direction of the mandibular growth.²⁻⁴ Aiming to supply these deficiencies, the appliance MARA (Mandibular Anterior Repositioning Appliance) was developed, which promotes the correction of Class II through the anterior repositioning of the jaw into a normal molar relationship.

Developed by Eckhart and Toll in 1998, the MARA appliance, was given less attention in the literature^{2,5-7} despite the growing interest on functional devices that don't rely on patients cooperation.⁸⁻¹¹ MARA appliance can be an alternative to the Herbst appliance, with the great advantage of treating the Class II malocclusion associated with fixed appliances,^{2,7} which represents a decrease in treatment time and, furthermore, it has the differential that there is no connection between the upper and lower arches, resulting in an increase of freedom of mandibular movement.⁷

Seeking to correct the anteroposterior discrepancy of Class II malocclusion, MARA promotes an anterior and inferior displacement of the condyles, resulting in a remodeling of the temporomandibular joint.¹² Many studies have sought to evaluate the efficiency of MARA in mandibular growth stimulus, however contradictory results are found in the literature,^{2,5,6} some find a significant dimensional change, while others did not observe significant differences when compared to control groups with untreated class II malocclusion.^{6,13}

Growth occurs at different rates and in different directions of space. The high variability of growth was demonstrated by Björk, in 1968. Anthropometric studies of Craniofacial dimensions demonstrated that significant changes occur in humans, even during adulthood. However, late growth changes can be responsible for relapse, especially after correction of malocclusions.¹⁴

Orthopedic treatment of Class II, Division 1 may result in the interruption of the growth pattern both during treatment and after the completion of the orthodontic treatment. Patients treated with removable orthopedic appliances, may present more vertical pattern of the mandibular growth during treatment when compared to growth presented in untreated patients. On the other hand, the direction of post-treatment growth tends to be more horizontal than during treatment.¹⁵

Observational studies have demonstrated long-term stability of the anteroposterior position of the maxilla and mandible after Class II discrepancy

treatment. However, a slight relapse of maxilomandibular relationship correction has been reported, probably because the maxilla resumes its normal development and there is smaller mandibular growth rate.¹⁶

Successful treatment of class II Division 1 malocclusion is also implied to the long-term stability of treatment changes and many are the factors that can influence that. Noticing the lack of long-term investigations with this therapy, this study aimed to cephalometrically assess, after a minimum of five years, the long-term stability of the skeletal changes obtained in the correction of Class II, division 1 malocclusion with the MARA associated with fixed orthodontic appliances.

MATERIAL AND METHODS

This study was approved by the Ethics in Research Committee of Bauru Dental School – University of São Paulo, and all subjects signed informed consent.

The sample size was calculated based on an alpha significance level of 0.05 and a beta of 0.2 to detect a mean difference of 0.5° with a standard deviation of 0.5° in ANB angle change between the posttreatment and long-term posttreatment stages.¹⁷ The sample size calculation showed that 12 patients were needed for the treatment group.

Therefore, 36 lateral cephalometric headfilms of 12 Class II division 1 malocclusion patients (09 male; 03 female) who were treated with the MARA combined with fixed appliances, were retrospectively selected from the files of the Orthodontic Department at Bauru Dental School – University of São Paulo.

The sample was selected according to the following inclusion criteria: at least symmetric, half-cusp bilateral Class II molar relationship; absence of agenesis, supernumerary or lost teeth; convex profile; mandibular retrognathism; mandibular arch with slight or no crowding; and without history of previous orthodontic treatment.¹⁸ No cephalometric characteristic was considered as inclusion criteria. All patients were treated without extractions for a mean period of 3.30 years (S.D. = 0.66, range 2.07-4.05 years). The mean initial age of the patients was 12.35 years (S.D. = 1.31, range 10.79-14.99 years) and the mean final age was 15.65 years (S.D. = 1.08, range 13.99-17.59 years). The mean age at the long-term posttreatment stage was 22.53 years (S.D. = 1.57, range 20.53-25.43 years). The mean long-term posttreatment period was 6.88 years (S.D. = 0.87, range 5.90-8.51 years).

All patients were treated by the same clinician and the treatment protocol consisted of installation of the MARA appliance, a transpalatal arch and a lingual arch. Which were maintained until the correction of the Class II with overcorrection of at least a quarter-cusp bilateral Class III. After that relation was obtained, the appliance remained as active retention for 6 months. The mean time of the MARA use was 0.73 year (SD, 0.15; range, 0.47-0.96 year). After Class II anteroposterior correction and removal of the MARA, the fixed orthodontics appliance, Roth .022x.028" prescription was installed and lasted a mean time of 2.24 year (SD, 0.70; range, 0.89-2.99 years). During the orthodontic phase, Class II intermaxillary elastics were frequently used as active retention. After comprehensive treatment, each patient was given a fixed mandibular canine to canine retainer, used for a minimum period of five years or until the end of growth, and a Hawley plate for daily use during one year.

The control group comprised 12 subjects (03 girls, 09 boys) with normal occlusion and an initial mean age of 15.08 years (S.D. = 1.17, range 13.9-17.0 years) and final mean age of 22.47 years (S.D. = 3.46, range 18.0-26.9 years) comparable to the treatment group at the posttreatment and long-term posttreatment stages. This group was selected from the longitudinal growth study sample of the "Iowa Facial Growth Study" (Department of Orthodontics, College of Dentistry, University of Iowa, USA) obtained from the online American Association of Orthodontists Foundation (AAOF) Craniofacial Growth Legacy Collection.¹⁹

Three lateral headfilms were obtained of each patient in the following stages of orthodontic treatment: T1 (pretreatment), T2 (posttreatment, when the multibracket appliances were removed) and T3 (long-term posttreatment). For the control group two lateral headfilms were selected from each patient matching the ages of the experimental group at T2 and T3. The headfilms were digitized (MICROTEK ScanMaker, model i800), traced and analyzed with Dolphin Imaging 11.5 (Patterson Dental Supply, Inc., Chatsworth, CA). The software corrected the image magnification factors because the lateral headfilms were obtained from different x-ray machines. A customized cephalometric analysis generated 11 variables, 5 angular and 6 linear, for each tracing (Table I).

ERROR STUDY

Twenty lateral headfilms were randomly selected, redigitized, retraced and remeasured by the same examiner (C.F.F.), after a 30-day interval. Random errors were calculated according to Dahlberg's formula ($Se^2 = \sum d^2/2n$),²⁰ and the systematic errors were evaluated with dependent *t* tests, at $P < 0.05$.²¹

STATISTICAL ANALYSES

Normal distribution was evaluated with Kolmogorov-Smirnov tests and all variables showed normal distribution.

Intergroup comparability regarding ages at T2 and T3 and regarding the posttreatment and observational periods of the treatment and control groups, respectively, were performed with *t* tests. Intergroup sex distribution was the same since both groups have the same number of male and female.

Repeated measures analysis of variance (ANOVA), followed by Tukey tests were used for intragroup comparison of the treatment group at the three stages. To compare the changes during the posttreatment period (T3 – T2) in the treatment group with the changes during a comparable period for the control group, *t* tests were used.

The statistical tests were performed with Statistica software (Statistica for Windows 6.0; Statsoft, Tulsa, OK). Results were considered statistically significant at $P < 0.05$.

RESULTS

Only one variable showed random errors greater than 1.0 mm or 1.5° (Pg-NPerp) and none of the 11 evaluated variables showed statistically significant systematic errors.

The groups were comparable regarding the ages at the posttreatment and long-term posttreatment stages, posttreatment period and sex distribution (Tables II).

Observing the skeletal component, treatment produced a significant reduction of the maxillary protrusion, which remained stable at the posttreatment stage, despite the significant increase in the effective maxillary length during treatment and long-term posttreatment periods; (Table III; Fig. 1 and 2). During the posttreatment period there was significant mandibular protrusion while the effective mandibular length increased during treatment. During treatment, there was significant improvement in

the maxillomandibular relationship, which remained stable after treatment with no significant changes in the posttreatment period. The facial pattern angles remained stable with treatment but significantly decreased in the long-term posttreatment period, while the anterior facial height showed a significant increase during treatment.

Intergroup comparison of the posttreatment changes with normal growth changes showed that the increase in maxillary and mandibular effective length were significantly higher on the control group, than the treatment group, as well as the anterior facial height (Table IV).

DISCUSSION

Maxillary component

The MARA appliance produced considerable skeletal effects that remained stable during the posttreatment period, such as reduction of the maxillary protrusion (Table III; Fig. 1 and 2). Described as the “headgear” effect, the restriction of the maxillary anterior displacement, was observed in several MARA studies,^{2,6,7,13,22} this treatment outcome tend to remain stable in the posttreatment period after Class II malocclusion correction^{16,23} and therefore, is not associated with the possibility of the discrepancy relapse.²⁴ In the present study, the patients were observed during growth, consequently, the maxillary effective length presented a significant increase during treatment, while, during the posttreatment stage the increase was not statistically significant. Then, when comparing with normal occlusion, the changes presented by the experimental group were significantly smaller than the development shown by the normal occlusion group used in this study, showing a probably latter and higher growth potential by this group during this age (Table IV).

Mandibular component

The beneficial effect of mandibular protrusion advancement, reported with other functional appliances, like Herbst,^{22,25} was not observed with MARA therapy. Treatment produced a slight but not significant mandibular protrusion (Table III; Fig. 1 and 2), that is probably more associated with normal growth and development, than with therapy skeletal stimulation effect, similar treatment findings were previously observed.¹³ Since all patients were treated prior or during the growth peak, the mandibular protrusion and effective length not only remained stable during the

posttreatment period but also continue to increase (Table III; Fig. 1 and 2), in agreement with prior reports.^{7,22} This outcome had similar behavior to the changes presented by the control group during the comparable period (Table IV), however, as discussed before, for the maxillary effective length, the mandibular effective length also presented a significant greater increase on the control group, probably due to different potential of growth during the observational period. A significantly smaller rate than normal growth has also been described for Class II patients before,²⁶⁻²⁸ and still, despite the different amount of mandibular growth the amount of mandibular protrusion was similar to normal changes in the posttreatment period (Table IV).

Maxillomandibular Relationship

Due to the skeletal beneficial effects of the MARA therapy, a significant improvement of the maxillomandibular relationship was observed during treatment (Table III; Fig. 1 and 2), in agreement with several studies.^{2,7} During the posttreatment period, that relation presented a slight tendency to relapse with no statistical significance. However, that behavior was similar to normal growth changes (Table IV).

Vertical component

No significant changes were observed on the facial pattern angles with treatment (Table III; Fig. 1 and 2). Meanwhile, these angles experienced a significant reduction during the posttreatment period (Table IV), reflecting a counterclockwise rotation of the mandible that is a normal characteristic of growth and development.^{24,29-31}

As commonly observed after functional appliances therapy,^{10,24,29,32-35} the anterior facial height presented a significant increase during treatment that remained stable during the subsequent period (Table III; Fig. 1 and 2). Treatment group also had a significant smaller increase of the anterior facial height during the follow-up period probably due to the different amount of growth presented by the control group, as discussed before (Table IV) and this is usually expected with some dentoskeletal structures in response to treatment. The posttreatment changes are usually smaller than normal when there has been significant changes with treatment.³⁶⁻³⁸

CONCLUSIONS

- The reduction of the maxillary protrusion obtained with treatment remained stable at the posttreatment stage, despite the significant increase of the effective maxillary length.
 - The significant improvement of the maxillomandibular relationship, remained stable after treatment with no difference from normal occlusion behavior.
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FIGURE LEGENDS

Fig. 1. Mean tracings of the treatment group generated by Dolphin Imaging 11.5 software superimposed on Sella-Nasion at Sella. The pretreatment tracing is black, the posttreatment, red and the long-term posttreatment, green.

Fig. 2. Mean tracings of the treatment group generated by Dolphin Imaging 11.5 software. (A) superimposition on the palatal plane, centered at the anterior nasal spine. (B) Superimposition on the mandibular plane, centered at the symphysis. black, pretreatment; red, posttreatment; green, long-term posttreatment.

Fig. 1

Fig. 2

Table I. Skeletal cephalometric variables.

Skeletal cephalometric variables	
<i>Maxillary componente</i>	
SNA (°)	SN to NA angle
A-NPerp (mm)	A-point to nasion-perpendicular
Co-A (mm)	Condylion to A-point distance
<i>Mandibular componente</i>	
SNB (°)	SN to NB angle
Pg-NPerp (mm)	Pg-point to nasion-perpendicular
Co-Gn (mm)	Condylion to gnathion distance
<i>Maxillomandibular relationship</i>	
ANB (°)	NA to NB angle
Wits (mm)	Distance between perpendicular projections of Points A and B on functional occlusal plane
<i>Vertical component</i>	
FMA (°)	Frankfort mandibular plane angle
SNGoGn (°)	SN to GoGn angle
LAFH (mm)	Distance from ANS to menton

Table II. Intergroup comparability regarding the ages at T1, T2 and T3, the treatment and long-term posttreatment periods and sex distribution (t test)

	<u>TREATMENT</u> <u>GROUP</u> n = 12		<u>CONTROL</u> <u>GROUP</u> N = 12		
Stage/Period	Mean	SD	Mean	SD	P
T1 age (y)	12.35	1.31	-----	-----	-----
T2 age (y)	15.65	1.08	15.08	1.17	0.225
T3 age (y)	22.53	1.57	22.47	3.46	0.957
Treatment period (T2-T1) (y)	3.30	0.66	-----	-----	-----
Posttreatment period (T3-T2) (y)	6.88	0.87	7.39	3.73	0.645
Sex	Male	Female	Male	Female	
	09 (75%)	03 (25%)	09 (75%)	03 (25%)	

Table III. Intra-treatment group comparison of the cephalometric variables at the three stages (repeated measures ANOVA followed by Tukey tests)

	Pretreatment (T1)		Posttreatment (T2)		Long-term posttreatment (T3)		
Variable	Mean	SD	Mean	SD	Mean	SD	P
Maxillary componente							
SNA	82.3 ^A	4.9	80.4 ^B	4.4	80.8 ^B	3.7	0.003*
A-NPerp	4.1 ^A	4.8	2.5 ^B	5.3	3.3 ^{AB}	4.9	0.015*
Co-A	83.5 ^A	3.7	85.8 ^B	3.7	87.2 ^B	3.1	0.000*
Mandibular component							
SNB	76.6 ^A	4.3	77.1 ^{AB}	4.4	78.1 ^B	4.4	0.020*
Pg-NPerp	-1.0 ^A	6.4	0.7 ^A	8.6	3.4 ^B	8.8	0.001*
Co-Gn	107.9 ^A	4.9	116.6 ^B	5.2	119.2 ^B	6.0	0.000*
Maxillomandibular relationships							
ANB	5.7 ^A	1.8	3.3 ^B	1.7	2.7 ^B	2.1	0.000*
Wits	4.6 ^A	2.8	1.4 ^B	1.6	0.7 ^B	2.2	0.000*
Vertical component							
FMA	21.8 ^A	4.8	22.0 ^A	5.6	18.5 ^B	5.8	0.000*
SN.GoGn	31.5 ^A	5.7	31.7 ^A	6.7	28.4 ^B	6.4	0.000*
LAFH	61.7 ^A	4.6	66.4 ^B	4.3	66.6 ^B	4.6	0.000*

*Statistically significant at $P<0.05$.

Table IV. Intergroup comparison of the long-term posttreatment changes and normal growth changes (t tests)

	Treatment Group		Control Group		
Variable	Mean	SD	Mean	SD	p
Maxillary componente					
SNA	0.38	1.47	-0.03	1.03	0.437
A-NPerp	0.76	1.65	0.03	1.25	0.232
Co-A	1.36	2.21	4.86	3.79	0.011*
Mandibular component					
SNB	1.03	0.79	0.57	1.10	0.254
Pg-NPerp	2.72	2.08	2.18	3.91	0.675
Co-Gn	2.59	1.96	8.48	6.76	0.008*
Maxillomandibular relationships					
ANB	-0.63	1.31	-0.55	1.13	0.868
Wits	-0.70	1.79	-0.88	1.47	0.795
Vertical componente					
FMA	-3.46	2.63	-1.41	1.80	0.036*
SN.GoGn	-3.33	2.42	-1.59	1.87	0.062
LAFH	0.13	1.26	4.17	3.81	0.002*

*Statistically significant at $P<0.05$.

ARTICLE 2

LONG-TERM STABILITY OF THE DENTAL CHANGES INDUCED BY THE MARA APPLIANCE

ABSTRACT

Introduction: Treatment of Class II division 1 malocclusion with orthopedic devices combined with fixed orthodontic appliances has shown excellent results when used in growing patients. **Objective:** This research aimed to evaluate the long-term stability of the dental changes obtained during Class II malocclusion correction with the MARA (Mandibular Anterior Repositioning Appliance) associated with fixed appliances. **Methods:** The treatment group comprised 12 patients who were evaluated at three stages: pretreatment (T1), posttreatment (T2) and long-term posttreatment (T3). The mean initial age of the patients was 12.35 years and the mean final age was 15.65 years. The mean age at the long-term posttreatment stage was 22.53 years and the mean long-term posttreatment period was 6.88 years. The control group comprised 12 subjects with normal occlusion and an initial mean age of 15.08 years and final mean age of 22.47 years comparable to the treatment group at the posttreatment and long-term posttreatment stages. Intra-treatment group comparison between the three stages was performed with repeated measures analysis of variance (ANOVA), followed by Tukey tests. Intergroup comparison of posttreatment changes and normal growth changes of the treatment group were performed with t tests. **Results:** Maxillary incisors inclination and overjet presented a tendency to relapse in relation to the control group. Mandibular incisors showed no alterations during treatment and posttreatment periods **Conclusions:** Palatal inclination of the maxillary incisors and the overjet improvement showed a slight tendency towards relapse when compared to normal occlusion. Therefore, an increase of active retention time could be recommended to prevent that.

INTRODUCTION

Developed by Eckhart and Toll in 1998, the MARA (Mandibular Anterior Repositioning Appliance), is a functional device that corrects the Class II discrepancy towards the repositioning the mandible. This appliance was given less attention in the

literature,¹⁻⁴ despite the growing interest on functional devices that don't rely on patients cooperation.⁵⁻⁸ MARA appliance can be an alternative to the Herbst appliance, with the great advantage of treating the Class II malocclusion associated with fixed appliances,^{2,4} which represents a decrease in treatment time and, furthermore, it has the differential that there is no connection between the upper and lower arches, resulting in an increase of freedom of mandibular movement.⁴

Few dental side effects are observed in the treatment with the MARA device, like the proclination of lower incisors,¹ distal movement of the upper molars and mesial movement of lower molars.²

Orthodontic correction is considered to be stable when the teeth are aligned and in a normal occlusion, receiving adequate retainer and a vigorous masticatory function.⁹ However, orthodontists have observed that treatment outcomes are susceptible to changes, at least similar, to changes presented by normal occlusion, and that there is certainly limitations on long-term stability of corrections.¹⁰

Correction of a class II into a normal molar relationship can have a beneficial effect on growth, promoting the maintenance of the molar relationship. In addition, the overcorrection of occlusal relationship as a finalization procedure has been recommended to control the relapse of the Class II.¹¹⁻¹³

In the current literature there are studies that observed the effectiveness of the appliance MARA, without the use of control group,¹ with untreated control group but with no posttreatment follow-up^{2,3} or using an short observational period.⁴ The long-term stability of treatment with the MARA still needs proof. Noticing that, this study aimed to cephalometrically assess, after a minimum of five years, the long-term stability of the dental changes obtained in the correction of Class II, division 1 malocclusion with the MARA associated with fixed orthodontic appliances.

MATERIAL AND METHODS

This study was approved by the Ethics in Research Committee of Bauru Dental School – University of São Paulo, and all subjects signed informed consent.

The sample size was calculated based on an alpha significance level of 0.05 and a beta of 0.2 to detect a mean difference of 0.5° with a standard deviation of 0.5° in ANB angle change between the posttreatment and long-term posttreatment stages.¹⁴ The sample size calculation showed that 12 patients were needed for the treatment group.

Therefore, 36 lateral cephalometric headfilms of 12 Class II division 1 malocclusion patients (09 male; 03 female) who were treated with the MARA combined with fixed appliances, were retrospectively selected from the files of the Orthodontic Department at Bauru Dental School – University of São Paulo.

The sample was selected according to the following inclusion criteria: at least symmetric, half-cusp bilateral Class II molar relationship; absence of agenesis, supernumerary or lost teeth; convex profile; mandibular retrognathism; mandibular arch with slight or no crowding; and without history of previous orthodontic treatment.¹⁵ No cephalometric characteristic was considered as inclusion criteria. All patients were treated without extractions for a mean period of 3.30 years (S.D. = 0.66, range 2.07-4.05 years). The mean initial age of the patients was 12.35 years (S.D. = 1.31, range 10.79-14.99 years) and the mean final age was 15.65 years (S.D. = 1.08, range 13.99-17.59 years). The mean age at the long-term posttreatment stage was 22.53 years (S.D. = 1.57, range 20.53-25.43 years). The mean long-term posttreatment period was 6.88 years (S.D. = 0.87, range 5.90-8.51 years).

All patients were treated by the same clinician and the treatment protocol consisted of installation of the MARA appliance, a transpalatal arch and a lingual arch. Which were maintained until the correction of the Class II with overcorrection of at least a quarter-cusp bilateral Class III. After that relation was obtained, the appliance remained as active retention for 6 months. The mean time of the MARA use was 0.73 year (SD, 0.15; range, 0.47-0.96 year). After Class II anteroposterior correction and removal of the MARA, the fixed orthodontics appliance, Roth .022x.028" prescription was installed and lasted a mean time of 2.24 year (SD, 0.70; range, 0.89-2.99 years). During the orthodontic phase, Class II intermaxillary elastics were frequently used as active retention. After comprehensive treatment, each patient was given a fixed mandibular canine to canine retainer, used for a minimum period of five years or until the end of growth, and a Hawley plate for daily use during one year.

The control group comprised 12 subjects (03 girls, 09 boys) with normal occlusion and an initial mean age of 15.08 years (S.D. = 1.17, range 13.9-17.0 years) and final mean age of 22.47 years (S.D. = 3.46, range 18.0-26.9 years) comparable to the treatment group at the posttreatment and long-term posttreatment stages. This group was selected from the longitudinal growth study sample of the "Iowa Facial Growth Study" (Department of Orthodontics, College of Dentistry, University of Iowa,

USA) obtained from the online American Association of Orthodontists Foundation (AAOF) Craniofacial Growth Legacy Collection.¹⁶

Three lateral headfilms were obtained of each patient in the following stages of orthodontic treatment: T1 (pretreatment), T2 (posttreatment, when the multibracket appliances were removed) and T3 (long-term posttreatment). For the control group two lateral headfilms were selected from each patient matching the ages of the experimental group at T2 and T3. The headfilms were digitized (MICROTEK ScanMaker, model i800), traced and analyzed with Dolphin Imaging 11.5 (Patterson Dental Supply, Inc., Chatsworth, CA). The software corrected the image magnification factors because the lateral headfilms were obtained from different x-ray machines. A customized cephalometric analysis generated 13 variables (2 angular and 11 linear) for each tracing (Table I; Fig. 1).

ERROR STUDY

Twenty lateral headfilms were randomly selected, redigitized, retraced and remeasured by the same examiner (C.F.F.), after a 30-day interval. Random errors were calculated according to Dahlberg's formula ($Se^2 = \sum d^2/2n$),¹⁷ and the systematic errors were evaluated with dependent *t* tests, at $P < 0.05$.¹⁸

STATISTICAL ANALYSES

Normal distribution was evaluated with Kolmogorov-Smirnov tests and all variables showed normal distribution.

Intergroup comparability regarding ages at T2 and T3 and regarding the posttreatment and observational periods of the treatment and control groups, respectively, were performed with *t* tests. Intergroup sex distribution was the same since both groups have the same number of male and female.

Repeated measures analysis of variance (ANOVA), followed by Tukey tests were used for intragroup comparison of the treatment group at the three stages. To compare the changes during the posttreatment period (T3 – T2) in the treatment group with the changes during a comparable period for the control group, *t* tests were used.

The statistical tests were performed with Statistica software (Statistica for Windows 6.0; Statsoft, Tulsa, OK). Results were considered statistically significant at $P < 0.05$.

RESULTS

Only one variable showed random errors greater than 1.0 mm or 1.5° (Mx6-APerp) and none of the 13 evaluated variables showed statistically significant systematic errors.

The groups were comparable regarding the ages at the posttreatment and long-term posttreatment stages, posttreatment period and sex distribution (Tables II).

Assessing the dentoalveolar changes, the maxillary incisors presented palatal inclination and extrusion with treatment that remained stable during the posttreatment period (Table III; Fig. 2 and 3). While the maxillary molars had significant mesialization during both periods and extrusion during treatment. The mandibular incisors presented no significant changes during treatment and posttreatment stages, and the mandibular molar dentoalveolar height significant increased during both periods. Treatment also produced significant improvement of the dentoalveolar relationships, overjet, overbite and molar relationship, which remained stable at the posttreatment stage.

Intergroup comparison of the posttreatment changes with normal growth changes showed that the maxillary incisors and molars presented significant higher extrusion on the control group than the treatment group during the posttreatment period, and the maxillary molars showed significant more mesialization than the control group. The mandibular incisors presented a slight protrusion on the treatment group while the control group presented a retrusion. Control group had significantly greater mesial displacement of the mandibular molars than the treatment group. The mandibular incisors and molars also showed a significant higher dentoalveolar height increase on the control group than treatment group during the posttreatment stage. The overjet presented an opposite behavior, with tendency to increase in the treatment group and to decrease in the control group, but with no statistical significance (Table IV).

DISCUSSION

Maxillary Dentoalveolar component

As many functional devices, the MARA appliance successfully corrects the Class II malocclusion through skeletal and dentoalveolar changes.^{2,3,19} Observing the

effects of this therapy on the maxilla, a significant palatal inclination and extrusion of the incisors was found, and the incisors inclination showed a slight tendency to relapse but with no statistical significance on the posttreatment period (Table III; Fig. 2 and 3). This tendency of labial inclination goes in opposite direction of the normal occlusion (Table IV), and can be a sign that over time this relapse may become significant. Since it is generally agreed that teeth tend to return to its former position after ceasing treatment,²⁰ more active retention time could be increased to prevent that relapse. This is also reported with other similar devices.²¹

Assessing the sagittal position of the maxillary molars, a significant forward displacement was observed during both periods in the treatment group (Table III; Fig. 2 and 3). This movement occurred possibly after the removal of the MARA, during the use of multibracket appliances, and was also reported by other devices long-term studies.^{13,21} During the posttreatment period, that forward movement was significantly greater on treatment group than in normal occlusion (Table IV), raising the possibility of a relapse and encouraging an increase of the active retention period, as discussed before.

There was a significant smaller vertical dentoalveolar development of the incisors and molars on treatment group compared to normal occlusion (Table IV). This fact may still be a reflection of treatment since restriction of the eruption of the maxillary molars is commonly associated with the MARA appliance therapy and described before when comparing with untreated Class II patients.²

Mandibular Dentoalveolar component

One of the most propitious characteristics described for the MARA appliance is the absence of mandibular incisor labial inclination, a common effect during treatment with other functional devices.^{8,13,22-24} Therefore, no significant changes on the mandibular incisors inclination, protrusion and extrusion were observed during comprehensive treatment (Table III; Fig. 2 and 3). Incisors inclination and protrusion also remained with no alterations during the posttreatment period, except for a significant vertical development, that still was significantly smaller than the development presented by the control group (Table IV). That stability is probably associated with the use of a fixed mandibular retention, since studies that evaluated

stability of different functional appliances that used none or only short-term retention demonstrated that labial tooth inclination tends to rebound after treatment.^{22,25}

Mandibular molars also presented no significant sagittal changes during treatment and posttreatment periods (Table III; Fig. 2 and 3). However, a significant vertical development of the mandibular molars was observed during both periods, this outcome was previously reported due to the use of intermaxillary elastics as active retention after removal of functional appliances.^{13,26,27} Though this significant vertical development was presented by the treatment group, the normal occlusion group showed an even greater vertical posterior development, as discussed before, probably because, usually, the changes that occur consequent to treatment are smaller in the posttreatment period.²⁸⁻³⁰

Dental Relationships

Since the Class II malocclusion treatment with MARA appliance produced significant dentoalveolar corrections, the dental relationships were also improved, as described by many studies.^{4,31,32} The overjet, overbite and molar relationship presented a significant improvement, which remained stable during the posttreatment period (Table III; Fig. 2 and 3). The overjet showed a slight tendency to relapse, associated with the incisors minor labial inclination, but with no statistical significance on the posttreatment period (Table III; Fig. 2 and 3) and with no significant difference between treatment and normal occlusion groups (Table IV), this tendency to reestablish the Class II pattern is in agreement with similar findings described for the Herbst appliance.²⁹

CONCLUSIONS

- The palatal inclination of the maxillary incisors and the overjet improvement obtained with treatment remained stable at the posttreatment stage. However, a slight tendency towards relapse was observed when compared to normal occlusion. Therefore, an increase of active retention time could be recommended to prevent that.
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- One of the main advantages of the therapy with the MARA appliance, the absence of labial inclination and proclination of the mandibular incisors with treatment remained stable at the posttreatment stage.

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FIGURE LEGENDS

- Fig. 1.** Unusual cephalometric variables: 1, Mx1.PP; 2, Mx1-Apo; 3, Mx1-PP; 4, Mx6-APerp; 5, Mx6-PP; 6, Md1-MP; 7, Md6-PgPerp; 8, Md6-MP.
- Fig. 2.** Mean tracings of the treatment group generated by Dolphin Imaging 11.5 software superimposed on Sella-Nasion at Sella. The pretreatment tracing is black, the posttreatment, red and the long-term posttreatment, green.
- Fig. 3.** Mean tracings of the treatment group generated by Dolphin Imaging 11.5 software. (A) superimposition on the palatal plane, centered at the anterior nasal spine. (B) Superimposition on the mandibular plane, centered at the symphysis. black, pretreatment; red, posttreatment; gren, long-term posttreatment.
-

Fig. 1

Fig. 2

Fig. 3

Table I. Dental cephalometric variables.

Dental cephalometric variables	
<i>Maxillary dentoalveolar component</i>	
Mx1.PP (°)	Maxillary incisor long axis to palatal plane angle
Mx1-APerp (mm)	Distance between incisal edge of maxillary incisor and line perpendicular to palatal plane, tangent to A point
Mx1-PP (mm)	Perpendicular distance between incisal edge of maxillary incisor and palatal plane
Mx6-APerp (mm)	Distance between maxillary first molar occlusal and line perpendicular to palatal plane, tangent to A point
Mx6-PP (mm)	Perpendicular distance between maxillary first molar occlusal and palatal plane
<i>Mandibular dentoalveolar component</i>	
IMPA (°)	Mandibular incisor long axis to mandibular plane
Md1-PgPerp (mm)	Distance between most anterior point of crown of mandibular incisor and line perpendicular to mandibular plane, tangent to Pg point
Md1-MP (mm)	Perpendicular distance between incisal edge of mandibular incisor and mandibular plane
Md6-PgPerp (mm)	Distance between mandibular first molar occlusal and line perpendicular to mandibular plane, tangent to Pg point
Md6-MP (mm)	Perpendicular distance between mandibular first molar occlusal and mandibular plane
<i>Dental relationship</i>	
Overjet (mm)	Distance between incisal edges of maxillary and mandibular central incisors, parallel to functional occlusal plane
Overbite (mm)	Distance between incisal edges of maxillary and mandibular central incisors, perpendicular to Frankfort plane
M.Rel (mm)	Distance between mesial points of maxillary and mandibular first molars, parallel to Frankfort plane

Table II. Intergroup comparability regarding the ages at T1, T2 and T3, the treatment and long-term posttreatment periods and sex distribution (t test)

	<u>TREATMENT</u>		<u>CONTROL</u>		
	<u>GROUP</u> n = 12		<u>GROUP</u> N = 12		
Stage/Period	Mean	SD	Mean	SD	P
T1 age (y)	12.35	1.31	-----	-----	-----
T2 age (y)	15.65	1.08	15.08	1.17	0.225
T3 age (y)	22.53	1.57	22.47	3.46	0.957
Treatment period (T2-T1) (y)	3.30	0.66	-----	-----	-----
Posttreatment period (T3-T2) (y)	6.88	0.87	7.39	3.73	0.645
Sex	Male 09 (75%)	Female 03 (25%)	Male 09 (75%)	Female 03 (25%)	

Table III. Intra-treatment group comparison of the cephalometric variables at the three stages (repeated measures ANOVA followed by Tukey tests)

	Pretreatment (T1)		Posttreatment (T2)		Long-term posttreatment (T3)		
Variable	Mean	SD	Mean	SD	Mean	SD	p
Maxillary dentoalveolar component							
Mx1.PP	115.8 ^A	5.0	111.8 ^B	4.2	113.3 ^{AB}	5.9	0.020*
Mx1-APerp	-4.2 ^A	1.6	-3.2 ^A	1.5	-4.4 ^A	2.0	0.053
Mx1 – PP	27.3 ^A	3.4	28.8 ^B	3.4	28.7 ^{AB}	3.0	0.028*
Mx6 – Aperp	28.7 ^A	1.6	27.6 ^B	1.8	26.2 ^C	1.3	0.000*
Mx6 – PP	20.9 ^A	2.6	23.4 ^B	2.6	23.9 ^B	2.3	0.000*
Mandibular dentoalveolar componente							
IMPA	97.4 ^A	5.3	101.1 ^A	4.9	101.1 ^A	5.5	0.052
Md1 – PogPerp	8.3 ^A	2.2	8.4 ^A	1.9	7.8 ^A	2.1	0.578
Md1-MP	37.8 ^A	1.8	38.7 ^{AB}	1.7	39.4 ^B	2.3	0.004*
Md6 - PogPerp	33.9 ^A	1.7	33.2 ^A	2.0	32.9 ^A	2.1	0.058
Md6 – MP	26.9 ^A	2.0	29.8 ^B	1.7	31.4 ^C	2.4	0.000*
Dentoalveolar relationship							
OVERJET	7.1 ^A	1.5	2.7 ^B	0.6	3.2 ^B	0.7	0.000*
OVERBITE	4.2 ^A	1.7	1.8 ^B	1.1	2.1 ^B	0.9	0.000*
Molar Relationship	2.4 ^A	0.7	-1.1 ^B	0.8	-1.2 ^B	0.9	0.000*

*Statistically significant at $P < 0.05$.

Table IV. Intergroup comparison of the long-term posttreatment changes and normal growth changes (t tests)

	Treatment Group		Control Group		
Variable	Mean	SD	Mean	SD	p
Maxillary dentoalveolar component					
Mx1.PP	1.46	3.82	-0.25	2.02	0.184
Mx1 – Aperp	-1.16	1.52	-0.26	1.05	0.105
Mx1 – PP	-0.14	1.60	1.61	1.74	0.017*
Mx6 - APerp	-1.47	1.34	-0.23	1.22	0.026*
Mx6 – PP	0.44	1.02	1.72	1.81	0.044*
Mandibular dentoalveolar component					
IMPA	0.05	3.15	-1.71	3.47	0.207
Md1 – PogPerp	-0.61	1.01	1.48	1.70	0.001*
Md1-MP	0.72	1.12	2.93	2.22	0.005*
Md6 - PogPerp	-0.31	1.22	1.52	2.00	0.013*
Md6 - MP	1.61	1.65	3.43	2.37	0.040*
Dentoalveolar relationship					
OVERJET	0.49	0.68	-0.09	0.74	0.057
OVERBITE	0.34	1.28	0.23	1.04	0.821
Molar Relationship	-0.10	0.45	-0.33	0.49	0.240

*Statistically significant at $P<0.05$.

3 DISCUSSION

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Sample and Methodology

Although several cephalometric investigations on the short-term treatment effects of the Mandibular Anterior Repositioning Appliance in growing subjects with Class II malocclusion have been published,(PANGRAZIO-KULBERSH et al., 2003; GONNER et al., 2007; GHISLANZONI et al., 2011) no previous research has dealt with the issue of long-term response to this type of therapy. Since stability is known to be the fundamental key to successful outcome of orthodontic treatment, the present studies investigated the stability of dentoskeletal changes 6.88 years after treatment with the MARA associated with fixed appliances. Consequently, the results are due to several effects of the MARA associated with fixed appliances in addition to growth and development changes.

Skeletal Component

Functional appliances as the Herbst, MARA and others are known for the “headgear” effect they produce, restricting the anterior displacement of the maxilla (PANGRAZIO-KULBERSH et al., 2003; SIARA-OLDS et al., 2010; GHISLANZONI et al., 2011; PANGRAZIO et al., 2012; GHISLANZONI et al., 2013). Despite the controversy in the current orthodontic literature regarding the maxillary positioning in Class II malocclusion, it is known that the maxilla is more protruded in Class II division 1 (RENFROE, 1948). Therefore, as observed in this study, the skeletal effect of restriction of the maxillary growth shown by the decrease of the maxillary protrusion, is desirable and stable in the long-term. Other studies already confirmed that this outcome tend to remain stable in the posttreatment period after the Class II discrepancy correction (JANSON et al., 2004; FONCATTI et al., 2017). When the Class II is mainly caused by maxillary protrusion, and, therefore, not by mandibular retrusion, it can be observed a similar growth pattern, during the pubertal spurt, to that presented by normal occlusion patients, except only for the maxillary protrusion (VÁSQUEZ et al., 2009). Since both groups were followed during growth, a

significant increase of the maxillary effective length was observed. Nevertheless, despite the group comparability regarding the age and gender distribution, a significantly greater increase was presented by the control group, showing that this group had a higher growth potential during the observational period than the treatment group.

When comparing the mandibular size of Class I and Class II patients, a smaller and more retruded mandible is commonly observed (OPPENHEIM, 1928; NELSON; HIGLEY, 1948; MCNAMARA, 1981; KARLSEN, 1994; URSI; MC NAMARA JR, 1997; HENRIQUES et al., 1998). That is why the mandibular behavior in response of the Class II, division 1 treatment with functional appliances is a subject of wide interest in the literature. Specially the stimulus of the mandibular growth and, therefore, the increase of the mandibular effective length. However, the effectiveness of the functional appliances in achieving and maintaining that is still a source of many controversies (DEVINCENZO, 1991). This research did not observe a significant gain on the mandibular protrusion with MARA treatment, as reported with other appliances (BACCETTI et al., 2000; GHISLANZONI et al., 2013). Similar as other reports (STUCKI; INGERVALL, 1998; GHISLANZONI et al., 2011; GHISLANZONI et al., 2013), the mandibular effective length increased during treatment and posttreatment, since all patients were being followed during the growth period. This increase in the mandibular length can contribute to the stability of Class II discrepancy correction, even though the amount of mandibular development shown by the normal occlusion group was significantly higher, as discussed before for the maxillary development.

The present study also observed a significant improvement of the maxillomandibular relationship that did not present statistically significant changes on the posttreatment period. Since Class II, Division 1 patients tend to present a similar late dentofacial growth to the presented by young people with normal occlusion, the maxillomandibular discrepancy observed in the final stage of puberty mostly won't suffer any significant changes (BACCETTI; STAHL; MCNAMARA JR, 2009).

A counterclockwise rotation of the mandible can be observed after treatment with functional appliances, as a response to the vertical redirection of condylar growth (SCHUDY, 1974; FRANCISCONI et al., 2013). The facial pattern angles remained unaffected, in the present study, during treatment, but presented a significantly decrease during the long-term posttreatment period, similar to the

behavior presented during normal growth and development. This research observed a significant increase of the anterior facial height during treatment, this has been commonly reported by many functional appliances studies (PANCHERZ, 1979, 1985; BOLMGREN; MOSHIRI, 1986; HÄGG; DU; RABIE, 2002; KARACAY et al., 2006; CHIQUETO et al., 2013; FRANCISCONI et al., 2013). Previous studies have demonstrated that nearly 70% of Class II patients presented an increased lower facial height (MCNAMARA, 1981), that can also reflect on an increased mandibular plane inclination that turns the prognosis of the case much more difficult (DRELICH, 1948; HUNTER, 1967).

Dentoalveolar Component

When we isolated the dental effects of the MARA appliance therapy on the maxillary dentition, it was observed a significant palatal inclination of the incisors, same as reported by many other functional appliances (PANCHERZ, 1984; DRAGE; HUNT, 1990; COPE et al., 1994; WEILAND; BANTLEON, 1995; COVELL et al., 1999; NALBANTGIL et al., 2005; KARACAY et al., 2006; HERRERA et al., 2011). During the observational period, a small tendency to relapse was observed, when the maxillary incisors presented a slight but not significant buccal inclination, this behavior can be addressed as a relapse specially since the normal occlusion group presented an opposite inclination of the incisors during the follow-up period. Evidently, the overjet showed the same behavior of the maxillary incisors inclination, with a small tendency to relapse but with no statistically significant difference in the posttreatment period or in comparison with the control group.

The labial inclination of the mandibular incisors is a great concern during functional appliances therapy since its a result of mandibular anchorage loss, due to the anterior-directed force vector on the mandibular dentition, and was described by many previous reports (WEILAND; BANTLEON, 1995; STUCKI; INGERVALL, 1998; COVELL et al., 1999; NALBANTGIL et al., 2005; KARACAY et al., 2006; DE OLIVEIRA et al., 2007; KUCUKKELES; ILHAN; ORGUN, 2007; HERRERA et al., 2011; PANCHERZ; BJERKLIN, 2014). Treatment produced no significant changes on the mandibular incisors inclination, protrusion and extrusion, which is a great advantage of the MARA appliance in comparison with other functional devices

(PANCHERZ; HANSEN, 1986; COVELL et al., 1999; KUCUKKELES; ILHAN; ORGUN, 2007; HERRERA et al., 2011; PANCHERZ; BJERKLIN, 2014). Inclination and protrusion also remained stable during the posttreatment period, except for a significant vertical development of the incisors. That stability is probably due to the use of a fixed mandibular canine-to-canine retention, since labial inclination rebounding after treatment is commonly described by functional appliances stability studies (HANSEN; KOUTSONAS; PANCHERZ, 1997; PANCHERZ; BJERKLIN, 2014).

The extrusion of the mandibular molars is a common side effect of the use of intermaxillary elastics as active retention during the fixed appliances phase (LAI; MCNAMARA JR, 1998; CHHIBBER et al., 2010; HERRERA et al., 2011), in the present study we observed significant vertical development of the mandibular molars during both periods. In addition, both maxillary and mandibular molars showed a significant smaller extrusion on the experimental group during the posttreatment period. Other studies have already described that changes that occur during treatment normally tend to be smaller in the posttreatment period (FRANCHI; BACCETTI; MCNAMARA JR, 1999; JANSON et al., 2003; DE FREITAS et al., 2004). Since the treatment group presented less vertical posterior dentoalveolar development when compared to normal occlusion, that can also be a sign of the greater amount of growth and development potential of the control group, as discussed before for the skeletal components.

In consequence of the dentoalveolar changes produced by the MARA combined with fixed appliances therapy, the dentoalveolar relationships as the overjet, overbite and molar relationship presented a significant improvement as well, this was previously reported by many studies (GHISLANZONI et al., 2011; PANGRAZIO et al., 2012; CHIQUETO et al., 2013). The improvement observed in these relations remained stable during the posttreatment period, showing a great stability outcome.

4 FINAL CONSIDERATIONS

4 FINAL CONSIDERATIONS

Despite the significant increase of the effective maxillary length due to normal growth and development, the reduction of the maxillary protrusion obtained with treatment remained stable at the posttreatment stage as well as the significant improvement of the maxillomandibular relationship.

Dental changes remained stable, palatal inclination of the maxillary incisors and the overjet presented a slight tendency towards relapse when compare to normal occlusion behavior. Therefore, in other to prevent that, an increase of the active retention time could be recommended. The absence of labial inclination and proclination of the mandibular incisors was a great advantage of this option of treatment and showed stability during the posttreatment stage

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APPENDIXES

APPENDIXES

APPENDIX A – Declaration of exclusive use of the article 1 in thesis.

DECLARATION OF THE USE OF THE ARTICLE IN THESIS

We hereby declare that we are aware that the article "Long-term stability of the skeletal changes induced by the MARA appliance" will be included in the thesis of the student Camilla Fiedler Foncatti and may not be used in other works of Graduate Programs at the Bauru Dental School, University of São Paulo.

Bauru, January 15th of 2018.

Camilla Fiedler Foncatti

Signature

José Fernando Castanha Henriques

Signature

Guilherme Janson

Signature

APPENDIX B - Declaration of exclusive use of the article 2 in thesis.

DECLARATION OF THE USE OF THE ARTICLE IN THESIS

We hereby declare that we are aware that the article "Long-term stability of the dental changes induced by the MARA appliance" will be included in the thesis of the student Camilla Fiedler Foncatti and may not be use (Ctrl) + works of Graduate Programs at the Bauru Dental School, University of São Paulo.

Bauru, January 15th of 2018.

Camilla Fiedler Foncatti

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José Fernando Castanha Henriques

Signature

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Signature

ANNEXES

ANNEXES

ANNEX A – Research Institutional Board approval, protocol number 59793316.4.0000.5417 (front)

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PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Avaliação da estabilidade em longo prazo da correção da Classe II divisão 1 com aparelho MARA associado ao aparelho ortodôntico fixo

Pesquisador: Camilla Fiedler Fonçatti

Área Temática:

Versão: 1

CAAE: 59793316.4.0000.5417

Instituição Proponente: Universidade de São Paulo

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 1.745.662

Apresentação do Projeto:

Informa a pesquisadora que o tratamento da Classe II divisão 1 com dispositivos ortopédicos combinados à aparatologia ortodôntica fixa tem mostrado resultados excelentes quando utilizado em pacientes em crescimento. Desta forma, observando que a terapia com o aparelho MARA (Mandibular Anterior Repositioning Appliance) associado ao aparelho ortodôntico fixo se mostrou eficaz na correção da Classe II, este trabalho tem por objetivo avaliar cefalométricamente a estabilidade em longo prazo das correções obtidas durante este tratamento. Assim, serão analisadas as alterações durante e após o tratamento através das tomadas radiográficas em norma lateral de 30 pacientes nas fases: inicial (T1), final (T2) e pós-tratamento (T3) e comparadas a um Grupo Controle compatível compostos de 30 indivíduos com oclusão normal, não tratados ortodonticamente, obtidos do acervo da Disciplina de Ortodontia da Faculdade Odontologia de Bauru – USP. Os dados obtidos serão analisados através da análise de variância (ANOVA) para medidas repetidas e o teste de comparações múltiplas de Tukey. O teste t pareado será utilizado para avaliar as alterações ocorridas entre os estágios. As alterações ocorridas no período de pós-tratamento serão comparadas com as alterações do Grupo Controle utilizando o teste t independente. Além disso, para avaliar a influência das variáveis cefalométricas

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iniciais na quantidade de alterações sofridas após o término do tratamento, será realizada a análise de regressão linear múltipla.

Objetivo da Pesquisa:

Avaliar cefalométrica a estabilidade das alterações dentoalveolares e tegumentares de jovens com má oclusão de Classe II, 1ª divisão, tratados com o aparelho MARA associado ao aparelho ortodôntico fixo, na clínica de pós-graduação da disciplina de Ortodontia da Faculdade de Odontologia de Bauru, após um período médio de 5 anos.

Avaliação dos Riscos e Benefícios:

Riscos:

Uma vez que trata-se de um estudo que avaliará as radiografias presentes no arquivo da disciplina realizadas durante o tratamento ortodôntico e acompanhamento dos pacientes, essa pesquisa não oferecerá riscos aos sujeitos participantes da amostra, uma vez que será mantido o sigilo das informações.

Benefícios:

Uma vez que os sujeitos participantes da amostra já realizaram o tratamento ortodôntico e finalizaram o acompanhamento, essa pesquisa não oferecerá benefícios aos mesmos. Entretanto, este estudo poderá contribuir na melhor indicação de terapias ortodônticas de pacientes com classe II, divisão 1ª.

Comentários e Considerações sobre a Pesquisa:

Não há.

Considerações sobre os Termos de apresentação obrigatória:

Todos os documentos exigidos foram apresentados.

Recomendações:

Não há.

Conclusões ou Pendências e Lista de Inadequações:

Diante da apresentação de todos os documentos corretamente, sou de parecer favorável a aprovação do projeto.

Considerações Finais a critério do CEP:

Esse projeto foi considerado APROVADO na reunião ordinária do CEP de 21.09.2016, com base nas normas éticas da Resolução CNS 466/12. Ao término da pesquisa o CEP-FOB/USP exige a apresentação de relatório final. Os relatórios parciais deverão estar de acordo com o cronograma e/ou parecer emitido pelo CEP. Alterações na metodologia, título, inclusão ou exclusão de autores,

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cronograma e quaisquer outras mudanças que sejam significativas deverão ser previamente comunicadas a este CEP sob risco de não aprovação do relatório final. Quando da apresentação deste, deverão ser incluídos todos os TCLEs e/ou termos de doação assinados e rubricados, se pertinentes.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_754415.pdf	09/09/2016 01:09:32		Aceito
Cronograma	CRONOGRAMA.pdf	09/09/2016 01:08:52	Camilla Fiedler Fonçatti	Aceito
Outros	Declaracaodecompromisso.pdf	09/09/2016 01:07:26	Camilla Fiedler Fonçatti	Aceito
Outros	QuestionarioTecnicoPesquisador1.pdf	09/09/2016 01:06:26	Camilla Fiedler Fonçatti	Aceito
Folha de Rosto	folha_de_rosto.pdf	29/07/2016 16:24:10	Camilla Fiedler Fonçatti	Aceito
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Projeto Detalhado / Brochura Investigador	PROJETO.pdf	29/07/2016 16:17:26	Camilla Fiedler Fonçatti	Aceito

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BAURU, 26 de Setembro de 2016

Assinado por:
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ANNEX B - Guidelines for AJO-DO submissions: Original Article

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Official Journal of the [American Association of Orthodontists](#), its constituent societies, the American Board of Orthodontics, and the College of Diplomates of the American Board of Orthodontics

AUTHOR INFORMATION PACK

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ISSN: 0889-5406

DESCRIPTION

Published for more than 100 years, the *American Journal of Orthodontics and Dentofacial Orthopedics* remains the leading **orthodontic** resource. It is the official publication of the [American Association of Orthodontists](#), its constituent societies, the American Board of Orthodontics and the College of Diplomates of the American Board of Orthodontics. Each month its readers have access to original peer-reviewed articles that examine all phases of **orthodontic treatment**. Illustrated throughout, the publication includes tables, photos (many in full color), and statistical data. Coverage includes successful diagnostic procedures, imaging techniques, bracket and archwire materials, extraction and impaction concerns, orthognathic surgery, TMJ disorders, removable appliances, and adult therapy.

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