UNIVERSIDADE DE SÃO PAULO
FACULDADE DE ODONTOLOGIA DE BAURU

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Relapse of maxillary anterior crowding: short- and long-term study

Recidiva do apinhamento anterossuperior: um estudo em curto e longo prazo

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Orientador: Prof. Dr. Marcos Roberto de Freitas

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Dedico este trabalho

Primeiramente à Deus pela contínua proteção e pelas inúmeras graças alcançadas.

Aos meus queridos pais, JUAREZ e VÂNIA:

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Ao meu querido irmão TIAGO:

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Você representa fielmente o significado da palavra irmão.

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1 INTRODUCTION

1 INTRODUCTION

Orthodontic treatment has several objectives, and the stability of the corrections achieved is one of the most important. There is a consensus in the orthodontic literature that some occlusal changes will inevitably occur after the orthodontic treatment (LITTLE, 1990; PARKER, 1989; SINCLAIR; LITTLE, 1983). It would be of great benefit to orthodontists the possibility of a detailed prediction and prevention of different occlusal changes after orthodontic treatment. For this reason, the effects of various factors of diagnosis and treatment on the occlusal stability in the short- and long-term have been extensively researched (CANUTO et al., 2010; ERDINC; NANDA; ISIKSAL, 2006; FREITAS et al., 2007; GARDNER; HARRIS; VADEN, 1998; GUIRRO et al., 2016; VADEN; HARRIS; GARDNER, 1997).

Little, Riedel e Artun (LITTLE; RIEDEL; ARTUN, 1988), evaluated relapse of mandibular anterior crowding in 31 cases treated with 4-premolar extraction, 10 and 20 years postretention. Crowding continue to increase in the phase from 10 to 20 years postretention. Only 10% of the cases presented a clinically acceptable mandibular anterior alignment at the last evaluation. The authors did not evaluate maxillary anterior crowding relapse.

Vaden, Harris and Gardner (VADEN; HARRIS; GARDNER, 1997) assessed the changes in irregularity of the maxillary and mandibular incisors and dental arch dimensions 6 to 15 years after the removal of retainers. The sample consisted of 36 patients treated with extraction by the clinician same. It was observed that both the maxillary and mandibular arches showed some reduction. After 15 years of the end of treatment, the results showed a reduction of only 0.3 mm in the irregularity of the maxillary incisors, which corresponded to 96% of stability of the crowding correction during treatment. Overall, 90% of patients showed postretention occlusion condition better than the pretreatment one.

Dyer, Vaden and Harris (DYER; VADEN; HARRIS, 2012) conducted a long-term study to evaluate the stability 25 years after treatment, however, the sample consisted of women subjects only. The results showed that the irregularity of the mandibular incisors in the long term was less than 3.5 mm in 77% of patients. The

correction of the maxillary crowding was relatively stable in the long term. The authors concluded that orthodontic treatment can produce reasonably good long-term stability in both the occlusal correction as in teeth alignment.

As mentioned, the long-term stability of orthodontic corrections has been widely studied. However, most studies had evaluated the stability only a few years after treatment, and are focused mainly in mandibular anterior crowding relapse. There is lack of long-term studies, comparing with the short-term posttreatment changes, regarding maxillary anterior crowding stability.

There are controversies in the literature regarding the long-term posttreatment maxillary crowding relapse in different types of malocclusions, Class I and Class II (GUIRRO et al., 2016; ORMISTON et al., 2005; UHDE; SADOWSKY; BEGOLE, 1983). Ormiston et al. (ORMISTON et al., 2005) affirmed that Class II subjects are about twice as likely to be unstable during long-term posttreatment when compared to Class I subjects. However, other studies found no significant differences in stability of maxillary anterior crowding treatment in Class I and Class II subjects (GUIRRO et al., 2016; UHDE; SADOWSKY; BEGOLE, 1983).

However, there are really few long-term studies with follow-up of 15 years or more evaluating the maxillary crowding relapse. Vaden, Harris and Gardner (VADEN; HARRIS; GARDNER, 1997) assessed the changes in irregularity of the maxillary and mandibular incisors 6 to 15 years after the removal of retainers. After 15 years of the end of treatment, the results showed a reduction of only 0.3 mm in the irregularity of the maxillary incisors, which corresponded to 96% of stability of the crowding correction during treatment. Dyer, Vaden and Harris (DYER; VADEN; HARRIS, 2012) conducted a long-term study to evaluate the stability 25 years after treatment in women subjects. The correction of the maxillary crowding was relatively stable in the long-term.

Therefore, this research aimed to evaluate the relapse of maxillary anterior crowding in the short- and long-term, 5 and 35 years posttreatment, and compare this relapse in Class I and Class II malocclusions.

2 ARTICLES

2 ARTICLES

2.1 Article 1

The article presented in this thesis was written according to the *American Journal of Orthodontics and Dentofacial Orthopedics* instructions and guidelines for article submission.

Relapse of maxillary anterior crowding: short- and long-term study

ABSTRACT

Objective: The aim of this study was to evaluate the relapse of maxillary anterior crowding in the short and long-term, 5 and 35 years posttreatment. **Material and methods:** The sample comprised 28 patients, 15 Class I and 13 Class II, treated with 4 premolars extraction, with mean initial age of 12.72 years (s.d.=0.99), final age of 14.74 years (s.d.=1.26) and mean treatment time of 2.02 years (s.d.=0.66). The mean short-term posttreatment age was 20.15 years (s.d.=1.34), and long-term was 49.40 years (s.d.=4.54). The mean time of short-term posttreatment evaluation was 5.40 years (s.d.=0.43) and long-term was 34.65 years (s.d.=4.25). The modified Little irregularity index for maxillary arch was assessed, in the dental casts of initial, final, short- and long-term posttreatment stages. Little index was compared among the 4 stages by repeated measures ANOVA and Tukey tests. Correlation between initial Little index and short- and long-term relapse of this index was verified with Pearson correlation test. **Results:** The maxillary anterior crowding was significantly corrected with treatment, presented a significant relapse in the short-term of 2.59mm, and presented a slight and not statistically significant increase of 0.41mm from short- to long-term posttreatment evaluation. The severity of initial maxillary anterior crowding was not correlated to short- and long-term relapse. **Conclusions:** The maxillary anterior crowding presented a significant relapse in the short-term and remained stable from short- to long-term posttreatment evaluation, 35 years after the end of active orthodontic treatment.

Key-words: Orthodontics, Relapse, Stability.

Introduction and statement of the problem

Orthodontic treatment has several objectives, and the stability of the corrections achieved is one of the most important. There is a consensus in the orthodontic literature that some occlusal changes will inevitably occur after the orthodontic treatment.[1-3] It would be of great benefit to orthodontists the possibility of a detailed prediction and prevention of different occlusal changes after orthodontic treatment. For this reason, the effects of various factors of diagnosis and treatment on the occlusal stability in the short- and long-term have been extensively researched.[4-9]

There are not a lot of studies in orthodontic literature that evaluated the maxillary crowding relapse in the short- and long-term.[5,7-18] It seems that the amount of maxillary incisor irregularity long-term out of retention is smaller than that seen before treatment.[12,16-18]

Little, Riedel e Artun[19], evaluated relapse of mandibular anterior crowding in 31 cases treated with 4-premolar extraction, 10 and 20 years postretention. Crowding continue to increase in the phase from 10 to 20 years postretention. Only 10% of the cases presented a clinically acceptable mandibular anterior alignment at the last evaluation. The authors did not evaluate maxillary anterior crowding relapse.

Vaden, Harris and Gardner[5] assessed the changes in irregularity of the maxillary and mandibular incisors and dental arch dimensions 6 to 15 years after the removal of retainers. The sample consisted of 36 patients treated with extraction by the clinician same. It was observed that both the maxillary and mandibular arches showed some reduction. After 15 years of the end of treatment, the results showed a reduction of only 0.3 mm in the irregularity of the maxillary incisors, which corresponded to 96% of stability of the crowding correction during treatment. Overall, 90% of patients showed postretention occlusion condition better than the pretreatment one.

Dyer, Vaden and Harris[20] conducted a long-term study to evaluate the stability 25 years after treatment, however, the sample consisted of women subjects only. The results showed that the irregularity of the mandibular incisors in the long term was less than 3.5 mm in 77% of patients. The correction of the maxillary crowding was relatively stable in the long term. The authors concluded that orthodontic

treatment can produce reasonably good long-term stability in both the occlusal correction as in teeth alignment.

As mentioned, the long-term stability of orthodontic corrections has been widely studied. However, most studies had evaluated the stability only a few years after treatment, and are focused mainly in mandibular anterior crowding relapse. There is lack of long-term studies, comparing with the short-term posttreatment changes, regarding maxillary anterior crowding stability.

Therefore, the present study aimed to evaluate the relapse of maxillary anterior crowding in the short- and long-term, 5 and 35 years posttreatment.

Material and Methods

Material

The present study was approved by the Ethics Committee in Humans Research of the Bauru Dental School, University of São Paulo.

The sample size calculation was based on an alpha significance level of 5% (0.05) and a beta of 20% (0.20) to achieve a 80% power of the test to detect a mean difference of 0.89mm with standard deviation of 1.17 for the maxillary irregularity index.[20] Thus, the sample size calculation showed the need for 28 individuals.

The sample comprised the retrospective records of subjects treated by graduate students at Bauru Dental School, University of São Paulo, chosen according to the following criteria:

- Class I or Class II malocclusion present at the beginning of orthodontic treatment;
- Treatment protocol with extraction of the four first premolars;
- Complete course of orthodontic treatment with full maxillary and mandibular fixed appliances (slot 0.022” x 0.028”), with Edgewise mechanics;
- All permanent teeth erupted up to the first molars, at the pretreatment stage;
- Absence of tooth agenesis and anomalies;
- Maxillary removable appliance (Hawley), worn for one year, and mandibular fixed canine to canine retainers worn for at least one year, and a maximum of 3 years posttreatment, and no retention at the time of the follow-up records;
- Pretreatment (T1), posttreatment (T2) and approximately 5-years posttreatment (T3) dental casts available at the time of the study, when subjects were called for a

new follow-up that should be at least 20 years after the end of orthodontic treatment (T4).

The sample comprised 28 subjects of both sexes (9 male; 19 female). The ages, treatment time and times of short and long-term posttreatment evaluation are described in Table 1. The mandibular 3x3 was used, on average, 1.70 years (s.d. 0.60, minimum 0.79, maximum 3.33).

Methods

Pretreatment (T1), posttreatment (T2), short-term postretention (T3) and long-term posttreatment (T4) dental casts were used. The modified Little irregularity index[8,21] was accessed in dental casts (Figure 1), with a 0.01mm precision digital caliper (Mitutoyo America, Aurora, Illinois) by one calibrated examiner (WJGG).

The modified Little irregularity index is the summed displacement of the five anatomic contact points of the maxillary anterior teeth (from right maxillary canine to left maxillary canine). The irregularity index scoring represents a planar distance between the vertical projections of the anatomic contact points of adjacent teeth. To ensure recording horizontal displacement, the caliper should be parallel to the occlusal plane.

The difference between the initial and final values of the maxillary index (T2-1) was calculated to express the amount of correction with treatment. The difference was calculated from the short and long-term posttreatment with the final stage of the maxillary Little index (T3-2 and T4-2), to express the amount of changes after orthodontic treatment in the two follow-up evaluations performed. It was also calculated the difference between the two stages short and long-term posttreatment (T4-3) to evaluate the changes between these two phases.

Error study

After a month interval from the first measurement, the dental casts of 10 subjects (40 pairs of dental casts) were randomly selected and re-measured by the same examiner (WJGG). The casual error was calculated according to Dahlberg's[22] formula ($Se^2 = \Sigma d^2/2n$), and the systematic error with dependent t tests, for $p<0.05$.

Statistical analysis

Descriptive statistics were performed (mean, standard deviation, maximum and minimum) for the initial, final, short and long-term posttreatment ages, treatment time, retention time and time of short and long-term posttreatment evaluations, and the maxillary Little irregularity index (Mx LII) at the stages T1, T2, T3 and T4 and also in the periods evaluated (T2-1, T3-2, T4-3, T4-2).

The normality of the data was checked and confirmed using the Kolmogorov-Smirnov test for the whole sample and for groups.

In order to evaluate changes in Mx Little irregularity index among the four stages evaluated (T1, T2, T3 and T4), the repeated measures ANOVA and Tukey tests were used.

It was verified the presence of correlation between the initial Mx LII and short-, long-term and relapse of Mx LII (T3-2, T4-2 and T4-3), using the Pearson's correlation test.

All tests were performed with the Statistica software (Statistica for Windows, version 7.0, Copyright StatSoft, Inc., Tulsa, Oklahoma, USA, 2005), with a significance level of 5% ($P < 0.05$).

Results

There was no systematic error and casual errors varied from 0.12mm for the final maxillary Little irregularity index (Mx LII T2) to 0.47 for the initial maxillary Little irregularity index (Mx LII T1).

Short-term relapse of maxillary anterior crowding was 2.18mm and long-term relapse was 2.59mm, showing only an increase of 0.41mm from short- to long-term posttreatment evaluation (Table 2).

The maxillary anterior crowding was significantly corrected with treatment, presented a significant relapse in the short-term, and remained stable from short- to long-term posttreatment evaluation (Table 3).

The severity of initial maxillary anterior crowding was not correlated to short- and long-term relapse (Table 4).

Discussion

For a more homogeneous sample, some selection criteria were adopted. It was standardized the initial malocclusion, the treatment protocol used, and the type of orthodontic mechanics used. Accordingly, the stability results achieved with orthodontic treatment can be evaluated with increased reliability.

The time of short-term evaluation is in consonance with literature regarding evaluation of stability of orthodontic correction, since approximately half of the total relapse observed occurs in the first two years after the end of active orthodontic treatment, with good stability of the main characteristics after 5-years posttreatment.[23]

The long-term evaluation time of almost 35 years posttreatment is the greatest described in the orthodontic literature until the present moment. The studies with longer follow-up times was Vaden, Harris and Gardner[5], that evaluated 15 years posttreatment, Little, Riedel and Artun[19] that evaluated 10 and 20-years posttreatment and Dyer, Vaden and Harris[20], with follow-up of 25 years posttreatment.

The initial maxillary anterior crowding of 10.14mm was significantly corrected with treatment to 1.07mm at the final stage (reduction of 9.07mm), presented a statistically significant relapse in the short-term showing a maxillary crowding of 3.25mm at this stage (increase of 2.18mm from final to short-term posttreatment stage) and remained stable from short- to long-term posttreatment evaluation, increasing only 0.41mm, showing a maxillary irregularity of 3.66 at the long-term posttreatment stage, approximately 35 years after the end of orthodontic treatment (Tables 2 and 3).

This is in agreement with the long-term study of Vaden, Harris and Gardner[5] that evaluated the changes in irregularity of maxillary and mandibular incisors 6 to 15 years out of retention and found, at 15 years postretention evaluation, a worse of only 0.3mm in maxillary incisors irregularity, which correspond to a 96% stability of the crowding correction achieved with orthodontic treatment. Dyer, Vaden and Harris[20] also found that the correction of the maxillary crowding was relatively stable in the long-term when evaluating the stability 25 years after treatment in women subjects.

In the present study, there was 24.03% of relapse in the short-term and only more 4.52% of relapse until the 35-years long-term evaluation, showing a long-term

total relapse of 28.55%. Our relapse is greater than the found by Vaden, Harris and Gardner[5] and Dyer, Vaden and Harris[20], however, it can be considered a long-term stability, mainly when contrasted with the relapse of mandibular anterior crowding that is always greater, even in the long-term evaluation.

This small increase of 0.41mm from the short- to long-term evaluation stages, i.e., evaluating patients from 20 to 50 years of age approximately, is probably due to physiologic changes observed with time even in untreated cases. This variation of crowding from 18 to 50 years of age was already evaluated by Richardson[24] but only for mandibular arch, and crowding increase varied from 0.2 to 2.5mm. We speculated that, for maxillary arch, this increase in crowding would be small, and probably similar to the changes observed in the present study treated cases.

The severity of initial maxillary anterior crowding was not correlated to short- and long-term posttreatment irregularity status and neither correlated with the short- and long-term maxillary crowding relapse (Table 4).

This 35-year long-term occlusal evaluation should be extremely cautious because the relapse of crowding is combined to physiological changes already expected in maturation and aging of the occlusion, including the increase of anterior crowding.[24-26] It is difficult to distinguish the real relapse from changes due to normal aging process because increase of crowding with time occurs even in untreated cases.[24,25] Dental movement is a normal process of occlusal aging and maturation, then it is expected that teeth will get more crowded with age.[24-27]

Conclusions

The maxillary anterior crowding, evaluated by the Little irregularity index, was significantly corrected with treatment, presented a significant relapse in the short-term, and remained stable from short- to long-term posttreatment evaluation, 35 years after the end of active orthodontic treatment.

The severity of initial maxillary anterior crowding was not correlated to short- and long-term relapse.

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FIGURE LEGENDS:

Figure 1. Modified Little irregularity index = A+B+C+D+E.

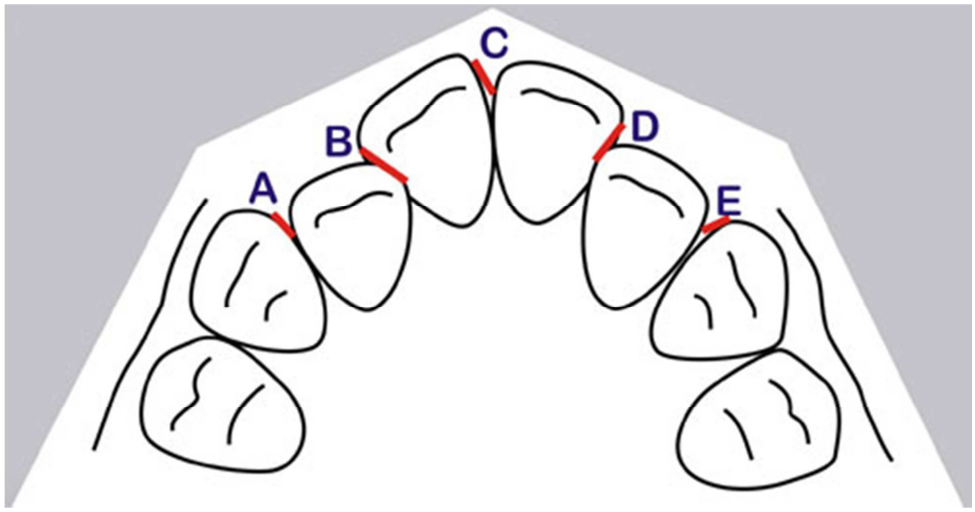

Figure 1

Table 1. Descriptive statistics of the ages, times and periods evaluated (N=28).

Variables (years)	Mean	s.d.	Minimum	Maximum
Initial age (T1)	12.72	0.99	10.58	14.85
Final age (T2)	14.74	1.26	12.58	18.09
Age at short-term posttreatment evaluation (T3)	20.15	1.34	17.75	24.08
Age at long-term posttreatment evaluation (T4)	49.40	4.54	35.76	55.12
Treatment time (T2-1)	2.02	0.66	0.99	3.33
Retention time	1.70	0.60	0.79	3.33
Time of short-term posttreatment evaluation (T3-2)	5.40	0.43	4.72	6.14
Time of long-term posttreatment evaluation (T4-2)	34.65	4.25	22.48	39.51

Table 2. Descriptive statistics of the maxillary Little irregularity index (Mx LII) in the several stages and periods of evaluation (N=28).

Variables (mm)	Mean	s.d.	Minimum	Maximum
Initial Mx LII (T1)	10.14	3.27	5.12	16.46
Final Mx LII (T2)	1.07	0.39	0.00	1.59
Short-term posttreatment Mx LII (T3)	3.25	1.21	1.58	5.34
Long-term posttreatment Mx LII (T4)	3.66	1.18	1.91	5.87
Mx LII treatment change (T2-1)	-9.07	3.27	-15.34	-4.24
Mx LII short-term posttreatment change (T3-2)	2.18	1.15	0.13	4.48
Mx LII long-term posttreatment change (T4-2)	2.59	1.07	0.46	4.80
Mx LII short- to long-term posttreatment change (T4-3)	0.41	0.43	0.02	1.63

Table 3. Comparison of the Mx LII in the 4 stages evaluated (N=28)(repeated measures ANOVA and Tukey tests).

Variable	**Initial (T1)**	**Final (T2)**	**Short-term (T3)**	**Long-term (T4)**	**P**
	Mean (s.d.)	**Mean (s.d.)**	**Mean (s.d.)**	**Mean (s.d.)**	
Mx LII (mm)	10.14 (3.27)^{A}	1.07 (0.39)^{B}	3.25 (1.21)^{C}	3.66 (1.18)^{C}	**0.000***

* Statistically significant at P<0.05.
Different letters indicate the presence of a statistically significant difference.

Table 4. Results of Pearson's correlation test between the initial and short-, long-term and relapse of Mx LII (T3-2, T4-2 e T4-3).

Correlations	r	P
Mx LII T1 x Mx LII T3	0.133	0.499
Mx LII T1 x Mx LII T4	0.108	0.583
Mx LII T1 x Mx LII T3-2	0.126	0.522
Mx LII T1 x Mx LII T4-2	0.104	0.596
Mx LII T1 x Mx LII T4-3	-0.076	0.699

* Statistically significant at P<0.05

2.2 Article 2

Long-term relapse of maxillary anterior crowding: comparison of Class I and II malocclusions

ABSTRACT

Objective: The aim of this study was to compare the relapse of maxillary anterior crowding between Class I and II malocclusions, in the short- and long-term, 5 and 35 years posttreatment. **Material and methods:** The sample comprised 28 patients, divided into 2 groups: G1, including 15 Class I patients, at a mean initial age of 12.63 years (s.d. 0.94), age at short-term follow-up of 19.91 years (s.d. 1.02) and age at long-term posttreatment evaluation of 50.17 years (s.d. 3.20). The mean time of short-term evaluation was 5.50 years (s.d. 0.42) and the mean time of long-term posttreatment was 35.75 years (s.d. 2.99). G2, comprised 13 Class II patients with a mean initial age of 12.82 years (s.d. 1.09), age at short-term evaluation of 20.41 years (s.d. 1.64) and age at long-term posttreatment of 48.51 years (s.d. 5.74). The mean time of short-term evaluation was 5.29 years (s.d. 0.43) and the mean time of long-term posttreatment follow-up was 33.39 years (s.d. 5.20). The modified Little irregularity index for maxillary arch was assessed, in the dental casts of initial, final, short- and long-term posttreatment stages. The intergroup comparison of Modified Little index was performed by independent t test. Comparison of maxillary crowding in the four stages evaluated in each group was performed by repeated measures ANOVA and Tukey tests. **Results:** There was no statistically significant difference between the Class I and Class II groups in the maxillary crowding relapse in the short- and long-term posttreatment. In both groups, the maxillary anterior crowding presented a significant correction with treatment, a significant relapse in the short-term and remained stable from short- to long-term posttreatment evaluation. **Conclusions:** Class I and II malocclusions presented similar maxillary anterior crowding relapse in the short- and long-term posttreatment. Maxillary anterior crowding presented a significant relapse in the short-term and remained stable in the long-term posttreatment in both groups.

Key-words: Orthodontics, Relapse, Stability.

Introduction and statement of the problem

The stability of the occlusion obtained with treatment is one of the most important objectives in Orthodontics. Unfortunately, it is known that some occlusal changes inevitably occur in posttreatment period.[1-3] It would be of great benefit to orthodontists the possibility of a detailed prediction and prevention of different occlusal changes after orthodontic treatment. This way, the effects of many diagnostic and treatment factors on short- and long-term occlusal stability have been broadly investigated.[4-9]

There are not a lot of studies in orthodontic literature that evaluated the maxillary crowding relapse in the short- and long-term.[5,7-18] It seems that the amount of maxillary incisor irregularity long-term out of retention is smaller than that seen before treatment.[12,16-18]

There are controversies in the literature regarding the long-term posttreatment maxillary crowding relapse in different types of malocclusions, Class I and Class II.[9,16,19] Ormiston et al.[19] affirmed that Class II subjects are about twice as likely to be unstable during long-term posttreatment when compared to Class I subjects. However, other studies found no significant differences in stability of maxillary anterior crowding treatment in Class I and Class II subjects.[9,16]

However, there are really few long-term studies with follow-up of 15 years or more evaluating the maxillary crowding relapse, and none of them compared the relapse in Class I and Class I malocclusions. Vaden, Harris and Gardner[5] assessed the changes in irregularity of the maxillary and mandibular incisors 6 to 15 years after the removal of retainers. After 15 years of the end of treatment, the results showed a reduction of only 0.3 mm in the irregularity of the maxillary incisors, which corresponded to 96% of stability of the crowding correction during treatment. Dyer, Vaden and Harris[20] conducted a long-term study to evaluate the stability 25 years after treatment in women subjects. The correction of the maxillary crowding was relatively stable in the long-term.

As mentioned, most studies had evaluated the stability only a few years after treatment, and are focused mainly in mandibular anterior crowding relapse. There is lack of long-term studies comparing maxillary crowding relapse in Class I and Class II malocclusion in the short and long-term posttreatment.

Therefore, the present study aimed to compare the relapse of maxillary anterior crowding between Class I and II malocclusion subjects, in the short- and long-term, 5 and 35 years posttreatment.

Material and Methods

Material

The present study was approved by the Ethics Committee in Humans Research of the Bauru Dental School, University of São Paulo.

The sample size calculation was based on an alpha significance level of 5% (0.05) and a beta of 20% (0.20) to achieve a 80% power of the test to detect a mean difference of 1.32mm with standard deviation of 1.17 for the maxillary irregularity index[20]. Thus, the sample size calculation showed the need for 13 subjects in each group.

The sample comprised the retrospective records of subjects treated by graduate students at Bauru Dental School, University of São Paulo, chosen according to the following criteria:

- Class I or Class II malocclusion present at the beginning of orthodontic treatment;
- Treatment protocol with extraction of the four first premolars;
- Complete course of orthodontic treatment with full maxillary and mandibular fixed appliances (slot 0.022” x 0.028”), with Edgewise mechanics;
- All permanent teeth erupted up to the first molars, at the pretreatment stage;
- Absence of tooth agenesis and anomalies;
- Maxillary removable appliance (Hawley), worn for one year, and mandibular fixed canine to canine retainers worn for at least one year, and a maximum of 3 years posttreatment, and no retention at the time of the follow-up records;
- Pretreatment (T1), posttreatment (T2) and approximately 5-years posttreatment (T3) dental casts available at the time of the study, when subjects were called for a new follow-up that should be at least 20 years after the end of orthodontic treatment (T4).

All patients wear, at the end of active orthodontic treatment, for retention, a removable Hawley plate in the maxillary arch, and a 3x3 bonded from canine to

canine in the mandibular arch. The mandibular 3x3 was used, on average, 1.70 years (s.d. 0.60, minimum 0.79, maximum 3.33).

Fifteen subjects presented Class I malocclusion and 13 had Class II malocclusion (severity: 8 half-cusp Class II and 5 full-cusp Class II).

Sample was divided into 2 groups, aiming to observe any difference in stability between the types of malocclusion, Class I and Class II.

Group 1 included 15 Class I patients and Group 2 comprised Class II subjects. The sex distribution and the ages and the treatment and short- and long-term evaluation times of both groups are described in Tables 1 and 2.

Methods

Pretreatment (T1), posttreatment (T2), short-term postretention (T3) and long-term posttreatment (T4) dental casts were used. The Modified Little irregularity index[8,21] was accessed in dental casts (Figures 1 and 2), with a 0.01mm precision digital caliper (Mitutoyo America, Aurora, Illinois) by one calibrated examiner (WJGG).

The Modified Little irregularity index is the summed displacement of the five anatomic contact points of the anterior teeth (from right maxillary canine to left maxillary canine). The irregularity index scoring represents a planar distance between the vertical projections of the anatomic contact points of adjacent teeth. To ensure recording horizontal displacement, the caliper should be parallel to the occlusal plane.

The difference between the initial and final values of the Little index (T2-1) was calculated to express the amount of correction with treatment. The difference was calculated from the short and long-term posttreatment with the final stage of the Little index (T3-2 and T4-2), to express the amount of changes after orthodontic treatment in the two follow-up evaluations performed. It was also calculated the difference between the two stages short and long-term posttreatment (T4-3) to evaluate the changes between these two phases.

Error study

After a month interval from the first measurement, the dental casts of 10 subjects (40 pairs of dental casts) were randomly selected and re-measured by the

same examiner (WJGG). The casual error was calculated according to Dahlberg's[22] formula ($Se^2 = \Sigma d^2/2n$), and the systematic error with dependent t tests, for $p<0.05$.

Statistical analysis

The normality of the data was checked and confirmed using the Kolmogorov-Smirnov test.

The intergroup comparability of sex distribution and ages and times of evaluation was verified with the chi-square and independent t tests, respectively.

The intergroup comparison of maxillary Little irregularity index in the stages and periods evaluated was performed by independent t test.

The intragroup comparison of the Little irregularity index among the four stages evaluated was performed with repeated measures ANOVA and Tukey tests.

All tests were performed with the Statistica software (Statistica for Windows, version 7.0, Copyright StatSoft, Inc., Tulsa, Oklahoma, USA, 2005), with a significance level of 5% ($P <0.05$).

Results

There was no systematic error and casual errors varied from 0.12mm for the final maxillary Little irregularity index (Mx LII T2) to 0.47 for the initial maxillary Little irregularity index (Mx LII T1).

There was comparability of sex distribution (Table 1), initial, final, short- and long-term ages, retention time, and times of short- and long-term posttreatment evaluation (Table 2). Treatment time was significantly longer for Class II group when compared to Class I group (Table 2). Groups were also comparable regarding initial maxillary anterior crowding (Table 3).

There was no statistically significant difference between the groups in maxillary crowding relapse in the short- and long-term posttreatment (Table 3).

In both groups, the maxillary anterior crowding presented a significant correction with treatment, a significant relapse in the short-term and remained stable from short- to long-term posttreatment evaluation (Table 4).

Discussion

The groups were comparable regarding several parameters that could influence their comparison: sex distribution; initial, final, short- and long-term ages; retention time; times of short- and long-term posttreatment evaluation (Tables 1 and 2).

The retention time comparable between the groups is of great importance, as it is reported in the literature that the duration of use of the retainers can affect the stability of the results.[23-27] In addition, all patients received the same retention protocol, a Hawley plate on the maxillary arch and a steel wire bonded from canine to canine in the mandibular arch (3x3).

Treatment time was significantly longer for Class II when compared to Class I group (Table 2). This was expected, since both groups were treated with 4-premolars extraction, and in the Class II group the anteroposterior discrepancy and Class II molar relationship had to be corrected and spent more treatment time,[28-30] maybe due to the need for more patient cooperation.[28,31]

The maxillary anterior crowding was similar at the initial stage in both groups (Table 3). This comparability of initial maxillary crowding severity allowed a reliable comparative evaluation of the short- and long-term posttreatment changes.

Maxillary anterior crowding (Little irregularity index) was similar between the groups in the four stages studied: initial, final, short- and long-term posttreatment (Table 3), and also showed similar changes with treatment (T2-T1) and in the short- (T3-2) and long-term posttreatment (T3-T2) periods and from short- to long-term evaluations (Table 3).

These results are in consonance with previous studies of Uhde et al.[16] and Guirro et al.[9] that also found no differences in maxillary crowding relapse in Class I and Class II malocclusion cases.

In both groups, the maxillary anterior crowding presented a significant correction with treatment, a significant relapse in the short-term and remained stable from short- to long-term posttreatment evaluation, approximately 35 years after the end of active orthodontic treatment (Table 4).

This is in agreement with the long-term study of Vaden, Harris and Gardner[5] that evaluated the changes in irregularity of maxillary and mandibular incisors 6 to 15 years out of retention and found, at 15 years postretention evaluation, a worse of only 0.3mm in maxillary incisors irregularity, which correspond to a 96% stability of

the crowding correction achieved with orthodontic treatment. Dyer, Vaden and Harris[20] also found that the correction of the maxillary crowding was relatively stable in the long-term when evaluating the stability 25 years after treatment in women subjects.

In the present study, Class II group showed 24.88% of relapse in the short-term and only more 3.41% of relapse until the 35-years evaluation, showing a long-term total relapse of 28.29%. The Class I group showed similar percentages with a relapse of 23.44% in the short-term and more 5.34% of relapse from short- to long-term evaluation, totalizing a relapse of 28.81% of the maxillary anterior crowding. Our relapse is greater than the found by Vaden, Harris and Gardner[5] and Dyer, Vaden and Harris[20], however, it can be considered a long-term stability, mainly when contrasted with the relapse of mandibular anterior crowding that is always greater, even in the long-term evaluation.

In this study, both Class I and Class II malocclusions treated with 4-premolars extraction showed a good and similar stability of maxillary teeth alignment after 35 years long-term posttreatment.

Conclusions

There was no statistically significant difference in maxillary anterior crowding relapse in the short- and long-term posttreatment between Class I and II malocclusions.

Maxillary anterior crowding presented a significant relapse in the short-term and remained stable in the long-term posttreatment in both groups.

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FIGURE LEGENDS:

Figure 1. Maxillary Little irregularity index = A+B+C+D+E.

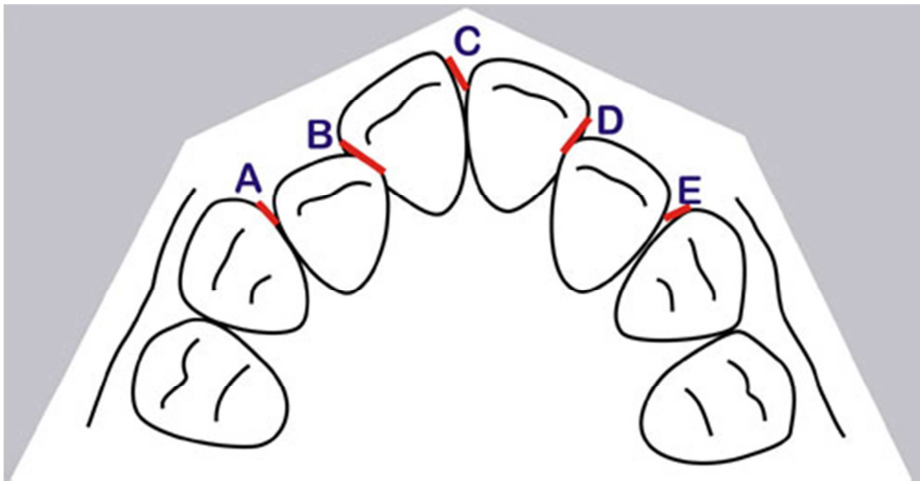

Figure 1

Table 1. Intergroup comparability of sex distribution (chi-square test).

Sex / Group	Males	Females	Total
Group 1 Class I	5	10	15
Group 2 Class II	4	9	13
Total	9	19	28
X^2=0.02		**DF=1**	**P=0.884**

Table 2. Intergroup comparability of the ages, times and periods evaluated (independent t tests).

Variables (years)	Group 1 Class I (N=15)		Group 2 Class II (N=13)		P
	Mean	s.d.	Mean	s.d.	
Initial age (T1)	12.63	0.94	12.82	1.09	0.630
Final age (T2)	14.41	0.90	15.12	1.53	0.144
Age at short-term posttreatment evaluation (T3)	19.91	1.02	20.41	1.64	0.338
Age at long-term posttreatment evaluation (T4)	50.17	3.20	48.51	5.74	0.343
Treatment time (T2-1)	1.78	0.42	2.29	0.79	**0.039***
Retention time	1.63	0.55	1.79	0.67	0.145
Time of short-term posttreatment evaluation (T3-2)	5.50	0.42	5.29	0.43	0.499
Time of long-term posttreatment evaluation (T4-2)	35.75	2.99	33.39	5.20	0.218

* Statistically significant at P<0.05.

Table 3. Intergroup comparison of the maxillary Little irregularity index (Mx LII) in times and periods evaluated (independent t tests).

Variables (mm)	Group 1 Class I (N=15)		Group 2 Class II (N=13)		P
	Mean	s.d.	Mean	s.d.	
Initial Mx LII (T1)	10.30	3.20	9.95	3.46	0.784
Final Mx LII (T2)	1.00	0.38	1.15	0.41	0.361
Short-term posttreatment Mx LII (T3)	3.18	1.12	3.34	1.35	0.736
Long-term posttreatment Mx LII (T4)	3.68	0.98	3.64	1.43	0.929
Mx LII treatment change (T2-1)	-9.29	3.25	-8.80	3.41	0.701
Mx LII short-term posttreatment change (T3-2)	2.17	1.10	2.19	1.24	0.966
Mx LII long-term posttreatment change (T4-2)	2.67	0.86	2.49	1.29	0.230
Mx LII short- to long-term posttreatment change (T4-3)	0.50	0.50	0.30	0.31	0.662

Table 4. Comparison of the Mx LII in the 4 stages evaluated for Class I and Class II groups (repeated measures ANOVA and Tukey tests).

Variable	Initial (T1)	Final (T2)	Short-term (T3)	Long-term (T4)	P
	Mean (s.d.)	Mean (s.d.)	Mean (s.d.)	Mean (s.d.)	
Class I group Mx LII (mm) N=15	10.30 (3.20)^{A}	1.00 (0.38)^{B}	3.18 (1.12)^{C}	3.68 (0.98)^{C}	**0.000***
Class II group Mx LII (mm) N=13	9.95 (3.46)^{A}	1.15 (0.41)^{B}	3.34 (1.35)^{C}	3.64 (1.43)^{C}	**0.000***

* Statistically significant at P<0.05.
Different letters indicate the presence of a statistically significant difference.

3 DISCUSSION

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Once the main objective of this research was to evaluate the relapse of maxillary anterior crowding in the short and long-term posttreatment, 5 and at least 20 years after the end of orthodontic treatment, respectively, the sample was selected from the files of Orthodontics Department from Bauru Dental School, University of São Paulo. We previously selected patients with Class I and Class II malocclusions, treated with extraction of the 4 first premolars, and who had complete documentation in the files from the initial (pretreatment), final (posttreatment) and short-term (approximately 5-years posttreatment) stages. Subjects who lack this documentation were excluded from the sample. In addition, it was included only patients who completed orthodontic treatment by the year 1993 because, as the controls were carried out in 2013 and 2014, it will count approximately 20 years posttreatment, the minimum necessary for inclusion in this sample.

After this selection, these individuals were called again for a follow-up control, at least 20 years after the end of active orthodontic treatment. A current orthodontic dental casts was performed in these individuals and also a clinical examination was carried out. Cases that underwent orthodontic retreatment were excluded from the sample.

For a more homogeneous sample, some other selection criteria were adopted. It was standardized the initial malocclusion, the treatment protocol used, and the type of orthodontic mechanics used. Accordingly, the stability results achieved with orthodontic treatment can be evaluated with increased reliability.

One of the basic criteria of sample selection was that the patients presented initially Angle Class I or Class II malocclusion. The literature shows variations on the posttreatment behavior of the Class I and Class II malocclusions regarding the anterior crowding relapse (KAHL-NIEKE; FISCHBACH; SCHWARZE, 1996; LITTLE, 1999; LITTLE; RIEDEL; ARTUN, 1988; UHDE; SADOWSKY; BEGOLE, 1983), however, in order to give a substantial number of sample, it was decided to include the two types of malocclusion, and then compare to check whether there were differences between the different types of malocclusion.

Another sample selection criterion was that all patients had been treated with fixed Edgewise orthodontic mechanics (GRABER; VANARSDALL, 1994; SALZMANN, 1966), with extraction of the four first premolars. As the literature shows no consensus regarding the stability of the cases treated with and without extractions (LITTLE, 1999; LITTLE; RIEDEL; ARTUN, 1988; LITTLE; WALLEN; RIEDEL, 1981; UHDE; SADOWSKY; BEGOLE, 1983), there was included only cases treated with extraction of the 4 first premolars.

This way, sample comprised 28 subjects. The number was considered sufficient, given the difficulty in obtaining the sample, the need to call patients for a follow-up control after more than 20 years posttreatment. Many could not be found, they found others did not attend the appointment, and many lived in other cities, making them difficult to contact.

The time of short-term evaluation is in consonance with literature regarding evaluation of stability of orthodontic correction, since approximately half of the total relapse observed occurs in the first two years after the end of active orthodontic treatment, with good stability of the main characteristics after 5-years posttreatment (AL YAMI; KUIJPERS-JAGTMAN; VAN 'T HOF, 1999).

The long-term evaluation time of almost 35 years posttreatment is the greatest described in the orthodontic literature until the present moment. The studies with longer follow-up times was Vaden, Harris and Gardner (VADEN; HARRIS; GARDNER, 1997), that evaluated 15 years posttreatment, Little, Riedel and Artun (LITTLE; RIEDEL; ARTUN, 1988) that evaluated 10 and 20-years posttreatment and Dyer, Vaden and Harris (DYER; VADEN; HARRIS, 2012), with follow-up of 25 years posttreatment.

The division of the sample into two groups was performed according to the type of malocclusion, Class I or Class II. Many studies have reported that age does not significantly influence the amount of relapse (DUGONI et al., 1995; HARRIS et al., 1994; LITTLE, 1990; LITTLE, 2002), but even so, an independent t test was performed for comparison of the ages, times and periods evaluated between the two groups. The results showed comparability of the groups regarding the ages in all

times and periods evaluated and also of the retention time and short- and long-term evaluation periods.

The retention time comparable between the groups is of great importance, as it is reported in the literature that the duration of use of the retainers can affect the stability of the results (AL YAMI; KUIJPERS-JAGTMAN; VAN 'T HOF, 1999; LITTLE; WALLEN; RIEDEL, 1981; NANDA; NANDA, 1992; RIEDEL, 1960; SHAH, 2003). In addition, all patients received the same retention protocol, a Hawley plate on the maxillary arch and a steel wire bonded from canine to canine in the mandibular arch (3x3).

The first article reports the results regarding the relapse of maxillary anterior crowding in the short- and long-term posttreatment, including the whole sample. The maxillary anterior crowding was significantly corrected with treatment, presented a significant relapse in the short-term of 2.59mm, and presented a slight and not statistically significant increase of 0.41mm from short- to long-term posttreatment evaluation. This article also performs some correlation, showing that the severity of initial maxillary anterior crowding was not correlated to short- and long-term relapse.

In the second article, sample was divided into two groups, and the relapse of maxillary anterior crowding was compared between the Class I and Class II malocclusions. The results showed that there was no statistically significant difference between the Class I and Class II groups in the maxillary crowding relapse in the short- and long-term posttreatment. In both groups, the maxillary anterior crowding presented a significant correction with treatment, a significant relapse in the short-term and remained stable from short- to long-term posttreatment evaluation.

3.1 Suggestion for future works

- To evaluate short- and long-term stability and relapse of crowding in cases treated nonextraction

- To compare short- and long-term stability and relapse of crowding in cases treated extraction and nonextraction

- To evaluate long-term occlusal stability using occlusal indexes

4 CONCLUSIONS

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The maxillary anterior crowding, evaluated by the Little irregularity index, was significantly corrected with treatment, presented a significant relapse in the short-term, and remained stable from short- to long-term posttreatment evaluation, 35 years after the end of active orthodontic treatment.

The severity of initial maxillary anterior crowding was not correlated to short- and long-term relapse.

There was no statistically significant difference between the Class I and Class II groups in the maxillary crowding relapse in the short- and long-term posttreatment. In both Class I and Class II malocclusions, the maxillary anterior crowding presented a significant correction with treatment, a significant relapse in the short-term and remained stable from short- to long-term posttreatment evaluation.

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