UNIVERSIDADE DE SÃO PAULO
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Stability of nonextraction Class II malocclusion treatment with elastics

Avaliação da estabilidade do tratamento da má oclusão de Classe II sem extrações com uso de elásticos

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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. Dr. Guilherme Janson.

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DEDICATÓRIA

À minha família que é a maior bença da vida!

Amo vocês!

*Ás minhas **amigas** de turma da minha querida Facultad de Odontología - Universidad Nacional de Asunción,*

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ABSTRACT

Stability of nonextraction Class II malocclusion treatment with elastics

The objective of this study was to evaluate the long-term stability after successful nonextraction Class II malocclusion treatment with elastics. A sample of 43 patients with Class II malocclusion was divided into two groups. The elastic group (EG) consisted of 20 patients who were treated with fixed appliances associated with Class II elastics. The headgear group (HG), consisted of 23 patients treated with fixed appliances and extraoral headgear. Pre-, post-treatment, and long-term post-treatment lateral radiographs and dental casts were evaluated. T-tests were used to compare the treatment changes and long-term post-treatment changes between the groups. The groups were matched regarding initial age, time of long-term post-treatment evaluation, initial malocclusion severity, quality of treatment result, and all pretreatment cephalometric variables. Patients of the EG presented greater treatment time, were older at the post-treatment and at the long-term post-treatment evaluation stages. During treatment both groups showed similar changes. Intergroup comparisons of long-term post-treatment changes showed slight mandibular retrusion in the EG and mandibular protrusion in the HG. The maxillary molar showed significant mesialization in the HG group. There were no intergroup significant occlusal differences during the long-term post-treatment period, with exception of the overjet, which maintained stable in the EG and showed improvement in the HG group. Nonextraction Class II malocclusion treatment with elastics or with extraoral headgear have similar long-term post-treatment stability.

Keywords: Stability. Malocclusion, Angle Class II. Intermaxillary elastics.

RESUMO

Avaliação da estabilidade do tratamento da má oclusão de Classe II sem extrações com uso de elásticos

O objetivo do presente estudo foi avaliar a estabilidade do tratamento sem extrações da má oclusão de Classe II com elásticos. Uma amostra de 43 pacientes com má oclusão de Classe II foi dividida em dois grupos. O grupo elástico (GE) consistiu em 20 pacientes que foram tratados com aparelho fixo associado a elásticos de Classe II. O grupo controle (GC), consistiu em 23 pacientes tratados com aparelho fixo associado ao aparelho extrabucal. Telerradiografias e modelos iniciais (T1), finais (T2) e pós-tratamento (T3) foram avaliados. Os grupos foram compativéis em relação à idade inicial, tempo de avaliação pós-tratamento, severidade inicial da má oclusão, qualidade do resultado do tratamento e em relação às variáveis cefalométricas pré-tratamento. Os pacientes do GE apresentaram maior tempo de tratamento, e maior idade ao final e no pós-tratamento. Após o tratamento, ambos os grupos apresentaram alterações semelhantes. Com respeito as alterações no periodo pós-tratamento, no GE, a mandíbula se mostrou ligeiramente retruida e no GC ocorreu uma ligeira protrusão. Em relação às variáveis dentoalveolares, o molar maxilar mostrou mesialização significativa no GC. Não houve diferenças entre os grupos em relação às alterações oclusais no periodo pós-tratamento, com exceção do overjet, que manteve-se estável no GE e mostrou melhoras no GC. A estabilidade do tratamento de má oclusão de Classe II com elásticos ou com aparelho extrabucal é semelhante.

Palavras-chave: Estabilidade. Má oclusão de Angle Classe II. Elásticos intermaxilares.

TABLE OF CONTENTS

1. INTRODUCTION

1. INTRODUCTION

It is well known that in orthodontics, seeking a successful finishing of active treatment is not enough, but optimization of the results in the long-term is the main issue. Relapse is a dentoalveolar and skeletal change after orthodontic treatment towards its original pretreatment position, and relapse tendencies are still present in successfully treated cases (CRUM; ANDREASEN, 1974).

There are several treatment options to correct a Class II malocclusion and studies confirm that Class II correction stability does not depend on the treatment protocol (SADOWSKY; SAKOLS, 1982; FIDLER et al. 1995; ELMS; BUSCHANG; ALEXANDER, 1996; JANSON et al. 2009; JANSON et al. 2010). In addition, most studies showed that the occlusal status at the postretention stage present good stability (FIDLER et al., 1995; AL YAMI; KUIJPERS-JAGTMAN; VAN 'T HOF, 1999; JANSON et al., 2010).

In general, Class II, division 1 malocclusion can be corrected with the use of intermaxillary elastics. As effects, the elastics produce lingual tipping, retrusion and extrusion of the maxillary incisors, labial tipping and intrusion of the mandibular incisors, mesialization and extrusion of the mandibular molars and slight distalization of maxillary molars (EDWARDS, 1983; BLAKE; WOODSIDE; PHAROAH, 1995; ELLEN; SCHNEIDER; SELLKE, 1998; NELSON; HANSEN; HAGG, 1999, 2000; REDDY et al., 2000; NELSON et al., 2007; JANSON et al., 2013). Thus, orthodontic correction with elastics is achieved almost exclusively by tooth movement.

Adverse effects may also occur. It has been stated that the vertical vector of force may extrude the maxillary incisors and mandibular molars, causing clockwise rotation of the occlusal plane and the mandible, when Class II elastics are used (BIEN, 1951; PHILIPPE, 1995; ELLEN; SCHNEIDER; SELLKE, 1998). These immediate treatment effects seem to decrease, and are almost insignificant in the long-term (NELSON et al., 2007).

In spite of that, there are still widespread speculation that the extensive reciprocating disto-mesial movements of the maxillary and mandibular teeth to normal occlusion produced by the intermaxillary elastics is very susceptible to relapse after treatment (CASE, 2003), furthermore, there is a need of elucidating

the long-term implications of the adverse effects (EDWARDS, 1983; ELLEN; SCHNEIDER; SELLKE, 1998; UZEL; UZEL; TOROGLU, 2007) that make the prognosis with this mechanics to be inconclusive. Because of that, the purpose of this study was to evaluate the long-term cephalometric and occlusal stability after successful treatment of nonextraction Class II malocclusion with elastics.

2. ARTICLES

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

- ARTICLE 1: Cephalometric stability of Class II malocclusion treatment with elastics
- ARTICLE 2: Occlusal stability of Class II malocclusion treatment with elastics

2.1. ARTICLE 1

2.1. ARTICLE 1

CEPHALOMETRIC STABILITY OF CLASS II MALOCCLUSION TREATMENT WITH ELASTICS

Abstract

Introduction: The objective of this study was to compare the long-term cephalometric stability after successful therapy of nonextraction Class II malocclusion with elastics and with headgear. **Methods:** A sample of 43 patients with Class II malocclusion was divided into two groups. The elastic group (EG) consisted of 20 patients who were treated with fixed appliances associated with Class II elastics. The headgear group (HG), consisted of 23 patients treated with fixed appliances and extraoral headgear. Pre-, post-treatment, and long-term post-treatment lateral radiographs were evaluated. T-tests were used to compare the long-term post-treatment changes between the groups. **Results:** The groups were matched regarding initial age, time of long-term post-treatment evaluation, initial malocclusion severity, quality of treatment result, and all pretreatment cephalometric variables. Patients of the EG presented greater treatment time, were older at the post-treatment and at the long-term post-treatment evaluation stages. Intergroup comparisons of long-term post-treatment changes showed slight mandibular retrusion in the EG and mandibular protrusion in the HG. The maxillary molar showed significant mesialization in the HG group. **Conclusion:** Nonextraction Class II malocclusion treatment with elastics or with extraoral headgear have similar long-term post-treatment stability.

INTRODUCTION

There are several treatment options to effectively correct a Class II malocclusion. Studies confirm that Class II correction stability does not depend on the treatment protocol and occlusal status present good stability in the long-term.[1-5]

Elastics have been an option to correct Class II malocclusion since the late 1800s[6-9], and normal occlusion can usually be obtained with the intermaxillary force with primarily dentoalveolar effects.[10-13]

The elastics produce palatal tipping and retrusion of the maxillary incisors, mesialization and protrusion of mandibular molar and incisors respectively, and

slight distalization of maxillary molars.[6,10-14] As Class II elastics are used usually from one point in the maxillary canine area to a point on the mandibular molar area, the unfavorable collateral effect is the clockwise rotation of the occlusal and mandibular plane that could be attributed to extrusion of the maxillary incisors and mandibular molars.[8,12,15]

Comprehensive long-term post-treatment follow-up studies of Class II malocclusion correction with elastics are scarce.[1,16] Fidler et. al.[1] published an article that showed good long-term stability of Class II malocclusion, but in this study Class II elastics were used only occasionally. Nelson et. al.[16] evaluated the follow-up changes of treatment with elastics associated to Begg technique and with Herbst appliance, and found that the unfavorable effects of the elastics did not persist in the long-term. In general, long-term effects of Class II malocclusion with elastics, are similar to fixed functional appliances.[11,16]

Despite these studies showing that the long-term effects of Class II elastics in Class II malocclusions are mostly favorable, there are still widespread speculation that the extensive reciprocating disto-mesial movements of the maxillary and mandibular teeth to a normal occlusion produced by the intermaxillary elastics is responsible for relapse after treatment,[17] suggesting that the prognosis with this mechanics is unfavorable. Therefore, the purpose of this study was to evaluate the long-term cephalometric stability after successful treatment of nonextraction Class II malocclusion with Class II elastics.

MATERIAL AND METHODS

Ethical approval was obtained from the Ethics in Research Committee of Bauru Dental School, University of São Paulo, and all subjects signed informed consent.

The sample size estimation was calculated for the difference in overjet change between the post-treatment and follow-up stages, based on an alpha significance level of 5% and a beta of 20%. The mean difference tested was 1.5 mm with a standard deviation of 1.1 mm.[16] The results showed that a minimum of 12 patients were needed for each group.

A sample of 43 patients was retrospectively selected from the files of the Orthodontic Department at Bauru Dental School, University of São Paulo,

according to the following criteria: 1) Angle Class II, division 1 malocclusion with a minimum of half Class II molar relationship[18,19] treated nonextraction (excluding third molars), 2) Good occlusal finishing, (established by the Cast-Radiograph Evaluation) and 3) Availability of lateral cephalometric radiographs, panoramic radiographs and dental casts at 3 stages (T1, pretreatment; T2, post-treatment; and T3, long-term post-treatment). The occlusal relationship and cephalometric characteristics at T3 were not considered in sample selection.

The sample was divided into two groups, according to the treatment protocol used to correct the Class II malocclusion.

The elastic group (EG) consisted of 20 Class II malocclusion patients (11 male; 9 female) treated with Class II elastics to correct the anteroposterior discrepancy. The mechanics consisted of standard fixed Edgewise or Roth pre-adjusted appliances with 0.022 x 0.028–inch slots and a usual wire sequence characterized by an initial 0.015 inch twist-flex or a 0.016 inch Nitinol, followed by 0.016, 0.018, 0.020 and 0.019 x 0.025 or 0.018 x 0.025 inch stainless steel archwires. Deep overbites were corrected by reversed and accentuated curve of Spee. Class II anteroposterior discrepancy was corrected with Class II elastics on both sides for at least 6 months, for 15 to 18 hours a day, with a mean force of 200g, measured with a tension gauge. The elastics were used more on one side than the other, when necessary (Fig 1).

The headgear group (HG), consisted of 23 Class II division 1 malocclusion patients (13 male; 10 female), matched regarding age and sex, and followed during a comparable period to the EG long-term post-treatment period (T2-T3). The patients were treated using only the headgear followed by orthodontic treatment with fixed appliances to correct the Class II molar relationship. They were instructed to wear the appliance for least 16 hours per day, with a mean force of 450g on each side (Fig 1).

The retention protocol in both groups included a maxillary Hawley retainer worn full time during the first six months and as night-time wear for the subsequent six months. In the mandibular arch a canine-to-canine bonded retainer was installed and recommended to be used for 3 years. At the long-term post-treatment stage, 16 (80%) patients of the EG and 13 (56.5%) patients of the HG group still worn fixed canine-to-canine retainers.

Cephalometric analysis

Lateral cephalometric headfilms of all patients were obtained in centric occlusion with passive lip posture and were digitized (MICROTEK ScanMaker, model i800), traced and analyzed with Dolphin Imaging 11.5 software (Patterson Dental Supply, Inc., Chatsworth, California, USA), which corrected the image magnification factors. A custom cephalometric analysis was performed and generated measurements at each stage: T1, T2 and T3: Several angular and linear measurements were obtained from lateral cephalograms to analyze the skeletal and dental changes during the long-term post-treatment period (Table I, Fig 2). The lateral cephalograms were blindly traced by a previously calibrated examiner (A.N.).

Cast and Panoramic Radiograph Analyses

To evaluate the initial malocclusion severity of the groups, the PAR index[20] was calculated by one examiner on the pretreatment dental study casts of each patient. Initial dental cast analysis was carried out using the US-weighted PAR Index.[21] The scores were weighted for the separate components, and summed to obtain a total score (PAR Index), expressing the severity of malocclusion.

Treatment result was evaluated based on the Cast-Radiograph Evaluation (C-R Eval) developed by the American Association of Orthodontist.[22] This system for scoring dental casts and panoramic radiographs contains eight criteria: alignment, marginal ridges, buccolingual inclination, occlusal relationships, occlusal contacts, overjet, interproximal contacts, and root angulation. The scores were blindly assigned by a previously calibrated examiner (A.N.).

Error study

After a 30-day interval, a random sample of lateral cephalometric, panoramic radiographs and dental cast were selected and remeasured by the same examiner (A.N). The random errors were calculated according to Dahlberg's formula ($Se2 = \sum d2/2n$)[23], where Se^2 is the error variance and d is the difference between two determinations of the same variable. The systematic errors were evaluated with dependent t tests, at $P<0.05$.[24]

Statistical analyses

Normal distribution of the variables was verified with Kolmogorov-Smirnov tests. All variables showed normal distributions.

Therefore, group comparability regarding initial, final and long-term post-treatment ages, treatment time, long-term post-treatment time, initial malocclusion severity (PAR Index) and the quality of treatment results in both groups were compared with t-tests. Intergroup sex, severity of Class II malocclusion relationship and presence of canine-to-canine retainer distributions at T3 were compared with chi-square tests. The intergroup initial cephalometric characteristics were also compared with t tests.

T-tests were used to compare the intergroup treatment changes (T2-T1) and the long-term post-treatment changes (T3-T2). The results were considered significant at $P<0.05$. The statistical analyses were performed with Statistica for Windows 10 software (Statsoft, Tulsa, Okla).

RESULTS

Intraexaminer reliability of the initial PAR and Cast-Radiograph evaluation (C-R eval) showed random errors within acceptable levels and no statistically significant systematic errors.[25] Among the 24 cephalometric variables, no variable showed random errors greater than 1.2 mm (overjet) to 1 mm (Co-Gn), and only 3 had a systematic error: SNA, Pg-Na Perp, SN-GoGn.[26]

The groups were comparable regarding the initial age, time of long-term post-treatment evaluation, initial PAR index, quality of treatment result (C-R Eval), sex, severity of Class II molar relationship, and presence of canine-to-canine retainer distributions at T3. All pretreatment cephalometric variables were similar in the groups. However, patients of the EG presented greater post-treatment and long-term posttreatment ages and treatment time (Table II).

During treatment, the HG group presented significantly greater maxillary anterior displacement restriction, increases in mandibular length, lower anterior face height, and in maxillary molar vertical displacement. It also presented significantly smaller mandibular incisor protrusion, greater mandibular incisor vertical development, and smaller mandibular molar mesialization (Table IV).

During the posttreatment period, the HG group presented significantly greater mandibular protrusion and maxillary molar mesialization (Table V).

To avoid an influence of the different intergroup treatment time in the results, subgroups with matching treatment times were also compared with t-tests. The results were similar to those with the original groups (Tables VI and VII).

DISCUSSION

Elastics for Class II malocclusion correction have been widely used, nevertheless, there still remains some conviction that the extensive reciprocating sagittal movements of the teeth with elastics could lead to unstable treatment results in the long-term.[17] Therefore, in this study, patients with Class II division 1 malocclusion, treated with and without Class II elastics, were evaluated in the long-term post-treatment.

To verify the stability of Class II treatment with elastics, we compared the long-term post-treatment results with patients treated with extraoral headgear associated with fixed appliances, which has been traditionally used for a long time, and its effects are widely described in the literature.[14,27,28]

The initial malocclusion severity using PAR index and Class II molar relationship classification (at least a half Class II),[18] and all pretreatment cephalometric variables were comparable between the groups. And to ensure that the changes in the long-term are only consequent to the different treatment protocols, a good quality of occlusal results at post-treatment (C-R Eval) were determinant to included patients in each group (Tables II and III).

Selection criteria for the sample were rigidly applied to attain a homogenous sample. The groups were statistically comparable regarding initial age, sex distribution, long-term post-treatment period and the presence of canine-to-canine retainer at T3. However, the treatment time, final age and the age at the long-term post-treatment evaluation were greater in the EG (Table II).

The long-term post-treatment time was more than 5 years after orthodontic appliances removal in both groups. The mean time of post-treatment evaluation was 6.94 years (SD 4.90) in the EG and 5.27 years (SD 2.40) in the HG.

Accordingly, stability after orthodontic treatment with both mechanics could be evaluated with high reliability since immediate relapse occurs in the first years after fixed appliance removal, with almost 50% of the relapse occurring during the first 2 years after treatment.[29,30]

To better understand the stability or relapse in the long-term post-treatment, treatment changes between the groups will be briefly discussed.

When we compared the treatment changes between patients treated with elastics and with headgear, we found that changes were very similar, with the difference that maxillary forward growth was efficiently restricted in the HG, this result was expected because of the light force applied with elastics when compare with the heavier forces used with headgear. In the vertical plane, the lower facial height increased more in the HG group, probably as an effect of the greater maxillary first molar extrusion in the same group. Mesial movement of the mandibular first molar and mandibular incisor labial tipping was significantly more pronounced in the EG. In general, other studies have also found similar results when evaluating the treatment changes in nonextraction Class II malocclusion.[10,31,32]

Class II elastics are usually responsible for the unfavorable collateral effect of clockwise rotation of the occlusal and mandible planes, consequent to extrusion of the maxillary incisors and mandibular molars.[8,12,15] In this study this did not occur, and similar results were observed in a previous study.[32] Compensation by reversed and accentuated curve of Spee archwires were used in almost all patients in the EG, which may have controlled the vertical effects during treatment. Besides, maxillary first molar extrusion is often associated with cervical headgear effects.[33,34]

Comparing the behavior of the groups during the long-term post-treatment period, both showed similar changes for most variables with the exception of the position of the mandible related to the cranial base (SNB) that was significantly different between the groups (Table V). In the EG the mandible position related the SNB angle, showed a retruded position, with a decrease of 0.31 degrees. In the HG the same angle increased 0.67 degrees during the long-term period, causing statistical difference between the groups. As the HG patients were significantly younger at post-treatment, with a mean age of 14.61 years (SD 1.24),

the mandible could be affected by the normal growth trends at puberty, which has been previously verified in Class II patients.[35,36] However, these slight different changes in the groups did not produce significantly different intergroup changes in the apical base relationships. This result agreed with previous study.[16]

Regarding the dentoalveolar variables, the changes were similar for most of the variables and even though the maxillary molar showed mesialization during the long-term post-treatment in the HG, this change was not enough to produce significant intergroup differences in molar relationship.

The intergroup treatment time difference was 0.65 years (7.8 months), probably, this difference occurred because of the Class II elastics protocol used. Patients used elastics on both sides for 10.45 months on average (15 to 18 hours a day) with 0.019 x 0.025 or 0.018 x 0.025 inch stainless steel archwires. Once the sagittal discrepancy was corrected, elastics continued to be used as active retention. This is recommended to attempt long-term stability of Class II correction with this mechanics.

Nevertheless, as treatment time could have an influence on the stability, it was decided to compare the long-term post-treatment changes, including only patients with comparable treatment time. The results were similar to those of the whole sample (Tables VI and VII).

The sagittal correction with treatment, regarding the maxilomandibular and molar relationships had very small relapses, not clinically significant, regardless of the orthodontic treatment mechanics. The presence of retainers seems unlikely to have had an influence on the stability of the sagittal relationship but might be beneficial for maintaining the alignment stability.[37]

Based on these results, it can be generally inferred that, for most dentoalveolar and skeletal variables, there was similar stability for both treatment protocols of Class II malocclusions.

CONCLUSIONS

- Overall, treatment of Class II malocclusions with intermaxillary elastic or with headgear appliance had similar long-term post-treatment stability.

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FIGURE LEGENDS

Fig 1. A – Initial, intermediate and final intraoral photographs of Class II malocclusion treatment with Class II intermaxillary elastics. B - Initial, intermediate and final intraoral photographs of Class II malocclusion treatment with extraoral headgear.

Fig 2. Unusual cephalometric variables: 1, Mx1.PP; 2, Mx1-APerp; 3, Mx1-PP; 4, Mx6-APerp; 5, Mx6-PP; 6, Md1-PgPerp, 7, Md1-MP; 8, Md6-PgPerp; 9, Md6-MP.

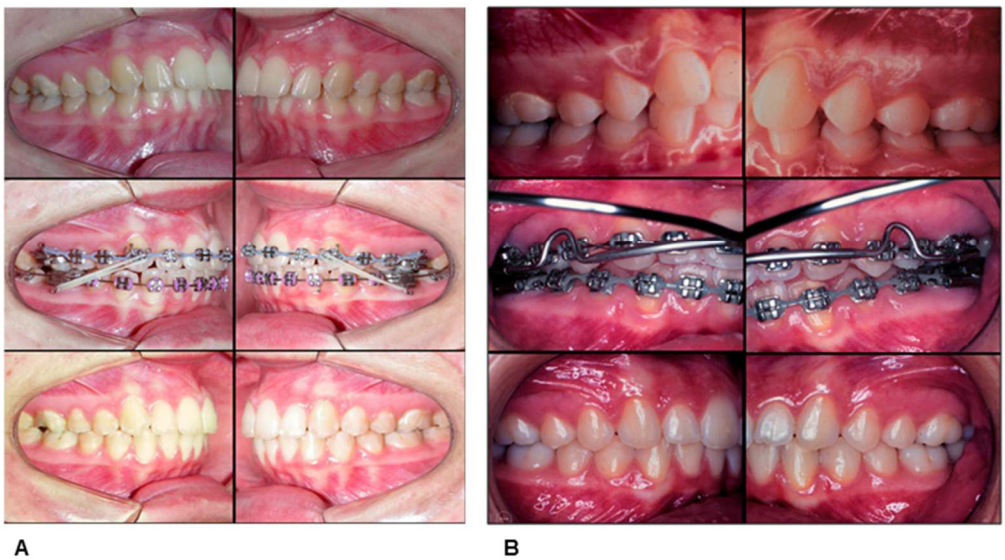

Figure 1.

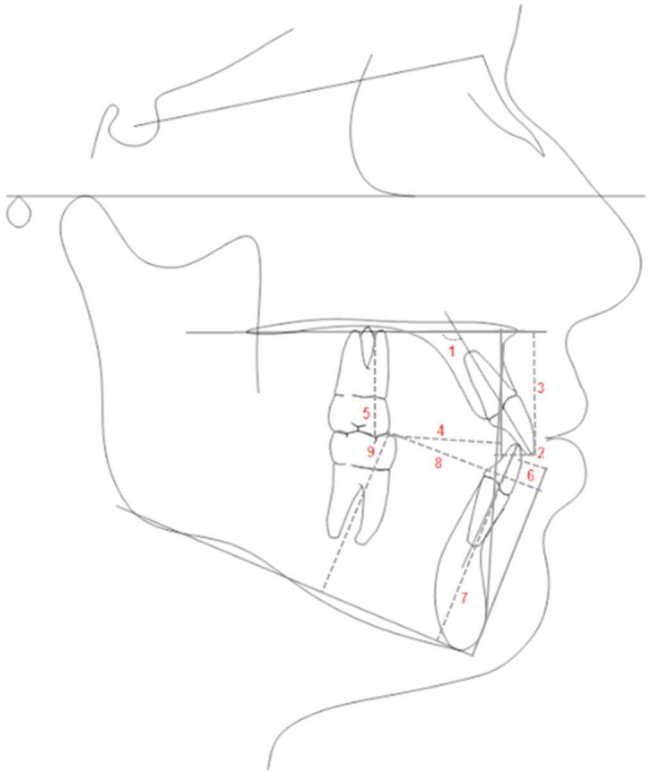

Figure 2.

Table I. Skeletal and dentoalveolar cephalometric variables

Skeletal cephalometric variables	
Maxillary component	
SNA (˚)	SN to NA angle
A-NPerp (mm)	A-point to nasion-perpendicular
Co-A (mm)	Condylion to A-point distance
Mandibular component	
SNB (˚)	SN to NB angle
Pg-NPerp (mm)	Pg-point to nasion-perpendicular
Co-Gn (mm)	Condylion to gnathion distance
Maxillomandibular relationship	
ANB (˚)	NA to NB angle
Wits (mm)	Distance between perpendicular projections of Points A and B on functional occlusal plane
Vertical component	
FMA (˚)	Frankfort mandibular plane angle
SNGoGn (˚)	SN to GoGn angle
LAFH (mm)	Distance from ANS to menton
Dental cephalometric variables	
Maxillary dentoalveolar component	
Mx1.PP (**°**)	Maxillary incisor long axis to palatal plane angle
Mx1-PP (mm)	Perpendicular distance between incisal edge of maxillary incisor and palatal plane
Mx1-APerp (mm)	Distance between most anterior point of maxillary incisor crown and a line perpendicular to palatal plane, tangent to A point. Reading is negative if the incisal edge is posterior to A point
Mx6-APerp (mm)	Distance between the mesio-buccal cusp tip of the maxillary first molar and a line perpendicular to palatal plane, tangent to A point. Reading is negative if the mesio-buccal cusp tip is posterior to A point molar occlusal and line perpendicular to palatal plane, tangent to A point
Mx6-PP (mm)	Perpendicular distance between the mesio-buccal cusp tip of the maxillary first molar and palatal plane
Mandibular dentoalveolar component	
Md1-PgPerp (mm)	Distance between the most anterior point of the mandibular incisor crown and a perpendicular to mandibular plane, tangent to Pg. Reading is negative if the incisal edge is posterior to Pg
Md1-MP (mm)	Perpendicular distance between incisal edge of mandibular incisor and mandibular plane
Md6-PgPerp (mm)	Distance between the mesio-buccal cusp tip of the mandibular first molar and a line perpendicular to mandibular plane, tangent to Pg. Reading is negative if the mesio-buccal cusp tip is posterior to Pg
Md6-MP (mm)	Perpendicular distance between the mesio-buccal cusp tip of the mandibular first molar and mandibular plane
IMPA (L1-MP) (**°**)	Mandibular incisor long axis to mandibular plane angle
Dental relationships	
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
Molar Relationship (mm)	Distance between mesial points of maxillary and mandibular first molars, parallel to Frankfort plane

Table II. Initial intergroup data comparison (T and Chi-square tests)

Variables	Elastic Group (n = 20) Mean / SD	Headgear Group (n = 23) Mean / SD	p
Initial age T1 (years)	14.14 / 5.62	12.14 / 1.21	0.209†
Final age T2 (years)	17.26 / 5.50	14.61 / 1.25	0.030*†
Age at long-term post-treatment evaluation (T3) (years)	24.36 / 6.19	19.88 / 2.72	0.003*†
Treatment time (years)	3.12 / 1.12	2.47 / 0.83	0.036*†
Time of long-term post-treatment evaluation (years)	6.95 / 4.90	5.19 / 2.38	0.153†
Initial PAR (Peer Assesment rating)	33.15 / 9.21	33.0 / 10.35	0.960†
C-R eval T2 (Quality of treatment result)	19.75 / 5.92	20.39 / 8.63	0.781†
Sex **Male** **Female**	 11 9	 13 10	0.920‡
Severity of Molar relationship **Complete Class II** **Half Class II**	 9 11	 11 12	0.852‡
Canine-to-canine retainer at T3 **Still wearing** **Not wearing**	 15 5	 13 10	1.632‡

*Statistically significant at $P<0.05$.
†t test; ‡chi-square test.

Table III. Initial intergroup cephalometric data comparison (T-tests)

Variable	Elastic Group (n = 20) Mean / SD		Headgear Group (n = 23) Mean / SD		p
Maxillary component					
SNA (°)	80.67	4.27	81.68	4.20	0.441
A-NPerp (mm)	0.01	2.38	-0.06	4.02	0.945
Co-A (mm)	79.57	3.80	82.09	4.57	0.058
Mandibular component					
SNB (°)	76.54	3.54	77.33	3.42	0.456
Pg-NPerp (mm)	-5.38	5.12	-5.99	6.39	0.732
Co-Gn (mm)	109.43	7.90	109.65	6.28	0.919
Maxillomandibular relationship					
ANB (°)	4.12	2.71	4.33	3.02	0.813
Wits (mm)	2.11	3.28	2.34	2.88	0.804
Vertical component					
FMA (°)	26.80	5.78	26.89	5.08	0.956
SNGoGn (°)	34.06	5.65	33.10	6.09	0.599
LAFH (°)	62.15	5.59	61.84	6.31	0.868
Maxillary dentoalveolar component					
Mx1.PP (°)	112.84	8.23	113.97	8.25	0.654
Mx1-PP (mm)	26.74	2.37	26.80	3.00	0.943
Mx1-APerp (mm)	4.74	3.01	4.90	3.41	0.868
Mx6-APerp (mm)	-25.62	2.67	-27.05	2.84	0.098
Mx6-PP (mm)	21.22	2.19	20.49	2.61	0.329
Mandibular dentoalveolar component					
Md1-PgPerp (mm)	8.28	3.21	8.33	2.31	0.952
Md1-MP (mm)	38.71	3.75	38.33	3.58	0.736
Md6-PgPerp (mm)	-27.86	3.14	-27.30	3.04	0.559
Md6-MP (mm)	32.66	2.62	33.83	2.77	0.165
IMPA (L1-MP) (°)	94.06	5.81	94.78	5.48	0.677
Dental relationships					
Overjet (mm)	4.95	2.11	5.83	2.52	0.227
Overbite (mm)	3.01	1.73	2.88	1.88	0.819
Molar relationship (mm)	1.95	1.80	2.37	1.84	0.456

Table IV. Intergroup comparisons of treatment changes (t test)

Variable	Elastic Group (n = 20) Mean / SD		Headgear Group (n = 23) Mean / SD		p
Maxillary component					
SNA (°)	0.32	2.88	-1.34	2.32	0.043*
A-NPerp (mm)	-0.41	3.53	-1.43	2.88	0.300
Co-A (mm)	1.06	4.24	1.43	3.02	0.734
Mandibular component					
SNB (°)	1.43	1.67	0.60	1.90	0.137
Pg-NPerp (mm)	1.18	3.98	1.03	5.08	0.921
Co-Gn (mm)	3.21	6.20	7.37	4.30	0.013*
Maxillomandibular relationship					
ANB (°)	-1.11	2.77	-1.93	2.23	0.291
Wits (mm)	-1.73	2.85	-2.47	2.80	0.390
Vertical component					
FMA (°)	-1.09	3.41	0.30	3.44	0.191
SNGoGn (°)	-1.81	2.97	-0.35	3.08	0.124
LAFH (°)	1.26	4.08	4.29	2.89	0.007*
Maxillary dentoalveolar component					
Mx1.PP (°)	1.51	8.66	0.76	8.44	0.777
Mx1-PP (mm)	-0.24	2.49	1.04	1.64	0.051
Mx1-APerp (mm)	0.20	3.28	0.29	3.27	0.931
Mx6-APerp (mm)	1.51	2.81	0.85	3.54	0.511
Mx6-PP (mm)	0.89	1.98	2.47	1.31	0.003*
Mandibular dentoalveolar component					
Md1-PgPerp (mm)	1.11	2.76	-0.56	1.86	0.024*
Md1-MP (mm)	0.16	2.67	1.72	1.74	0.027*
Md6-PgPerp (mm)	1.60	2.12	-0.90	4.16	0.020*
Md6-MP (mm)	1.91	2.07	2.77	1.92	0.166
IMPA (L1-MP) (°)	3.50	5.41	1.91	4.67	0.308
Dental relationships					
Overjet (mm)	-2.17	2.18	-2.87	2.55	0.337
Overbite (mm)	-1.76	1.73	-1.56	1.77	0.718
Molar relationship (mm)	-2.24	1.87	-3.05	2.05	0.187

*Statistically significant at $P<0.05$.

Table V. Intergroup comparisons of long-term post-treatment changes (t test)

Variable	Elastic Group (n = 20) Mean / SD		Headgear Group (n = 23) Mean / SD		p
Maxillary component					
SNA (°)	0.09	2.04	0.27	2.26	0.792
A-NPerp (mm)	-0.41	2.42	0.22	3.72	0.522
Co-A (mm)	1.69	3.16	0.97	3.58	0.491
Mandibular component					
SNB (°)	-0.31	1.12	0.67	1.63	0.030*
Pg-NPerp (mm)	-1.50	3.21	1.38	6.07	0.064
Co-Gn (mm)	1.95	4.17	2.74	3.99	0.525
Maxillomandibular relationship					
ANB (°)	0.42	1.61	-0.40	2.20	0.181
Wits (mm)	0.46	2.23	0.28	2.45	0.807
Vertical component					
FMA (°)	0.56	3.08	-0.73	2.97	0.171
SNGoGn (°)	-0.42	2.55	-0.58	2.08	0.814
LAFH (°)	1.55	3.03	0.97	1.63	0.431
Maxillary dentoalveolar component					
Mx1.PP (°)	1.02	1.75	0.33	1.00	0.115
Mx1-PP (mm)	-2.00	6.49	0.03	3.41	0.198
Mx1-APerp (mm)	0.89	2.61	-0.29	2.25	0.120
Mx6-APerp (mm)	-0.29	1.85	1.47	2.42	0.012*
Mx6-PP (mm)	0.54	1.07	0.87	1.15	0.331
Mandibular dentoalveolar component					
Md1-PgPerp (mm)	0.30	1.49	0.75	1.30	0.294
Md1-MP (mm)	1.35	1.76	0.91	1.26	0.346
Md6-PgPerp (mm)	0.35	1.58	0.22	1.16	0.770
Md6-MP (mm)	1.39	1.99	0.47	1.40	0.085
IMPA (L1-MP) (°)	0.10	1.59	-1.53	3.63	0.071
Dental relationships					
Overjet (mm)	-0.08	1.12	-0.19	0.82	0.719
Overbite (mm)	0.74	0.78	0.41	1.16	0.286
Molar relationship (mm)	0.15	1.00	0.03	0.91	0.696

*Statistically significant at $P<0.05$.

Table VI. Intergroup data comparison in subgroups with comparable treatment time (t test)

Variables	Elastic Group (n = 15) Mean / SD	Headgear Group (n = 15) Mean / SD	p
Initial age T1 (years)	14.73 / 6.09	12.40 / 1.40	0.158†
Final age T2 (years)	17.85 / 6.29	15.06 / 1.19	0.102†
Age at long-term post-treatment evaluation (T3) (years)	25.37 / 6.31	20.14 / 2.57	0.006*†
Treatment time (years)	2.69 / 0.98	2.77 / 0.87	0.819†
Time of long-term post-treatment evaluation (years)	7.36 / 5.02	5.08 / 2.44	0.124†
Initial PAR (Peer Assesment rating)	33.2 / 9.38	33.5 / 9.64	0.960†
C-R eval T2 (Quality of treatment result)	20.00 / 5.16	19.80 / 9.72	0.944†
Sex **Male** **Female**	 7 8	 7 8	1.000‡
Severity of Molar relationship **Complete Class II** **Half Class II**	 7 8	 7 8	0.715‡
Canine-to-canine retainer at T3 **Still wearing** **Not wearing**	 12 3	 5 9	0.015*‡

*Statistically significant at $P<0.05$.
†t test; ‡chi-square test.

Table VII. Intergroup comparisons of long-term post-treatment changes (T3-T2) including patients with comparable treatment time (t test)

Variable	Elastic Group (n = 15) Mean / SD		Headgear Group (n = 15) Mean / SD		p
Maxillary component					
SNA (°)	0.26	2.25	0.42	2.43	0.853
A-NPerp (mm)	-0.19	2.39	0.58	4.27	0.545
Co-A (mm)	2.34	3.20	0.65	3.75	0.194
Mandibular component					
SNB (°)	-0.35	1.06	1.09	1.50	0.005*
Pg-NPerp (mm)	-1.48	2.82	2.37	6.83	0.053
Co-Gn (mm)	2.55	4.08	2.85	4.02	0.837
Maxillomandibular relationship					
ANB (°)	0.62	1.77	-0.65	2.56	0.126
Wits (mm)	0.59	2.52	-0.42	2.18	0.252
Vertical component					
FMA (°)	0.37	1.87	-1.42	3.13	0.067
SNGoGn (°)	-0.32	2.24	-1.03	1.72	0.340
LAFH (°)	1.97	3.21	0.67	1.57	0.167
Maxillary dentoalveolar component					
Mx1.PP (°)	-3.68	5.95	-0.20	3.21	0.056
Mx1-PP (mm)	1.35	1.91	0.31	0.85	0.065
Mx1-APerp (mm)	1.14	2.85	-0.56	2.52	0.094
Mx6-APerp (mm)	-0.67	1.95	1.41	2.55	0.018*
Mx6-PP (mm)	0.61	1.15	0.48	1.05	0.755
Mandibular dentoalveolar component					
Md1-PgPerp (mm)	0.11	1.13	0.45	1.33	0.457
Md1-MP (mm)	1.28	1.80	0.93	0.98	0.518
Md6-PgPerp (mm)	-0.49	1.61	-0.15	0.97	0.490
Md6-MP (mm)	1.35	2.09	0.67	1.24	0.293
IMPA (L1-MP) (°)	0.13	1.41	-1.01	3.70	0.272
Dental relationships					
Overjet (mm)	-0.17	1.22	-0.26	0.90	0.813
Overbite (mm)	0.75	0.63	0.58	1.10	0.616
Molar relationship (mm)	0.17	0.99	0.01	0.89	0.631

*Statistically significant at $P<0.05$.

2.2. ARTICLE 2

2.2. ARTICLE 2

OCCLUSAL STABILITY OF NONEXTRACTION CLASS II MALOCCLUSION TREATMENT WITH ELASTICS

Abstract

Introduction: The objective of this study was to compare the long-term occlusal stability after successful therapy of nonextraction Class II malocclusion with elastics and with headgear. **Methods:** A sample of 43 patients with Class II malocclusion was divided into two groups. The elastic group (EG) consisted of 20 patients who were treated with fixed appliances associated with Class II elastics. The headgear group (HG), consisted of 23 patients treated with fixed appliances and extraoral headgear. Pre-, post-treatment, and long-term post-treatment dental casts were evaluated. The long-term intergroup post-treatment changes were compared with paired t-tests. T-tests were used to compare the long-term post-treatment changes between the groups. **Results:** The groups were matched regarding initial age, time of long-term post-treatment evaluation, initial malocclusion severity, quality of treatment result, and all pretreatment cephalometric variables. Patients of the EG presented greater treatment time, were older at the post-treatment and at the long-term post-treatment evaluation stages. During the long-term post-treatment period the marginal ridges alignment showed significant improvement in the EG. The HG also showed significant improvement in the marginal ridges alignment, and in the overjet. Only the overjet showed greater improvement in the HG than in the EG group. **Conclusion:** Nonextraction Class II malocclusion treatment with elastics or with extraoral headgear have similar long-term occlusal post-treatment stability.

INTRODUCTION

It is well known that in orthodontics, seeking a successful finishing of active treatment is not enough, but optimization of the results in the long-term is the main issue. Relapse is a dentoalveolar and skeletal change after orthodontic

treatment towards its original pretreatment position, and relapse tendencies are still present in successfully treated cases.[1]

In general, Class II, division 1 malocclusion correction by elastics produces lingual tipping, retrusion and extrusion of the maxillary incisors, labial tipping and intrusion of the mandibular incisors, mesialization and extrusion of the mandibular molars and slight distalization of maxillary molars[2-7] Thus, orthodontic correction with elastics is achieved almost exclusively by tooth movement. These changes, however, can only be considered satisfactory if they remain stable, as post-treatment tooth movement appears to be inevitable.[8]

To provide an objective evaluation of the occlusal characteristics of patients, several indexes have been reported in the literature.[9-13] The Peer assessment rating (PAR) is an occlusal index that evaluates the initial malocclusion severity and improvement of the case after treatment.[11] The Cast Radiograph Evaluation (C-R Eval), developed by the American Board of orthodontics (ABO), is used to score the final casts and the panoramic radiograph allowing a more specific qualification of the occlusal status.[9,14,15] Although these indexes are not perfect, they provide a more objective, reliable, and reproducible way of assessing the occlusal relationships.[8,13]

A well-finished orthodontic treatment minimizes relapse according to some researchers,[16] while others found that perfectly finished occlusal relationships might not ensure greater post-treatment stability.[8,17,18] The objective of this study was to compare the long-term occlusal stability after successful nonextraction Class II malocclusion treatment with elastics and with headgear, using the Cast-Radiograph evaluation method.

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 estimation was calculated for the difference in Cast-Radiograph Evaluation (C-R Eval) change between the post-treatment and follow-up stages, based on an alpha significance level of 5% and a beta of 20%,

to detect a minimum difference of 4.08 with a standard deviation of 4.40 in the score.[8] The results showed that a minimum of 19 patients were needed for each group.

The sample was retrospectively selected from the files of the Orthodontic Department at Bauru Dental School, University of São Paulo, according to the following criteria: 1) Angle Class II, division 1 malocclusion with a minimum of half Class II molar relationship[19,20] treated nonextraction (excluding third molars), 2) Good occlusal finishing, (established by the Cast-Radiograph Evaluation) and 3) Availability of panoramic radiographs and dental casts at 3 stages (T1, pretreatment; T2, post-treatment; and T3, long-term post-treatment) (Fig 1). The occlusal relationship and cephalometric characteristics at T3 were not considered in sample selection.

Two groups of patients were selected and divided according to the treatment protocol used to correct the Class II malocclusion.

The elastic group consisted of 20 Class II malocclusion patients (11 male; 9 female) treated with Class II elastics to correct the anteroposterior discrepancy. The mechanics consisted of standard fixed Edgewise or Roth pre-adjusted appliances with 0.022 x 0.028–inch slots and a usual wire sequence characterized by an initial 0.015 inch twist-flex or a 0.016 inch nitinol, followed by 0.016, 0.018, 0.020 and 0.019 x 0.025 or 0.018 x 0.025 inch stainless steel archwires. Deep overbites were corrected by reversed and accentuated curve of Spee. Class II anteroposterior discrepancy was corrected with Class II elastics on both sides for at least 6 months, for 15 to 18 hours a day, with a mean force of 200g, measured with a tension gauge. The elastics were used more on one side than the other, when necessary.

The headgear group (HG), consisted of 23 Class II division 1 malocclusion patients (13 male; 10 female), matched regarding age and sex, and followed during a comparable period to the EG long-term post-treatment period (T2-T3). The patients were treated using only with the headgear followed by orthodontic treatment with fixed appliances.

The retention protocol in both groups included a maxillary Hawley retainer worn full time during the first six months and as night-time wear for the

subsequent six months. In the mandibular arch a canine-to-canine bonded retainer was installed and recommended to be used for 3 years. At the long-term post-treatment stage, 16 (80%) patients of the EG and 13 (56.5%) patients of the HG group still worn fixed canine-to-canine retainers.

Cast and Panoramic Radiograph Analysis

The initial malocclusion severity of the groups was evaluated with the US-weighted peer assessment rating (PAR) index[10] and calculated by one examiner on the pretreatment dental study casts of each patient. The scores were weighted for the separate components, and summed to obtain a total score (PAR Index), expressing the malocclusion severity.

Treatment result at T2 and the occlusal status at T3 were evaluated based on the Cast-Radiograph Evaluation method (C-R Eval) developed by the American Association of Orthodontists.[9] This system for scoring dental casts and panoramic radiographs contains eight criteria: alignment, marginal ridges, buccolingual inclination, occlusal relationships, occlusal contacts, overjet, interproximal contacts, and root angulation (Fig. 2). A score greater than 30 is considered a failure. A score less than 30 is generally acceptable; a case that loses 20 points or less would be considered a successfully treated case (Table I).

The occlusal relationship criterion was split up into 8 subcomponents, thus resulting in the following: Second molar relationship, First molar relationship, Second premolar relationship, First premolar relationship and Canine relationship for the right and left buccal occlusions.

Scoring of the occlusal relationship criteria was as follow: the buccal cusps of the maxillary molars must align within 1 mm of the buccal groove of the mandibular molars. Premolars and canines must align within 1 mm of the interproximal embrasures of the mandibular posterior teeth. When the buccal cusp deviated more than 1 mm but less than 2 mm, then 1 point were subtracted for that tooth. If the buccal cusps deviated by more than 2 mm from ideal position, 2 points were subtracted (Table I).[9]

The scores were blindly assigned by a previously calibrated examiner (A.N.).

Error Study

Reproducibility of the measurements was assessed by analyzing the difference between double evaluations with a 30-day interval. A random sample of panoramic radiographs and dental cast were selected and remeasured by the same examiner (A.N). The random error was calculated according to Dahlberg's formula ($Se2 = \sum d2/2n$)[21], where Se^2 is the error variance and d is the difference between two determinations of the same variable. Systematic errors were evaluated with dependent t tests, at $P<0.05$.[22]

Statistical analyses

Normal distribution of the variables was verified with Kolmogorov-Smirnov test. All variables showed normal distributions.

Therefore, group comparability regarding initial, final and long-term post-treatment ages, treatment time, long-term post-treatment time, initial malocclusion severity (PAR Index) and the quality of treatment results in both groups were compared with t-tests. Intergroup sex, severity of Class II malocclusion relationship and presence of canine-to-canine retainer distributions at T3 were compared with chi-square tests. The intergroup post-treatment outcomes, evaluated by individual variables of the C-R Eval, were also compared with t-tests.

The intragroup long-term post-treatment occlusal changes and of its individual variables of the elastic and headgear groups were evaluated with paired t-tests.

The intergroup long-term post-treatment changes obtained by the C-R evaluation and its individual variables were compared with t tests.

The intergroup occlusal relationship changes molars, premolars and canines in the long-term post-treatment period were compared with t tests.

The results were considered significant at $P< 0.05$. The statistical analyses were performed with Statistica for Windows 10 software (Statsoft, Tulsa, Okla).

RESULTS

The random errors of the initial PAR and Cast-Radiograph evaluation (C-R eval) at T2 and T3 were within acceptable levels.[23] Values ranged from 1.07 to 1.74 points for the overall score, respectively.[23] There were no statistically significant systematic errors.

The groups were comparable regarding the initial age, time of long-term post-treatment evaluation, initial PAR index, quality of treatment result (C-R Eval), sex, severity of Class II molar relationship, presence of canine-to-canine retainer distributions at T3 and posttreatment outcomes individual variables (Tables II and III). However, patients of the EG presented greater post-treatment and long-term posttreatment ages and treatment time.

The EG showed significant improvement in marginal ridge alignment in the long-term post-treatment evaluation (Table IV). The HG also showed significant improvement in marginal ridge alignment and in the overjet.

The HG showed significantly greater overjet decrease than the EG in the long-term post-treatment period (Table V).

There were no significant intergroup differences regarding the molar, premolar and canine occlusal relationship changes during the long-term post-treatment period (Table VI).

Because the groups presented different treatment times, additional comparisons with subgroups with similar treatment times were conducted to eliminate any influence of this difference. These comparisons showed similar results to those found with complete groups (Tables VII and VIII).

DISCUSSION

Orthodontic treatment goals are esthetics, comfortable occlusion and excellent occlusal results. However, the real success in orthodontics is to achieve stability of the treatment results in the long-term. This is important not just for the

orthodontist but also for the patient, who is very interested in maintaining the improvement in his or her smile.

There are studies showing that Class II malocclusion treatment can be stable in the long-term and does not depend on the treatment protocol.[24-27] Elastics for Class II malocclusion correction have been widely used, nevertheless, there are some criticisms that treatment results are not stable[28] and there is a need of elucidating the long-term implications of the adverse effects[2,6,29] in long-term with this type of treatment.

During orthodontic treatment with elastics, Class II correction is achieved mostly by dento-alveolar movements with minor skeletal effects, for this reason we decided to evaluate the occlusal changes in long-term post-treatment period.[4,5,29]

The groups were statistically comparable regarding initial age, sex distribution, long-term post-treatment period and the presence of canine-to-canine retainer at T3, since some of these factors could contribute to the stability after orthodontic treatment (Table II). However, treatment time, final age and the age at the long-term post-treatment evaluation stage were greater in the EG, and could interfere in the comparisons of stability. This will be addressed ahead.

The number of patients in the groups appears to be small, but selection criteria for the sample were applied with great demand to attain a homogenous sample. The initial malocclusion severity using the PAR index, the Class II molar relationship severity[20] and the quality of occlusal results at post-treatment (C-R Eval) had to be similar for this comparison (Tables II and III). Therefore, several patients were excluded because they presented only mild Class II malocclusions, or because of poor finishing results.

Related to the quality of treatment result, special attention was dedicated to the sagittal relationship at the post-treatment stage. To evaluate the occlusal stability in long-term post-treatment after Class II malocclusion treatment with elastics and with headgear, all patients selected had to be successfully treated to a Class I sagittal molar and canine relationship, and normal overbite and overjet. Thus, the comparability of the quality of treatment result between the groups

allowed a reliable comparative evaluation of the long-term post-treatment changes.

The PAR index was used as a measure of malocclusion severity. The initial PAR index indicated a mild to moderate malocclusion, and was very similar between the groups.[10] This was expected, as severe Class II malocclusions are usually treated with premolar extractions or even with orthognatic surgery.[30,31]

The long-term post-treatment time was more than 5 years after orthodontic appliances removal in both groups. The mean time of post-treatment evaluation was 6.94 years (SD 4.90) in the elastic group and 5.27 years (SD 2.40) in the headgear group. Accordingly, the stability after orthodontic treatment with both mechanics could be evaluated with high reliability since it is reported in the literature that most occlusal traits relapsed during the first 2 years after treatment, continuing gradually over time until reaching a relative stability only after 5 years.[17]

Concerning the stability of orthodontic treatment results most studies[17,27,32-35] used the peer assessment rating index to assess occlusal stability. However, its interpretation does not allow knowing the specific location of relapse, which was the main point of interest in our study.

The C-R Eval as defined by the ABO, is widely used to assess the occlusal and radiographic quality of orthodontic treatment outcome.[9,13,36-39] In clinical studies it has been use to compare the quality of outcomes achieved by different treatment modalities.[14,15] In this work, we decided to use the C-R Eval to define the quality of treatment result at post-treatment as a criterion for sample selection, and later to compare the occlusal status in the long-term post-treatment dental casts.

This index provides an objective and precise protocol, using a point system with specific criteria in terms of finishing and detailing.[9] The ABO measuring gauge used allowed standardization of the measurements and ensured a relatively high intraexaminer agreement, showing good reliability.

There are some investigations that already used the ABO C-R Eval to measure long-term relapse.[8,40,41] For a better understanding of the behavior of

the occlusal changes with the C-R Eval during the long-term post-treatment period, each component was individually evaluated in both groups.

Overall, the total C-R Eval scores for the EG and HG numerically improved during the post-treatment period, although the magnitude of this improvement might not be clinically significant. Probably, most of the occlusal characteristics improved due to the natural settling of the teeth after orthodontic appliances removal.

Regarding the long-term post-treatment changes of alignment, no significant intragroup change was found in any group (Table IV). This is important because tooth alignment is one of the factors that patients perceive more easily and is commonly a main complaint.

There was significant improvement in marginal ridge leveling in the EG and in the HG, indicating fewer height discrepancies between adjacent marginal ridge heights (Table IV).

Buccolingual inclinations did not show changes in the EG, and in the HG showed signs of worsening, and this coincides with previous studies,[8,41,42] most authors suggest that buccolingual inclination does not depend on settling.[8,42]

There was a tendency of improvement regarding the posterior occlusal contacts in both groups. Both groups showed more teeth in contact in the long-term post-treatment cast. Probably, the improvement in marginal ridge heights helped to establish proper occlusal contacts. Nett et. al.[8] suggested that marginal ridges and occlusal contacts settle after treatment.

No significant intragroup changes occurred in the occlusal relationships in both groups (Table IV). This was expected, as we evaluated successfully treated cases and in general well-finished patients showed better absolute occlusal relationship over time.[8,18,33] However, we are not suggesting that perfect finishing occlusal relationships ensure greater post-treatment stability.

The overjet in the EG did not show significant changes during the long-term post-treatment period, but significantly decreased in the HG. This improvement in overjet in the HG can be explained by the natural growth changes of the mandible during the post-treatment period which includes the peak of the

pubertal growth spurt,[43] as patients of the HG were significantly younger than patients of the EG.

Root angulation during the long-term post-treatment did not show significant intragroup changes in both groups, showing stability of individual tooth positioning.[9]

The only significant intergroup change was the overjet that showed significantly greater decrease in the HG than in the EG (Tables V and VI). The possible explanation for this was the younger age of the HG patients at the end of treatment. The greater growth potential might have contributed for this intergroup difference. All the other components changes were similar in the groups.

To evaluate the sagittal correction with the elastics or headgear, the occlusal relationship criteria was used. The occlusal relationship component of the C-R Eval was evaluated with details. Molars, premolars and canine relationship did not show significant changes between the groups (Table VI).

As treatment time could have had influence on the stability, it was decided to compare the long-term post-treatment changes, including subgroups with only patients with comparable treatment time. The results were similar to the complete groups (Tables VII and VIII).

All patients had the same retention protocol (Hawley plate and canine-to-canine retainer). When evaluating these changes, however, it has to be taken into account that 16 patients of the EG and 13 patients the HG still wore fixed mandibular canine-to-canine retainers at T3. Nevertheless, in spite of the use of fixed retainers in the long-term, occlusal relapse can be expected.[44] The presence of retainers seems unlikely to have influence on the stability of sagittal relationships, but might be beneficial for maintaining overjet and alignment stability.

The patients in this study were well finalized, all accomplished high standards according to the American Board of Orthodontics, and patients presented better occlusal relationship at the long-term post-treatment stage. This indicated that the achieved orthodontic treatment outcome as measure by the C-R Eval remained stable at the long-term post-treatment stage.

Our results are in agreement with the results of Nett et. al.[8] and Kuncio et. al.[40], that found that overall C-R Eval scores also improved and still had better absolute occlusal relationships at long-term post-treatment.

These results confirm most studies that showed good stability of Class II correction. Class II correction stability does not depend on the treatment protocol. It can be stated based on these results, that long-term occlusal stability of Class II malocclusion correction with Class II elastics is similar to treatment with headgear.

CONCLUSION

- Overall, treatment of Class II malocclusions with elastics or with headgear appliances had similar long-term post-treatment occlusal stability.

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FIGURE LEGENDS

Fig 1. A – Dental casts at 3 stages: pretreatment; post-treatment; and long-term post-treatment of Class II malocclusion treatment with Class II intermaxillary elastics. B - Dental casts at 3 stages: pretreatment; post-treatment; and long-term post-treatment of Class II malocclusion treatment with extraoral headgear.

Fig 2. Cast-Radiograph Evaluation: A) Alignment, B) Marginal ridges, C) Buccolingual inclination, D) Occlusal contacts, E) Occlusal relationships, F) Interproximal contacts, G) Overjet, and H) Root angulation.[9]

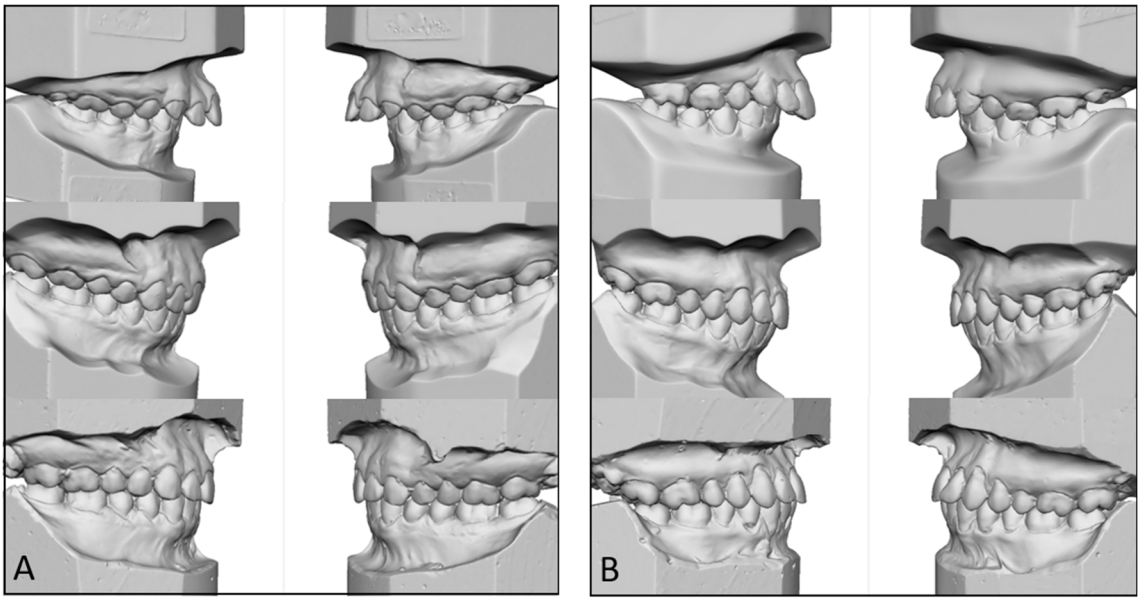

Figure 1.

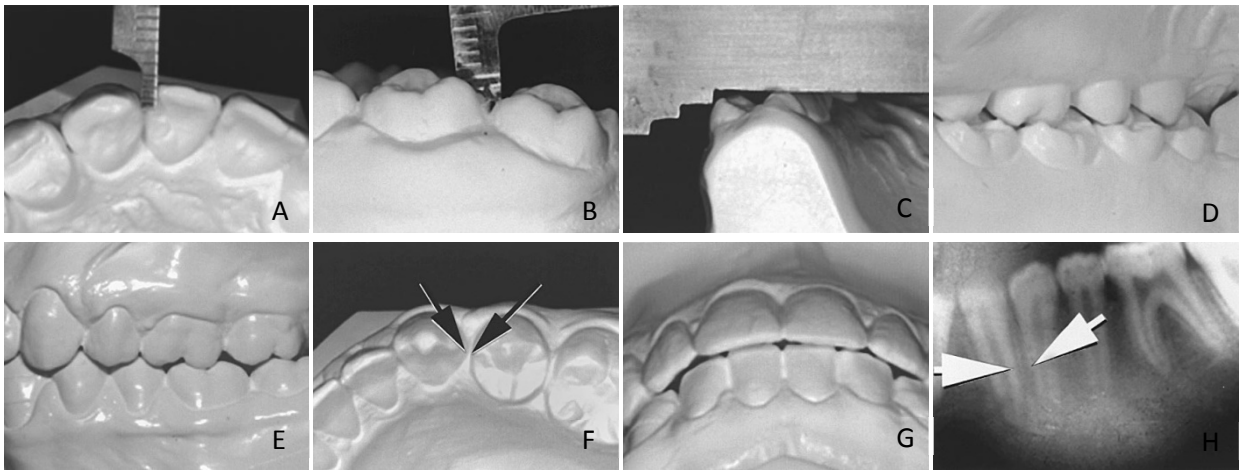

Figure 2.

Table I. ABO Grading System for the Cast-Radiograph Evaluation [9]

Component	Deviation from normality	Points deduction
Alignment	0.5 to 1 mm	1 for each deviated tooth
	1mm or more	2 for each deviated tooth
Marginal Ridges	0.5 to 1 mm	1 for each posterior interproximal contact
	1mm or more	2 for each posterior interproximal contact
Buccolingual Inclination	1.1 to 2mm	1 for each posterior tooth
	2mm or more	2 for each posterior tooth
Occlusal Contacts	Up to 1 mm	1 for each posterior tooth without contact
	1 mm or more	2 for each posterior tooth without contact
Occlusal Relationship	1 to 2 mm	1 for each upper tooth: cuspid to second molar
	2 mm or more	2 for each upper tooth: cuspid to second molar
Interproximal Contacts	0.6 to 1 mm	1 for each interproximal contact
	More than 1 mm	2 for each interproximal contact
Overjet	Up to 1 mm	1 for each upper tooth without contact
	More than 1 mm	2 for each upper tooth without contact
Root Angulation	Non parallel roots	1 for each root
	Root contact adjacet tooth	2 for each root

Table II. Initial intergroup data comparison (T and Chi-square tests)

Variables	Elastic Group (n = 20) Mean / SD	Headgear Group (n = 23) Mean / SD	p
Initial age T1 (years)	14.14 / 5.62	12.14 / 1.21	0.209†
Final age T2 (years)	17.26 / 5.50	14.61 / 1.25	0.030*†
Age at long-term post-treatment evaluation (T3) (years)	24.36 / 6.19	19.88 / 2.72	0.003*†
Treatment time (years)	3.12 / 1.12	2.47 / 0.83	0.036*†
Time of long-term post-treatment evaluation (years)	6.95 / 4.90	5.19 / 2.38	0.153†
Initial PAR (Peer Assesment rating)	33.15 / 9.21	33.0 / 10.35	0.960†
C-R eval T2 (Quality of treatment result)	19.75 / 5.92	20.39 / 8.63	0.781†
Sex **Male** **Female**	 11 9	 13 10	0.920‡
Severity of Molar relationship **Complete Class II** **Half Class II**	 9 11	 11 12	0.852‡
Canine-to-canine retainer at T3 **Still wearing** **Not wearing**	 15 5	 13 10	1.632‡

*Statistically significant at $P<0.05$.
†t test; ‡chi-square test.

Table III. Intergroup comparison of post-treatment outcomes by individual variables (T-tests)

Variables	Elastic Group (n = 20) Mean / SD		Headgear Group (n = 23) Mean / SD		p
Alignment	1.3	1.4	1.9	2.5	0.336
Marginal Ridges	3.5	1.6	3.0	3.3	0.578
Buccolingual Inclination	6.7	4.4	7.2	2.9	0.613
Occlusal Contacts	1.0	2.0	1.9	2.2	0.164
Occlusal Relationship	2.9	4.0	1.8	3.1	0.352
Interproximal Contacts	0.6	1.4	0.2	0.7	0.263
Overjet	3.9	3.4	4.3	3.4	0.635
Root Angulation	0.1	0.4	0.0	0.0	0.289

Table IV. Occlusal long-term post-treatment changes of the groups (Paired t tests)

Variables	Elastic group (n = 20)					Headgear group (n = 23)				
	Post-treatment Mean / SD		Long-term Post-treatment Mean / SD		p	Post-treatment Mean / SD		Long-term Post-treatment Mean / SD		p
C-R eval	19.8	5.9	18.2	8.9	0.293	20.4	8.6	17.1	8.5	0.104
Alignment	1.3	1.4	1.4	2.0	0.793	1.9	2.5	2.9	2.3	0.063
Marginal Ridges	3.5	1.6	1.7	1.5	0.000*	3.0	3.3	1.3	2.2	0.002*
Buccolingual Inclination	6.7	4.4	6.7	4.5	1.000	7.2	2.9	8.2	3.7	0.094
Occlusal Contacts	1.0	2.0	0.8	1.9	0.731	1.9	2.2	1.3	1.9	0.200
Occlusal Relationship	2.9	4.0	3.1	3.3	0.741	1.8	3.1	1.0	2.0	0.123
Interproximal Contacts	0.6	1.4	0.1	0.2	0.144	0.2	0.7	0.3	0.7	0.649
Overjet	3.9	3.4	3.9	3.7	0.947	4.3	3.4	2.2	3.5	0.006*
Root Angulation	0.1	0.4	0.0	0.0	0.330	0.0	0.0	0.0	0.0	0.000

*Statistically significant at $P<0.05$.

Table V. Intergroup comparisons of long-term post-treatment changes of the C-R evaluation index and its individual variables (T-tests)

Variables	Elastic Group (n = 20) Mean / SD		Headgear Group (n = 23) Mean / SD		p
C-R eval post-treatment changes (T3 – T2)	-1.60	6.61	-3.30	9.34	0.500
Alignment	0.1	1.7	1.0	2.4	0.174
Marginal Ridges	-1.8	1.7	-1.7	2.3	0.876
Buccolingual Inclination	0.0	3.6	1.0	2.6	0.319
Occlusal Contacts	-0.2	2.6	-0.7	2.4	0.551
Occlusal Relationship	0.2	2.7	-0.9	2.6	0.191
Interproximal Contacts	-0.5	1.5	0.1	0.9	0.117
Overjet	0.1	3.3	-2.2	3.4	0.038*
Root Angulation	-0.1	0.4	0.0	0.0	0.289

*Statistically significant at $P<0.05$.

Table VI. Intergroup comparisons of long-term post-treatment individual occlusal relationship changes of the C-R evaluation index (T-tests)

Occlusal Relationship	Elastic Group (n = 20) Mean / SD		Headgear Group (n = 23) Mean / SD		p
Right					
Second molar relationship	0.0	0.0	0.0	0.0	0
First molar relationship	0.0	0.3	-0.2	0.6	0.239
Second premolar relationship	-0.1	0.7	-0.2	0.6	0.710
First premolar relationship	-0.3	1.0	-0.3	0.7	0.833
Canine relationship	-0.2	0.9	-0.2	0.8	0.919
Left					
Canine relationship	-0.1	0.7	0.0	0.7	0.656
First premolar relationship	-0.2	0.8	-0.1	0.3	0.545
Second premolar relationship	-0.2	0.8	0.0	0.2	0.547
First molar relationship	-0.1	0.8	-0.1	0.7	0.872
Second molar relationship	0.2	0.5	0.0	0.2	0.092

*Statistically significant at $P<0.05$.

Table VII. Intergroup data comparison in subgroups with comparable treatment times (T tests)

Variables	Elastic Group (n = 15) Mean / SD	Headgear Group (n = 15) Mean / SD	p
Initial age T1 (years)	14.73 / 6.09	12.40 / 1.40	0.158†
Final age T2 (years)	17.85 / 6.29	15.06 / 1.19	0.102†
Age at long-term post-treatment evaluation (T3) (years)	25.37 / 6.31	20.14 / 2.57	0.006*†
Treatment time (years)	2.69 / 0.98	2.77 / 0.87	0.819†
Time of long-term post-treatment evaluation (years)	7.36 / 5.02	5.08 / 2.44	0.124†
Initial PAR (Peer Assesment rating)	33.2 / 9.38	33.5 / 9.64	0.960†
C-R eval T2 (Quality of treatment result)	20.00 / 5.16	19.80 / 9.72	0.944†
Sex **Male** **Female**	 7 8	 7 8	1.000‡
Severity of Molar relationship **Complete Class II** **Half Class II**	 7 8	 7 8	0.715‡
Canine-to-canine retainer at T3 **Still wearing** **Not wearing**	 12 3	 5 9	0.015*‡

*Statistically significant at $P<0.05$.
†t test; ‡chi-square test.

Table VIII. Intergroup comparisons of long-term post-treatment changes of individual variables of the C-R evaluation index in subgroups with comparable treatment times (T-tests)

Variables	Elastic Group (n = 15) Mean / SD		Headgear Group (n = 15) Mean / SD		p
C-R eval post-treatment changes (T3 – T2)	-0.73	6.60	-5.13	6.74	0.081
Alignment	0.21	1.67	0.44	1.75	0.725
Marginal Ridges	-1.36	1.39	-2.13	1.67	0.186
Buccolingual Inclination	0.43	3.55	0.56	1.75	0.894
Occlusal Contacts	-0.14	3.06	-0.88	1.63	0.369
Occlusal Relationship	0.00	2.72	-0.88	2.53	0.412
Interproximal Contacts	-0.71	1.73	0.19	0.54	0.057
Overjet	0.36	3.84	-2.69	3.61	0.033*
Root Angulation	-0.14	0.53	0.00	0.00	0.293

*Statistically significant at $P<0.05$.

3. DISCUSSION

3. DISCUSSION

Obtaining a successful result and maintaining it in the long-term are equally important. Our results showed that successful treatment of Class II malocclusions with intermaxillary elastic or with headgear appliance had similar long-term post-treatment stability.

Sample

The number of patients in both groups is relatively small. The number was reduced because many treated patients did not have a minimum of long-term post-treatment time or patients did not have the complete long-term post-treatment records. We made an effort to recall these patients, but they could not be located, were living too far away, had scheduling conflicts, or simply refused to participate for unspecified reasons. In spite of that, sample size can be regarded as acceptable considering that there was an average of over 6 years between the end of active orthodontic treatment and the follow-up examination.

Selection criteria for the sample were applied rigidly to attain a homogenous sample. As the objective of this study was to evaluate the long-term stability after successful treatment of nonextraction Class II malocclusion with elastics, the quality of occlusal results at post-treatment (C-R Eval) were determinant to included patients in each group.

Method

The PAR index was used as a measure of malocclusion severity. The initial PAR index indicated a mild to moderate malocclusion, being very similar between the groups. Concerning the stability of orthodontic treatment results most studies used the peer assessment rating index for assessment of occlusal stability (AL YAMI; KUIJPERS-JAGTMAN; VAN 'T HOF, 1999; BOCK et al., 2017). However the C-R Eval is an index that provides an objective and precise protocol of the occlusal evaluation (CASKO et al., 1998) and has been shown as a more sensitive index in assessing occlusal changes (KAMAL; SHAIKH; FIDA, 1999;). Moreover the same index includes the analyses of root inclination in panoramic radiograph.A single examiner (A.N.) measured all casts at each time period after

being calibrated for both the PAR and C-R Eval. To control for bias, identity of the cast was undisclosed, so the examiner did not know for which group the cast pertain.

Cephalometric and occlusal treatment results with Class II elastics

After treatment both groups showed similar changes. In the HG treatment produced a significant reduction of maxillary protrusion. There were increases in effective mandibular length and anterior facial height after treatment in both groups, being smaller in the EG. Regarding the dentoalveolar changes after treatment, there was a smaller maxillary first molar extrusion, greater mesialization of the mandibular molars and mandibular incisor protrusion, and smaller mandibular incisor extrusion in the EG.

The average of the C-R Eval after active orthodontic treatment was 19.75 (5.92) in the EG, this indicated a high standard quality of treatment, as is stated that a case report that loses less than 20 points will generally pass the ABO phase III examination (CASKO et al., 1998).

Long-term post-treatment changes

All patients were successfully treated to Class I sagittal molar and canine, and normal overjet and overbite. When evaluating the stability of the results, 16 (80%) patients of the EG and 13 (56.5%) patients the HG still worn fixed canine-to-canine retainers at T3. However, long-time wear of fixed retainers may not prevent a certain amount of unwanted occlusal changes after orthodontic treatment (STEINNES; JOHNSEN; KEROSUO, 2017).

Comparing the behavior of the groups during long-term post-treatment, both showed similar changes for most variables with the exception of the position of the mandible related to the cranial base (SNB) that was significantly different between the groups. In the EG the position of the mandible remained statistically stable, numerically, the SNB angle decreased 0.31 degrees. In the HG the same angle increased 0.67 degrees during the long-term period, causing statistical difference between the groups. However, this difference was too small to be considered clinically significant.

Overall, the total C-R Eval score for the EG and HG improved at post-treatment period, although the magnitude of this improvement might not be clinically significant. Our results are in agreement with the results of Nett et. al. 2005 and Kuncio et. al. 2007, that found that overall C-R Eval scores also improved and still had better absolute occlusal relationships at long-term post-treatment.

Based on these results, it can be generally inferred that there was similar stability for both treatment protocols of Class II malocclusions.

4. CONCLUSION

4. CONCLUSION

Overall, treatment of Class II malocclusions with intermaxillary elastic or with headgear appliance had similar long-term post-treatment cephalometric and occlusal stability.

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6. APPENDIXES

DECLARATION OF THE USE OF THE ARTICLE IN THESIS

We hereby declare that we are aware that the article “Cephalometric stability of Class II malocclusion treatment with elastics¨ will be included in the thesis of the student Ana Liesel Guggiari Niederberger 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.

Ana Liesel Guggiari Niederberger _____
Signature

Guilherme Janson _____
Signature

DECLARATION OF THE USE OF THE ARTICLE IN THESIS

We hereby declare that we are aware that the article “Occlusal stability of Class II malocclusion treatment with elastics” will be included in the thesis of the student Ana Liesel Guggiari Niederberger 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.

Ana Liesel Guggiari Niederberger _____
Signature

Guilherme Janson _____
Signature

7. ANNEX

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Avaliação da estabilidade do tratamento da má oclusão de Classe II sem extrações com uso de elásticos

Pesquisador: Ana Liesel Guggiari Niederberger

Área Temática:

Versão: 1

CAAE: 65047717.7.0000.5417

Instituição Proponente: Universidade de Sao Paulo

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 1.959.582

Apresentação do Projeto:

O projeto de pesquisa "Avaliação da estabilidade do tratamento da má oclusão de Classe II sem extrações com uso de elásticos" apresenta como pesquisador responsável Ana Liesel Guggiari Niederberger, e como orientador e integrante da equipe de pesquisa o Prof. Dr. Guilherme dos Reis Pereira Janson. É um estudo observacional retrospectivo que visa avaliar a estabilidade em longo prazo do tratamento ortodôntico sem extrações da Classe II com elásticos intermaxilares finalizados com sucesso. Para isso serão realizadas avaliações cefalométricas e oclusais de 25 casos tratados com elásticos de Classe II e 25 casos controle, e serão utilizadas telerradiografias laterais e modelos de estudo tomados no início e no final do tratamento e tomados após do término do mesmo.

Objetivo da Pesquisa:

Este estudo apresenta como objetivo avaliar a estabilidade em longo prazo do tratamento ortodôntico sem extrações da Classe II com elásticos intermaxilares finalizados com sucesso.

Avaliação dos Riscos e Benefícios:

Riscos:

Essa pesquisa não gera riscos nos pacientes já que todos os tratamentos foram finalizados e os pesquisadores não tem mais contato com os mesmos.

Benefícios:
Os beneficios desse trabalho se basam primeramente, no resultado que o tratamento gera aos pacientes em longo prazo, e ao mesmo tempo, buscar respostas para os ortodontistas, em relação ao tipo da mecânica ortodôntica que pode ser utilizada para a correção de uma má oclusão de Classe II.

Comentários e Considerações sobre a Pesquisa:
A pesquisa não apresenta comprometimento ético. Está bem descrita e detalhada, assim como faz parte da linha de pesquisa do orientador.

Considerações sobre os Termos de apresentação obrigatória:
Todos os termos obrigatórios foram apresentados. Pede dispensa de TCLE argumentando que todos os pacientes assinaram o TCLE quando eles iniciaram o tratamento anos atrás. Os pesquisadores já não tem contato com os pacientes que serão selecionados já que os mesmos foram tratados no passado (década de 90).

Recomendações:
Sem recomendações.

Conclusões ou Pendências e Lista de Inadequações:
Sugiro aprovação.

Considerações Finais a critério do CEP:
Esse projeto foi considerado APROVADO na reunião ordinária do CEP de 18.03.2017, 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, 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	PB_INFORMAÇÕES_BÁSICAS_DO_P	16/02/2017		Aceito

Básicas do Projeto	ETO_855332.pdf	00:48:58		Aceito
Folha de Rosto	Folha_de_rosto.pdf	16/02/2017 00:47:19	Ana Liesel Guggiari Niederberger	Aceito
Outros	cep_docs_proj_pesquisa_termo_de_aquiescencia.pdf	16/02/2017 00:32:05	Ana Liesel Guggiari Niederberger	Aceito
Outros	cep_docs_proj_pesquisa_carta_de_encaminhamento.pdf	16/02/2017 00:31:22	Ana Liesel Guggiari Niederberger	Aceito
Declaração de Instituição e Infraestrutura	Autorizacao_uso_arquivo.pdf	13/02/2017 14:03:29	Ana Liesel Guggiari Niederberger	Aceito
Outros	QuestionarioTecnicoPesquisador.pdf	13/02/2017 14:00:09	Ana Liesel Guggiari Niederberger	Aceito
Declaração de Pesquisadores	DeclaracaoCompromissoPesquisadorResultadosPesquisa.pdf	13/02/2017 13:55:50	Ana Liesel Guggiari Niederberger	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	Documento_Justificativa_Dispensa_TCLE.pdf	13/02/2017 13:55:22	Ana Liesel Guggiari Niederberger	Aceito
Projeto Detalhado / Brochura Investigador	AnaProjeto.pdf	13/02/2017 11:31:28	Ana Liesel Guggiari Niederberger	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

BAURU, 10 de Março de 2017

Assinado por:
Ana Lúcia Pompéia Fraga de Almeida
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