Relapse of maxillary anterior crowding in Class I and Class II malocclusion treated orthodontically without extractions

Willian J. G. Guirro*, Karina Maria Salvatore de Freitas**, Marcos Roberto de Freitas***, José Fernando Castanha Henriques***, Guilherme Janson****, Luiz Filiphe Gonçalves Canuto*****

Abstract

Objective: The present study aimed to retrospectively compare the postretention stability of maxillary anterior incisors alignment in patients with Class I and Class II malocclusions. **Methods:** Sample comprised 38 patients of both genders, treated with no extraction and Edgewise mechanics, divided into two groups: Group 1 comprised 19 patients, at a mean age of 13.06 years, with Class I malocclusion and initial maxillary anterior crowding greater than 3 mm. Group 2 comprised 19 patients, at a mean age of 12.54 years, with Class II malocclusion, and also with an initial maxillary anterior crowding greater than 3 mm. In the dental casts of pretreatment, post-treatment and postretention, the Little irregularity index, intercanine width and width between first and second premolars, intermolar width and maxillary arch length were measured. For intragroup comparison among the three evaluation times the one-way ANOVA was used followed by Tukey test. Intergroup comparison was performed by independent t test. To verify the presence of correlation, the Pearson correlation test was used. **Results:** Results evidenced greater stability of treatment in Group 2 (Class II), because during the postretention period it was observed a smaller relapse of maxillary anterior crowding in Group 2 (0.80 mm) than in Group 1 (1.67 mm). **Conclusion:** It was concluded that treatment of maxillary anterior crowding is more stable in Class II malocclusion than in Class I malocclusion.

Keywords: Relapse. Maxillary anterior crowding. Post-treatment stability.

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* MSc in Orthodontics, Bauru Dental School, University of São Paulo.
** MSc and PhD in Orthodontics, Bauru Dental School, University of São Paulo. Coordinator of the Masters in Dentistry, area of concentration: Orthodontics, Ingá University, Maringá-PR.
*** Head Professor, Department of Orthodontics, Bauru Dental School, University of São Paulo.
**** Head Professor, Department of Orthodontics, Bauru Dental School, University of São Paulo.
***** MSc and PhD in Orthodontics, Bauru Dental School, University of São Paulo.

INTRODUCTION

The orthodontic treatment has as main objective the correction of malocclusions, however, these corrections present considerable variation in relation to the postretention stability. Although there is a consensus in the orthodontic literature that some occlusal changes will inevitably occur after the end of orthodontic treatment,[19,30] it was evidenced that the stability of teeth alignment is highly variable and widely unpredictable.[2,20] In relation to the scientific approach, despite numerous studies regarding the etiology of the relapse in orthodontic correction of mandibular anterior crowding,[3,4,11,18] a small number of studies was conducted focusing the post-treatment changes in the maxillary anterior region and the possible factors associated to the magnitude of this relapse.[9,14,23,27,29]

LITERATURE REVIEW

The stability of orthodontically aligned teeth was found to be highly variable.[11] Little[17] and other authors[20,28,32] concluded that long-term decreases in arch perimeter and length are usual in extraction and non-extraction cases or even in patients who did not undergo orthodontic treatment. Little,[17] in 1990, stated that no clinical finding, dental cast or cephalometric parameter, before or after treatment, seemed to predict the relapse. However, as well as in most studies related to crowding relapse, only the mandibular arch was evaluated. Thus, extrapolation of these findings to the maxillary arch should be restricted.

Maxillary anterior crowding relapse is less prevalent when compared to the relapse in mandibular incisors alignment.[26,31,32]

After many decades of research, there is a consensus that stability of the aligned teeth is variable and largely unpredictable, particularly in the mandibular anterior segment.[11] Surbeck et al[29] noted that less than 7% of the patients had severe irregularity on the maxillary anterior teeth in the long-term out of retention. However, Kahl-Nieke et al[15] found that mean irregularity index of maxillary incisors increases in 23% from post-treatment to postretention.

According to Little,[16] postretention crowding of mandibular incisors is the first evidence of the progressive instability of orthodontic treatment outcomes. Regardless of the relapse etiology, irregularity of the mandibular incisors seems to be the precursor of maxillary crowding, overbite and deterioration of treatment.

In 1994, Sadowsky et al[27] studied orthodontic cases previously treated, aiming to evaluate maxillary and mandibular long-term alignment stability. All cases were treated non-extraction with fixed Edgewise appliances and stood without retainers for a minimum of 5 years. Data were obtained from dental casts. The average retention time with a mandibular fixed lingual retainer was 8.4 years. The pre-treatment irregularity index was 8.0 mm in the maxillary arch and 5.2 mm in the mandibular arch; at the end of treatment it was 0.9 mm and 1.0 mm, respectively, and at the postretention stage it was 2.0 mm and 2.4 mm, respectively. The treatment was accomplished without incisor advancement or distal movement of the mandibular molars; however, both arches were transversely expanded. During the postretention stage all variables showed relapse except for the intercanine and interpremolar width in the expanded maxillary arch.

Vaden et al,[32] in 1997, quantified changes in tooth relationships in a series of extraction cases at 6 years and again at 15 years postretention. The authors[32] concluded that maxillary and mandibular arches became shorter and narrower with age. After 15 years, most (96%) of the maxillary incisors irregularity correction was maintained. In general, 90% of the patients in this study were better off 15 years after treatment than they were before treatment.

Surbeck et al[29] assessed dental casts of 745 patients and studied the anterior maxillary teeth

alignment in the pre- (T1) and post-treatment (T2) stages, and also in the postretention stage, aiming to verify the influence of initial crowding amount at the postretention relapse. As a sample selection criterion, it was used the presence of all anterior maxillary teeth in the case of orthodontically treated patients, with or without tooth extraction. The sample was divided into 3 groups, according to the postretention dental casts configuration: One with significant spacing (1); one with significant irregularity (2); and one with perfect alignment (3). Logistic regression analyses revealed that irregularity was associated with greater anatomic contact displacement and with greater incisor rotation both at T1 and T2. Correlation analyses revealed that the pattern of pretreatment rotational displacement has a strong tendency to repeat itself after retention.

Huang and Artun[14] reported that previous studies had suggested a poor association between initial and postretention pattern of incisor irregularity. One explanation may be that the incisor movements are limited by the boundaries provided by the incisors in the opposite arch. If so, postretention displacement of the maxillary and mandibular incisors may be related to the forces exerted by the lips. According to the authors, the positioning of mandibular incisors and lip function could have a greater role at relapse in the buccolingual direction of anterior maxillary teeth than movements performed during orthodontic mechanics. They suggested that the positioning of the mandibular anterior teeth influences the positioning of the maxillary teeth and vice versa and, thus, relapse of the anterior teeth in one of the arches could be associated with the relapse of teeth alignment on the opposite arch.

To test this hypothesis, long-term postretention dental casts of 96 patients, most Class II malocclusion subjects, with acceptable occlusion at the time of appliance removal were examined. Postretention period ranged from 4 to 25 years. Statistical analyses demonstrated a significant association between the overall irregularity of the maxillary and mandibular incisors. The amount and direction of displacement of antagonistic pairs of maxillary and mandibular central incisors were also associated.

Naraghi et al[24] investigated the amount and pattern of relapse of maxillary anterior teeth previously retained with a bonded retainer. The study group consisted of 135 study casts from 45 patients. Recordings from dental casts before treatment (T1), at debonding (T2), and 1 year after removal of the retainer (T3) were assessed. All patients had been treated with fixed Edgewise appliances and the incisors irregularity index was calculated in the three groups. The mean irregularity index at T1 was 10.1 mm, at T2 it was 0.7 mm and at T3 it was 1.4 mm. In 42 patients, 55 teeth were corrected more than 20° between T1 and T2, and mean relapse in this group was 7.3°. Regarding alignment of the maxillary anterior teeth, the contact relationship between the laterals and centrals seems to be the most critical. It was concluded that minor or no relapse was noted at the 1-year follow-up.

Erdinc, Nanda and Isiksal[8] evaluated dental casts and cephalometric records of 98 patients, both genders, who presented Class I and Class II Division 1 malocclusions. They were evaluated before treatment, at post-treatment, and at postretention. The patients were divided into two groups (49 subjects each). Half of them had been treated with extractions, and half were non-extraction treated. There was no statistically significant growth in both groups during the evaluation period. Only the interincisal angle showed a significant difference between the extraction and non-extraction groups. Both groups showed statistically significant decreases in overjet with treatment and no significant postretention relapse occurred. Overbite decreased in both groups, but in the non-extraction group the results were better. However,

statistically significant relapse occurred for both groups. The treatment resulted in statistically significant improvement in the incisors crowding – both maxillary and mandibular – in both groups, and the mandibular incisors showed a significant relapse of this crowding, being, respectively, 0.97 mm and 0.99 mm in groups with and without extractions. Maxillary incisor irregularity relapse was smaller than mandibular incisor relapse for both groups. Clinically acceptable stability was obtained, accordingly to Little.[16] No statistically significant differences were recorded between the extraction and non-extraction groups regarding incisor alignment postretention stability.

Canuto,[5] compared the long-term stability of maxillary incisors alignment in cases treated with or without rapid maxillary expansion (RME) during orthodontic treatment. The sample comprised 48 subjects presenting Class I and Class II malocclusions, treated non-extraction and with Edgewise fixed appliances. The sample was divided into two groups according to the treatment protocol: Group 1 (with RME) comprised 25 patients at a mean initial age of 13.53 years, who underwent rapid maxillary expansion during orthodontic treatment. Group 2 (without RME) comprised 23 patients at a mean initial age of 13.36 years, treated with fixed appliances and no rapid maxillary expansion. Dental casts measurements were obtained at three evaluation times (pretreatment, post-treatment and postretention) and the variables assessed were Little irregularity index, intercanine, interpremolar and intermolar widths, and maxillary arch length and perimeter. The results evidenced significant transversal increases in the group treated with RME (Group 1), however, during the postretention period, no significant differences were observed between the groups in the amount of maxillary incisors alignment relapse (+1.52 mm in both groups), as well as in most of the variables evaluated. Therefore, it was concluded that the RME procedure did not influence the long-term maxillary anterior crowding relapse.

Martins[21] evaluated the influence of RME on maxillary anterior alignment stability in patients treated with premolar extraction. The sample comprised 60 patients of both genders, with Class I and Class II malocclusions, treated with extraction of 4 premolars and Edgewise mechanics. The sample was divided into two groups according to the treatment protocol. Group 1 comprised 30 patients, with initial mean age of 13.55 of years, orthodontically treated by extraction of four premolars. Group 2 also comprised 30 patients, with initial mean age of 13.98 years, orthodontically treated by rapid maxillary expansion followed by corrective mechanics with extraction of four premolars or two maxillary premolars. Dental casts obtained from all patients at initial (T1), final (T2) and postretention stages (T3) were assessed by measurements of the Little irregularity index, intercanine, interpremolar and intermolar widths, maxillary arch length and perimeter. The results demonstrated that the Little irregularity index presented 9.40% of relapse for Group 1 and 13.57% for Group 2. There was no statistically significant difference between groups regarding the relapse in intercanine, interpremolar and intermolar widths, length and perimeter of the maxillary arch. However, Group 2 exhibited a greater amount of relapse in the maxillary anterior crowding. Thus, rapid maxillary expansion influenced negatively the maxillary incisors alignment stability.

PROPOSITION

The objective of this retrospective study was to evaluate the relapse of the maxillary anterior crowding in cases treated orthodontically without extractions, using the Little irregularity index, aiming to:

» Compare the relapse of maxillary anterior

crowding between the Angle Class I and Class II malocclusions.

» Correlate the Little irregularity index, the intercanine, interpremolar and intermolar widths, as well as the arch length at the initial and final stages and postretention period.

MATERIAL AND METHODS

Material

The sample used in this retrospective study consisted of 38 orthodontic records of patients treated at the Postgraduate Course in Orthodontics, University of São Paulo – Bauru Dental School, which showed, initially, Class I or Class II malocclusion and orthodontic treatment without extractions.

The criteria for sample selection also included the presence of all permanent teeth erupted at the beginning of orthodontic treatment (up to the first molars) and the absence of dental anomalies of shape and/or number. All patients were treated with fixed appliances and Edgewise mechanics and had complete orthodontic records, including dental casts at the initial, final and postretention stages.

The sample was divided into two groups by the classification of malocclusion according to Angle.

Thus, the groups were distributed as follows:

» Group 1: Patients with Angle Class I — consisting of 19 patients who had maxillary anterior crowding at the beginning of orthodontic treatment.

» Group 2: Patients with Angle Class II — comprising 19 patients with maxillary anterior crowding at the beginning of orthodontic treatment.

All patients used as retention, at the end of active orthodontic treatment, a removable Hawley retainer in the maxillary arch and a bonded lingual retainer from canine to canine in the mandibular arch. The Hawley was used for an average of one year, while the bonded lingual retainer for a mean period of 3 years.

Angle Class I group: Group 1

The Angle Class I group had 19 Caucasian patients (12 females and 7 males), with initial mean age of 13.06 years (SD = 1.27). The mean time of orthodontic treatment was 2.15 years (SD = ± 0.89). After treatment, all patients had a satisfactory finishing. In this final phase, patients had a mean age of 15.19 years (SD = ± 1.24). Patients belonging to Group 1 were evaluated after a mean postretention period of 8.60 years (SD = ± 1.83).

Regarding the initial malocclusion, Group 1 had 19 patients with Class I malocclusion, with a maxillary anterior irregularity according to Little[16] greater or equal to 3 mm.

Angle Class II group: Group 2

Group 2 comprised patients who had an initial Angle Class II malocclusion, with 19 Caucasians patients (14 female and 5 male) with a mean age of 12.54 years (SD = ± 1.37) at the beginning of orthodontic therapy. The mean treatment time was 2.32 years (SD = ± 0.73). After treatment, all patients, as well as patients belonging to Group 1, had a satisfactory finishing. In this phase, patients had a mean age of 14.93 years (SD = ± 1.50) and were reassessed after a mean postretention period of 8.04 years (SD = ± 2.11).

Regarding the initial malocclusion, Group 1 had 19 patients with Class I malocclusion, with a maxillary anterior irregularity according to Little[16] greater or equal to 3 mm.

Methods

In the archives of the Department of Pediatric Dentistry, Orthodontics and Public Health of Bauru Dental School - University of São Paulo, Discipline of Orthodontics, all orthodontic records and dental casts of initial, final and postretention stages were examined, in order to select the sample following the above criteria. All these patients had been treated by

post-graduate students of specialization course (Latu sensu) and MSc/PhD (Strictu sensu) courses in Orthodontics at that institution. After the registration of all selected cases, those whose dental casts presented with artifacts of technique, absence of one or more follow-up stages (initial, final and postretention), or even badly damaged as to make it impossible their use were discarded.

The orthodontic records of the selected sample were used to obtain some relevant data to conduct this research. The personal information form was used to record the full patients names, gender and birth date. The clinical procedure records were examined as for beginning and end of treatment stages and completion of post-treatment controls. The time of retention removal was also noted. These data, together with the patient's date of birth, allowed accurate determination of the total treatment time, postretention time and patient ages in the studied phases.

When factors that might interfere with the sample standardization were noted, such as failures in the maintenance of records and models, inconsistencies in relation to the severity and type of malocclusion or inappropriate postretention evaluation period, the case was immediately excluded from the sample.

Dental casts' evaluation

Dental casts at the beginning of treatment (T1-initial), end of treatment (T2-final) and postretention (T3-postretention) were evaluated. The post-treatment dental casts were obtained at least 5 years after the end of treatment. All the measurements performed were obtained using a digital caliper (Mitutoyo Sul Americana Ltda., São Paulo, Brazil, model/code 500-143B), with a capacity of 150 mm, with precision of 0.01 mm.

The variables studied in the maxillary dental casts were:

Little Irregularity Index (modified) (LITTLE): The irregularity index proposed by Little[16] was ideally elaborated for the evaluation of the dental crowding in the mandibular anterior segment. However, due to its great reproducibility and precision, the same methodology to evaluate the dental displacement was used in the present study for the evaluation of the maxillary anterior crowding. Little index was calculated in the maxillary dental casts in the three studied phases (LITTLE1, LITTLE2 and LITTLE3). For this measurement, a digital caliper was used positioned parallel to the occlusal plane. The irregularity index was measured in this manner and characterized by the sum of the linear distance among the anatomic contact points of the maxillary anterior teeth (canines and incisors). This measure represents the distance in which the contact points should be moved to attain alignment. According to Little,[16] even though the contact points may vary in the vertical direction, the correction of these discrepancies will not affect significantly the anterior length of the arch, this way, changes in the vertical direction were not considered (Fig 1).

Intercanine width (INTERC): Distance measured in milimeters, from cusp to cusp of the right and left maxillary canines. In cases where canines presented wear surfaces, the cusp was estimated.

Interpremolar width (INTERPB and INTERPB'): Distances measured in milimeters, between the mesial cavity of the right and left first maxillary premolars (B) and of the second maxillary premolars (B'), respectively.

Intermolar width (INTERM): Distance measured in milimeters, from mesiobuccal cusps of the right and left first maxillary molars. In cases where molars presented wear surfaces, the cusp was estimated.

Maxillary arch length (ALENGTH): Sum of the distances measured between the contact point of the maxillary central incisors and the mesial surface of the first molars of the right and left sides.

Error of the method

The intra-examiner error was evaluated by new measurements of the studied variables performed on the initial, final and postretention casts of 10 randomly selected patients belonging to both groups. The reassessed variables (LITTLE, INTERC, INTERPB, INTERPB', INTERM and ALENGTH) were also randomly selected. The first and second measurements were performed with a one month time difference. The formula proposed by Dahlberg[6] ($Se^2 = \sum d^2/2n$) was used to estimate the order of magnitude of the casual errors, while the systematic errors were analyzed by paired t-tests, according to Houston.[13]

Statistical methods

Descriptive statistics was performed (mean, standard deviation and number) for Groups 1 (Class I) and 2 (Class II) for the measurements obtained by Little irregularity index, intercanine, interpremolar and intermolar widths and arch length, in the initial (T1), final (T2) and postretention (T3) phases. Descriptive statistic was also performed for the difference of the measures obtained from the dental casts between initial and final phases (T2-T1), characterizing the correction achieved with treatment, and for the difference between the postretention and final phases (T3-T2), characterizing the changes during postretention period, and for the difference between postretention and initial phases (T3-T1), characterizing the changes during the whole observation period.

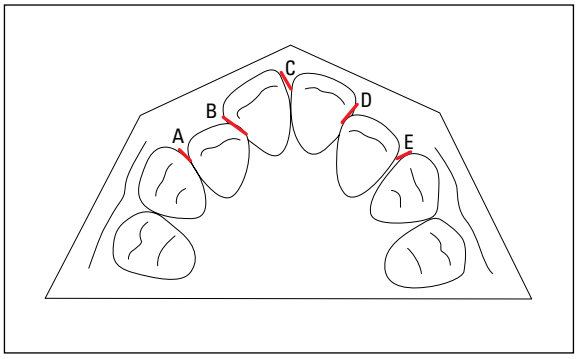

FIGURE 1 - Little irregularity index (modified) = A+B+C+D+E.

For compatibility evaluation between Groups 1 and 2 regarding gender distribution and in relation to the initial malocclusion severity, the Chi-square test was used. Aiming to verify compatibility between groups regarding the amount of initial crowding (LITTLE), initial age (Age T1), final age (Age T2) and age at postretention (Age T3), treatment time, retention time and postretention evaluation, independent t-test was used.

For intragroup comparison among the three evaluation times (Initial – T1; Final – T2; Postretention – T3), the dependent ANOVA test was used and, in case of a significant result, the Tukey test. The test was applied for the evaluation of the variables measured in dental casts from Groups 1 and 2 together, in the three evaluated periods.

For the intergroup comparison of the values obtained for variables evaluated in the dental casts of initial, final and postretention phases, as well as the changes of these variables during treatment (T2-T1), postretention (T3-T2) and total changes (T3-T1), the independent t-test was used.

Finally, to verify the presence of correlation between relapse of maxillary anterior crowding and relapse of the variables intercanine, interpremolar and intermolar widths and arch length, the Pearson's correlation test was used.

All tests were performed by STATISTICA for Windows software (Release 6.0 – StatSoft, Inc. 2001), adopting a significance level of 5%.

RESULTS

Table 1 shows the results of random and systematic errors, performed by the Dahlberg's formula[6] and paired t-tests, respectively, applied

to the variables LITTLE, INTERC, INTERPB, INTERPB', INTERM and ALENGTH, and measured on dental casts within a one-month interval.

Group compatibility regarding gender distribution was evaluated by the Chi-square test (Table 2). There was no statistically significant difference between the groups regarding gender distribution.

The independent t-test was used to assess the compatibility of groups regarding the amount of initial maxillary anterior crowding (LITTLE1), initial age (Age T1), final age (Age T2), age at postretention stage (Age T3), treatment time (TREATTIME) and postretention time (POSTTREATTIME). There was no significant difference between groups on these variables (Table 3).

The results of the ANOVA for the variables measured on dental casts of Groups 1 and 2, respectively, in the three studied periods (T1, T2 and T3) can be verified in Tables 4 and 5. In the presence of a significant result, the Tukey test was performed. The results for Group 1 showed a significant reduction in maxillary anterior crowding and statistically significant dimensional increments between the initial (T1) and final phases (T2), except for the intercanine width (INTERC) (Table 4).

It was observed that these changes tended to be stable in the postretention period, except for the interpremolar width (INTERPB), and arch length (ALENGTH), which had a statistically significant decrease in postretention (T3) (Table 4). The results of the ANOVA for Group 2 show that Little's index had significant changes during treatment and during the postretention period (Table 5). However, there were no statistically significant changes for most of the other variables during these phases, except for the intercanine (INTERC) and intermolar widths (INTERM) which showed a significant decrease between the final (T2) and postretention stages (T3) (Table 5).

TABLE 1 - Results of t test and Dahlberg's formula,[6] applied to the evaluated variables to estimate systematic and casual errors, respectively.

Variables	1st Measurement N=10		2nd Measurement N=10		Dahlberg	P
	Mean	SD	Mean	SD		
LITTLE1	7.02	3.08	7.05	3.13	0.05	0.397
LITTLE2	0.10	0.33	0.11	0.34	0.01	0.343
LITTLE3	1.47	0.81	1.49	0.80	0.02	0.422
INTERC1	34.21	3.06	33.25	4.58	0.25	0.322
INTERC2	34.38	2.28	34.44	2.25	0.07	0.135
INTERC3	34.60	2.33	34.57	2.34	0.05	0.527
INTERPB1	32.35	2.49	32.63	2.48	0.35	0.220
INTERPB2	36.03	2.09	35.82	2.23	0.26	0.246
INTERPB3	35.30	2.18	35.39	2.55	0.22	0.564
INTERPB'1	37.04	3.41	37.10	3.64	0.28	0.755
INTERPB'2	41.13	2.56	41.21	2.59	0.15	0.454
INTERPB'3	40.40	2.39	40.48	2.64	0.20	0.564
INTERM1	49.21	3.94	49.29	3.86	0.10	0.207
INTERM2	52.19	3.85	52.33	3.80	0.13	0.092
INTERM3	52.38	3.50	52.48	3.71	0.15	0.303
ALENGTH1	67.96	5.22	68.21	5.51	0.25	0.121
ALENGTH2	72.59	4.59	72.58	4.75	0.23	0.990
ALENGTH3	70.86	4.06	71.36	4.71	0.65	0.249

TABLE 2 - Results of the Chi-square test for evaluation of compatibility of the Groups 1 and 2 regarding gender distribution.

	Female	Male	Total
Group 1 - Class I	12	7	**19**
Group 2 - Class II	14	5	**19**
Total	**26**	**12**	**38**
X^2=0.49	df=1		p=0.485

TABLE 3 - Results of independent t test, applied to the variables initial Little index; initial, final and postretention age; treatment time and time of postretention evaluation for Groups 1 and 2, for evaluation of the intergroup compatibility.

Variables	Group 1 - Class I (N=19)		Group 2 - Class II (N=19)		P
	Mean	SD	Mean	SD	
LITTLE1	7.83	3.14	6.35	2.67	0.126
Age T1	13.06	1.27	12.54	1.37	0.233
Age T2	15.19	1.24	14.93	1.50	0.552
Age T3	21.67	2.52	20.62	2.41	0.201
TREATTIME	2.15	0.89	2.32	0.73	0.534
POSTTREATTIME	8.60	1.83	8.04	2.11	0.388

Tables 6, 7 and 8 show results of the independent t-test for intergroup comparison of the variables studied in the initial (T1), final (T2) and postretention stages (T3), respectively. In the initial phase, there was no statistically significant difference for all variables between Groups 1 and 2 (Table 6). In the final and postretention stages there were significant differences between Groups 1 and 2 for the amount of maxillary anterior crowding (LITTLE2 and LITTLE3, Tables 7 and 8, respectively).

Changes in variables measured in dental casts during treatment (T2-T1), during postretention period (T3-T2) and total changes (T3-T1) in both groups, were compared by t-tests (Tables 9, 10 and 11, respectively). In relation to changes that occurred during treatment (T2-T1), there were no significant differences between Groups 1 and 2 (Table 9). During the postretention period (T3-T2), only the amount of maxillary anterior crowding presented statistically significant difference between groups (Table 10). In relation to the total changes (T3-T1), there were no statistically significant differences between Groups 1 and 2 (Table 11).

Table 12 shows the results of the Pearson correlation test. There was a negative correlation, statistically significant, between the amount of maxillary anterior crowding relapse and the amount of reduction in the intermolar width (Table 12).

DISCUSSION

Previous long-term studies that investigated anterior crowding relapse have most often evaluated the mandibular arch.[3,4,11,17,18,20,30] There is a relative small number of studies that evaluated the maxillary arch and parameters that may be helpful in predicting its long-term

TABLE 4 - Results of ANOVA for the variables from dental casts, of Group 1 (N=19), in the three studied phases (T1, T2 and T3). In the presence of a significant result, the Tukey test was performed (different letters show significant difference between the measurements).

Variables	Initial T1	Final T2	Postretention T3	p
	Mean (SD)	Mean (SD)	Mean (SD)	
LITTLE	7.83 (3.14)^{A}	0.34 (0.68)^{B}	2.01 (1.87)^{B}	0.000*
INTERC	33.79 (2.36)^{A}	34.46 (1.48)^{A}	34.29 (1.47)^{A}	0.306
INTERPB	32.62 (1.91)^{A}	35.91 (1.63)^{B}	34.66 (1.54)^{C}	0.000*
INTERPB'	37.91 (2.94)^{A}	40.90 (2.19)^{B}	40.02 (2.04)^{B}	0.000*
INTERM	49.49 (3.16)^{A}	51.53 (2.86)^{B}	51.34 (2.69)^{B}	0.000*
ALENGTH	68.33 (4.72)^{A}	71.01 (3.45)^{B}	69.48 (3.38)^{A}	0.000*

*Statistically significant for p<0.05.

TABLE 5 - Results of ANOVA for the variables from dental casts, of Group 2 (N=19), in the three studied phases (T1, T2 and T3). In the presence of a significant result, the Tukey test was performed (different letters show significant difference between the measurements).

Variables	Initial T1	Final T2	Postretention T3	p
	Mean (SD)	Mean (SD)	Mean (SD)	
LITTLE	6.35 (2.67)^{A}	0.00 (0.00)^{B}	0.80 (0.76)^{C}	0.000*
INTERC	33.35 (2.71)^{A}	34.42 (1.86)^{B}	34.24 (2.06)^{AB}	0.038*
INTERPB	32.08 (1.98)^{A}	35.16 (1.76)^{B}	34.69 (2.17)^{B}	0.000*
INTERPB'	37.32 (2.51)^{A}	39.93 (2.34)^{B}	39.23 (2.07)^{B}	0.000*
INTERM	49.71 (2.66)^{A}	50.61 (2.04)^{A}	50.72 (2.88)^{A}	0.104
ALENGTH	68.59 (3.46)^{A}	71.21 (3.75)^{B}	70.06 (3.19)^{B}	0.000*

*Statistically significant for p<0.05.

stability,[8,9,14,23,29] probably because maxillary anterior crowding relapse is less prevalent when compared to the mandibular one.[27,31] Despite of that, the search for predictive factors that might improve dental alignment stability is valid, since treatment deterioration in this arch segment may also result in esthetic and functional deficiencies. Due to its location in the arch,

TABLE 6 - Results of independent t test, applied to the studied variables, to verify the differences in the initial stage (T1), between the Groups 1 and 2.

Variables	Group 1 - Class I (N=19)		Group 2 - Class II (N=19)		P
	Mean	SD	Mean	SD	
LITTLE1	7.83	3.14	6.35	2.67	0.126
INTERC1	33.79	2.36	33.35	2.71	0.603
INTERPB1	32.62	1.91	32.08	1.98	0.401
INTERPB'1	37.91	2.94	37.32	2.51	0.514
INTERM1	49.49	3.16	49.71	2.66	0.820
ALENGTH1	68.33	4.72	68.59	3.46	0.849

TABLE 7 - Results of independent t test, applied to the studied variables, to verify the differences in the final stage (T2), between Groups 1 and 2.

Variables	Group 1 - Class I (N=19)		Group 2 - Class II (N=19)		P
	Mean	SD	Mean	SD	
LITTLE2	0.34	0.68	0.00	0.00	0.034*
INTERC2	34.46	1.48	34.42	1.86	0.943
INTERPB2	35.91	1.63	35.16	1.76	0.182
INTERPB'2	40.90	2.19	39.93	2.34	0.198
INTERM2	51.53	2.86	50.61	3.04	0.347
ALENGTH2	71.01	3.45	71.21	3.75	0.868

*Statistically significant for p<0.05.

TABLE 8 - Results of independent t test, applied to the studied variables, to verify the differences in the postretention stage (T3), between Groups 1 and 2.

Variables	Group 1 - Class I (N=19)		Group 2 - Class II (N=19)		P
	Mean	SD	Mean	SD	
LITTLE3	2.01	1.87	0.80	0.76	0.012*
INTERC3	34.29	1.47	34.24	2.06	0.939
INTERPB3	34.66	1.54	34.69	2.17	0.958
INTERPB'3	40.02	2.04	39.23	2.07	0.246
INTERM3	51.34	2.69	50.72	2.88	0.498
ALENGTH3	69.48	3.38	70.06	3.19	0.591

*Statistically significant for p<0.05.

TABLE 9 - Results of independent t test, applied to the studied variables, to verify the differences in the treatment period (T2-T1), between Groups 1 and 2.

Variables	Group 1 - Class I (N=19)		Group 2 - Class II (N=19)		P
	Mean	SD	Mean	SD	
LITTLE2-1	-7.48	3.24	-6.35	2.67	0.247
INTERC2-1	0.56	2.67	1.06	2.07	0.525
INTERPB2-1	3.29	1.78	3.08	1.88	0.723
INTERPB'2-1	2.98	2.27	2.60	2.69	0.641
INTERM2-1	2.03	2.13	0.90	2.78	0.169
ALENGTH2-1	2.68	3.18	2.61	3.01	0.951

TABLE 10 - Results of independent t test, applied to the studied variables, to verify the differences in the post-treatment period (T3-T2), between Groups 1 and 2.

Variables	Group 1 - Class I (N=19)		Group 2 - Class II (N=19)		P
	Mean	SD	Mean	SD	
LITTLE3-2	1.67	1.45	0.80	0.76	0.026*
INTERC3-2	-0.16	0.89	-0.17	0.77	0.984
INTERPB3-2	-1.25	1.10	-0.47	1.47	0.072
INTERPB'3-2	-0.85	0.97	-0.70	1.21	0.670
INTERM3-2	-0.18	0.90	0.10	0.99	0.348
ALENGTH3-2	-1.53	0.75	-1.15	1.39	0.289

*Statistically significant for p<0.05.

TABLE 11 - Results of independent t test, applied to the studied variables, to verify the differences of changes in the whole period of observation (T3-T1), between Groups 1 and 2.

Variables	Group 1 - Class I (N=19)		Group 2 - Class II (N=19)		P
	Mean	SD	Mean	SD	
LITTLE3-1	-5.81	3.94	-5.55	2.34	0.804
INTERC3-1	0.50	2.03	0.89	2.34	0.588
INTERPB3-1	2.04	1.56	2.61	2.24	0.370
INTERPB'3-1	2.10	2.20	1.90	2.13	0.775
INTERM3-1	1.84	2.34	1.01	2.42	0.287
ALENGTH3-1	1.14	3.10	1.46	2.29	0.718

TABLE 12 - Results of the Pearson's correlation test.

Variables	r	P
LITTLE1 x LITTLE3	0.101	0.545
LITTLE1 x LITTLE3-2	0.104	0.533
LITTLE2-1 x LITTLE3-2	-0.021	0.899
LITTLE3-2 x INTERC3-2	0.128	0.441
LITTLE3-2 x INTERPB3-2	-0.296	0.071
LITTLE3-2 x INTERPB'3-2	-0.177	0.286
LITTLE3-2 x INTERM3-2	-0.342	0.035*
LITTLE3-2 x ALENGTH3-2	-0.301	0.065

*Statistically significant for p<0.05.

maxillary crowding tends to become more visible and, consequently, promote more esthetic problems than mandibular incisor irregularity. However, depending on patient's smile height, it may also not occur.

Sample selection included dental cast evaluation. Group 1 comprised patients who exhibited Class I molar relationship and Group 2 consisted of patients presenting at least ¾ of a Class II molar relationship. Both groups were treated without extractions. Another sample selection criterion was that all patients had been treated with fixed Edgewise appliances, in both arches.

During sample selection, one of the concerns was to eliminate possible factors that might influence the results. One of the main objectives during this study development was to obtain compatible groups which would facilitate comparison and, consequently, would favor interpretation and reliability of the results. For this, the characteristics were homogenized in the beginning and end of the orthodontic treatment. The groups were compatible regarding to treatment protocol, the kind of orthodontic accessory used, sex distributions and initial malocclusion. Besides, groups had other compatible characteristics, such as: Initial and final ages, treatment time, postretention evaluation time. Thus, the changes that occurred in the postretention period could be analyzed safely.

Regarding stability, there are considerable controversies in the literature about long-term post retention maxillary crowding relapse in different types of malocclusion (Class I and Class II subjects).[25,31] Some studies reported that the greater the initial malocclusion severity, the greater the long-term relapse.[10,18] Therefore, relapse of maxillary anterior crowding was evaluated in two groups that presented similar pretreatment incisors irregularity. The intergroup compatibility evaluation regarding pretreatment incisor irregularity was performed by t-test. No significant differences were observed between groups regarding initial irregularity (Table 3).

Intragroup comparison

The results for ANOVA and Tukey's test in Group 1 (Table 4) showed statistically significant changes in Little's irregularity index between initial and final or post-treatment phases. No statistically significant differences were noted between final and post-treatment phases. It may be inferred by interpreting these results, that orthodontic treatment resulted in significant maxillary crowding correction. During post-treatment period, there was no significant maxillary crowding relapse.

Intercanine width showed no significant changes during the three treatment stages (Table 4). These results could support the concept that stable results can be gained only when intercanine width is maintained.[12,28] However, it is difficult to distinguish between intercanine width relapse and the normal decrease of this measure that occurs over the years in normal occlusion development, as others studies have reported.[18,28]

Regarding changes in maxillary arch dimensions during treatment, significant transversal increases were noted (variables INTERPB, INTERPB' INTERM). Mean arch length increase was also significant. Only interfirstpremolar width decreased significantly during postretention, but not enough to reach initial values. The arch length width also showed a significant change during post-treatment, reaching a mean value close to the initial one.

Results for ANOVA and Tukey's test in Group 2 (Table 5) showed statistically significant differences in Little's irregularity index in the three stages evaluated. Thus, it was observed that the changes in variable LITTLE were not similar to Group 1. Significant reduction in maxillary crowding occurred during treatment. However, during post-treatment period, there was significant maxillary anterior irregularity relapse, that did not reach pretreatment mean value.

The variables INTERC, INTERPB, INTERPB' and ALENGTH showed statistically significant increases during treatment and did not exhibit a significant relapse when evaluating the final and postretention stages. The intermolar width showed no statistically significant changes in any of the studied phases.

Intergroup comparison

When comparing Groups 1 and 2 (Class I and Class II malocclusion subjects, respectively) in pretreatment, it was observed that none of the evaluated variables showed significant differences between groups (Table 6). Some studies that evaluated crowding relapse during long-term post-treatment mention that pretreatment irregularity is directly related to the amount of relapse,[1] although other authors have not observed this correlation.[20]

Regarding the maxillary arch dimensions, it was noted that Groups 1 and 2 exhibited similar transverse dimensions (Table 6). McNamara[22] commented that, generally, transpalatal widths from 36 to 39 mm may accommodate an average size permanent dentition, without crowding or spacing.

As previously mentioned, the initial maxillary crowding severity, and other pretreatment variables were similar between the groups at T1, allowing a reliable comparative evaluation of the long-term post-treatment changes.

When comparing Groups 1 and 2 at post-treatment, the only variable that differed significantly between the groups was Little's irregularity index. There was more incisor irregularity in Class I subjects, indicating that Group 2 patients exhibited more quality in maxillary incisor alignment at T2 (Table 7). Although statistically significant, difference in irregularity between the groups was only 0.34 mm, which may not be considered clinically significant. Accordingly to Little,[18] dental arch irregularity values between 0 and 1 mm consist in ideal alignments.

During postretention, the only variable that showed a significant intergroup difference was Little's irregularity index (LITTLE3), while other variables as INTERC3, INTERPB3, INTERPB'3, INTERM3 and ALENGTH3 showed no statistically significant differences (Table 8). These results suggested a similar behavior of the groups during postretention regarding dimensional changes.

Intergroup comparison of treatment changes revealed no significant difference between groups in the amount of maxillary crowding correction (LITTLE2-1, Table 9). This result was expected since there were no statistically significant differences between groups in the initial and final maxillary incisor irregularities.

During treatment, the amount of decrease in maxillary incisors irregularity was similar to previous studies that evaluated non-extraction treatment stability.[7,32] However, some studies reported less reduction in incisor irregularity

during treatment because the sample exhibited less pretreatment incisor irregularity.[8]

The fact is that all these studies aimed at eliminating the incisors irregularity during treatment. Thus, variation in the amount of crowding correction is often due to variation in initial crowding severity.

The amount of maxillary incisors crowding relapse (LITTLE3-2) was statistically different between groups. Group 1 (Angle Class I subjects) exhibited a mean crowding relapse of 1.67 mm (SD = 1.45 mm). Group 2 (Angle Class II subjects) showed a mean crowding relapse of 0.80 mm (SD = 0.76 mm). Thus, there was greater treatment stability in Group 2 (Table 10).

This significant difference between the groups regarding incisors alignment stability may be due to orthodontic mechanics performed in patients of each group. In Class II subjects (Group 2), treated without extraction, there was, necessarily, distalization of maxillary molars. Therefore, more space could be gained for teeth alignment and this fact might have favored on stability. In Group 1 (Class I malocclusion), the molars remained stable in their initial positions during treatment. The crowding was corrected by dental protrusion and maxillary arch expansion, perhaps contributing to maxillary anterior crowding relapse.

Sadowsky et al[27], while evaluating the long-term stability of non-extraction cases, observed a similar amount of relapse (1.1 mm) five years postretention. However, Moussa, O'Reilly and Close[23] observed more favorable results 8-10 years postretention. Vaden et al[32] found that 96% of maxillary crowding correction was maintained 15 years post-treatment. The amount of crowding increased from 1.5 mm (post-treatment) to 1.8 mm (postretention). Ferris et al[9] also evaluated the relapse of maxillary anterior crowding in cases treated without extractions and observed an increase in maxillary incisors irregularity of only 0.47 (SD = 1.19) during postretention (7.9 years). The greater maxillary incisors alignment stability of these studies may be due to the prolonged use of retention.[3,23,27] In Sadowsky et al[27] study, the mean retention period was 8.4 years. Moussa, O'Reilly and Close[23] study adopted a mean retention period of 6.6 years in the mandibular arch (fixed retention) and 2 years for the maxillary arch (Hawley retainer). In the research conducted by Vaden et al,[32] patients used Hawley retainers in mandibular and maxillary arches or Hawley retainer in the maxillary arch and bonded lingual retainer in the lower arch. The first long-term post-treatment evaluation was carried out only 6 years after treatment. In Ferris et al[9] study, patients were submitted to a retention protocol that included the use of maxillary removable retainers for at least 3 years (one year of continuous usage) and a bonded lingual retainer or a Hawley retainer in mandibular arch during a mean period of 3 years. In the present study, all patients used a Hawley retainer in the maxillary arch during 1 year and a mandibular bonded lingual retainer for a mean period of 3 years.

Erdinc, Nanda and Isiksal[8] evaluated long-term maxillary and mandibular incisors alignment stability in orthodontic patients treated with and without premolar extraction. An increase in maxillary and mandibular irregularities of 0.19 mm and 0.12 mm was observed in patients treated with and without extractions, respectively, 4 years and 11 months postretention. The extraction group had an initial crowding of 4.4 mm, whereas the non-extraction group showed a pretreatment crowding of 1.94 mm. The maxillary and mandibular removable retainers (Hawley) were removed at least two years before postretention assessment. The exceptional stability noted in this research may be related to the amount of initial irregularity and due to a short interval between retention removal and the long-term post-treatment evaluation.

Surbeck et al[29] observed a direct influence of pretreatment maxillary irregularity severity on amount of postretention relapse. The authors[29] suggested the adoption of individual retention protocols and that the orthodontist should explain to patients the probability of post-treatment relapse, accordingly to the initial irregularity severity.

However, analyzing the results of other authors and ours, a positive correlation between the amount of pretreatment crowding and the amount of long-term post-treatment relapse seems unlikely. For example, in the present study, Groups 1 and 2 presented 7.83 mm (SD = 3.14) and 6.35 mm (SD = 2.67) of pretreatment maxillary irregularity, respectively. A mean maxillary irregularity relapses of 1.67 mm (SD = 1.45 mm) for Group 1 and 0.80 mm (SD = 0.76 mm) for Group 2 was observed. The amount of irregularity relapse in the present study was greater than the crowding relapse observed by Ferris et al,[9] Sadowsky et al[27] and Vaden et al.[32] However, the sample in these studies showed greater maxillary pretreatment irregularity: 10.45 mm, 8.0 mm and 7.9 mm, respectively. Thus, even showing slightly greater amounts of initial crowding than the present study, maxillary incisors alignment in those studies was more stable during postretention (0.47 mm, 1.1 mm, 0.3 mm of long-term post-treatment relapse, respectively).

When evaluating overall changes (T3-T1), it was observed that maxillary anterior irregularity decreased 5.81 mm (SD = 3.94) and 5.55 mm (SD = 2.34) for Groups 1 and 2, respectively, and there were no statistically significant differences between groups (Table 11).

Correlation

Correlation tests were performed in the total sample to obtain the Pearson's correlation coefficients. Results showed a significant correlation between pretreatment and post-treatment incisors irregularity (LITTLE1 and LITTLE3), between initial crowding (LITTLE1) and post-treatment crowding relapse (LITTLE3-2), and between crowding correction (LITTLE2-1) and postretention crowding relapse (LITTLE3-2). We also attempted to determine a possible correlation between maxillary crowding relapse (LITTLE3-2) and postretention changes in maxillary arch dimensions (INTERC3-2, INTERPB3-2, INTERPB'3-2, INTERM3-2 and ALENGTH3-2). Results are shown in Table 12.

Most results of the correlation tests were not significant. It was observed that pretreatment maxillary crowding severity did not influence the postretention crowding relapse, as described in previous studies.[2,3,20] Surbeck et al,[29] however, reported a positive correlation between pretreatment crowding severity and the amount of maxillary anterior crowding relapse. Accordingly to the authors,[29] the odds of maxillary anterior relapse increase 2.3 times for every 0.2 mm displacement of incisors anatomic contact points relative to the dental arch, and 2.7 times for every 4° of incisor rotation. The authors also pointed out that incomplete alignment during active treatment is a significant risk factor for relapse.

Maxillary anterior crowding relapse (LITTLE3-2) showed a statistically significant ($p<0.035$) correlation with the postretention changes in intermolar width (INTERM3-2). The observed correlation coefficient has a negative value. Interpreting this result, it seems that the greater the postretention intermolar width reduction, the greater the maxillary anterior crowding relapse. However, although this result has statistical significance, the correlation coefficient value shows a weak correlation ('r' = -0.342). Therefore, it may be inferred that the observed correlation has no clinical significance. The postretention decreases in the intermolar width may have occurred due to some pretreatment molar rotation that was corrected during treatment, and relapsed during long-term post-treatment evaluation.

CONCLUSIONS

According to the sample and methodology used and based on the presented and discussed results, it was concluded that:

» Class I malocclusion subjects treated non-extraction exhibited greater maxillary anterior crowding relapse than Class II subjects treated with the same protocol.

» The dimensional variables evaluated showed an increase in their mean values during orthodontic treatment and slight relapses during long-term post-treatment. The only measure that was correlated to the maxillary anterior crowding relapse was the postretention changes in intermolar width.

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Contact address
Karina Maria Salvatore de Freitas
Rua Jamil Gebara, 1-25, apto. 111, Jd. Paulista
CEP: 17.017-150 – Bauru/SP, Brazil
E-mail: kmsf@uol.com.br