Comparison of the tooth alignment stability using canine-to-canine retainers bonded in two different forms

Comparaçao da estabilidade do alinhamento dos dentes anteroinferiores com uso de 3x3 colado de duas formas diferentes
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Dissertação constituída por artigo apresentada à Faculdade de Odontologia de Bauru da Universidade de São Paulo para obtenção do título de Mestre em Ciências no Programa de Ciências Odontológicas Aplicadas, na área de concentração Ortodontia.

Orientador: Prof. Dr. Marcos Roberto de Freitas

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ABSTRACT
ABSTRACT

COMPARISON OF THE TOOTH ALIGNMENT STABILITY USING CANINE-TO-CANINE RETAINERS BONDED IN TWO DIFFERENT FORMS

Objective: The purpose is to evaluate the stability of the mandibular anterior teeth alignment by comparing two forms of bonding of the fixed canine-to-canine retainer, bonded only to the canines and bonded to each of the mandibular incisors and canines, with 5 years follow-up. Material and Methods: 43 patients (22 female, 21 male) with Class I and Class II malocclusion, were divided into 2 groups: Group 1: 25 patients (13 females, 12 males) with retainer bonded only to the canines. Mean initial age, treatment time, long-term posttreatment time were 13.42 (SD, 1.51), 3.06 (1.56) and 5.60 (SD, 1.36) years, respectively. Group 2: 18 patients (9 females, 9 males) with retainer bonded to the all mandibular anterior teeth. Mean initial age, treatment time, long-term posttreatment time were 13.01 (SD, 2.94), 3.62 (SD, 1.84), 5.31 (SD, 0.77) years, respectively. Dental casts were obtained and digitized at pretreatment (T1), posttreatment (T2) and at a mean of 5 years long-term posttreatment (T3). The following measurements were obtained: Little irregularity Index, intercanine, interpirmolar and intermolar widths. The intergroup comparisons of the variables at pretreatment, posttreatment and long-term posttreatment stages and the treatment and long-term posttreatment changes were performed with independent t tests.

Results: The mandibular irregularity index showed a statistically significant decrease with treatment and remained stable in the long-term posttreatment follow-up. In the group 1, there was a significantly increase in the mandibular inter first premolars width with treatment and it was stable in the long-term posttreatment. In the group 2, the mandibular inter second premolars width showed a significantly increase with treatment and it remained stable in the long-term. The intergroup comparison at all stages (T1, T2 and T3) showed no statistically significant differences between the groups. Group 2 showed a greater decrease in the mandibular intercanine width than the all teeth group in the long-term posttreatment phase. Conclusions: There was no difference in the amount of relapse of mandibular anterior crowding with fixed canine-to-canine retainers bonded only to the canines and bonded all the six anterior teeth. Thus, both retainers can be recommended. However, the canine group showed a decrease in the mandibular intercanine width in long term posttreatment.

Keywords: Orthodontic retainer; Long-term stability; Relapse; Crowding.
RESUMO
RESUMO

Comparação da estabilidade do alinhamento dos dentes anteroinferiores com uso de 3x3 colado de duas formas diferentes

Objetivo: Avaliar a estabilidade do alinhamento dos dentes anteroinferiores, comparando duas formas diferentes de colagem de contenção 3x3 inferior: colada apenas em caninos e em cada um dos incisivos e caninos inferiores, com acompanhamento de 5 anos. Materiais e Métodos: 43 pacientes (22 mulheres, 21 homens) com más oclusões de Classe I e Classe II, foram divididos em 2 grupos: Grupo 1: 25 pacientes (13 mulheres, 12 homens) com contenção colada apenas nos caninos inferiores. A média de idade inicial, tempo de tratamento e tempo de pós-tratamento em longo prazo foram de 13,42 (DP: 1,51), 3,06 (1,56) e 5,60 (DP: 1,36) anos, respectivamente. Grupo 2: 18 pacientes (9 mulheres, 9 homens) com contenção colada em todos os dentes anteroinferiores. A média de idade inicial, tempo de tratamento e tempo de pós-tratamento em longo prazo foram de 13,01 (DP, 2,94), 3,62 (DP, 1,84), 5,31 (DP, 0,77) anos, respectivamente. Modelos dentários foram obtidos e digitalizados no pré-tratamento (T1), pós-tratamento (T2) e em uma média de 5 anos pós-tratamento (T3). As seguintes medidas foram obtidas: Índice de Irregularidade de Little, distâncias intercaninos, interpremolares e intermolares. As comparações intergrupos das variáveis nos estágios de pré-tratamento, pós-tratamento e acompanhamento em longo prazo foram realizadas com teste t independente, assim como as alterações com o tratamento e no acompanhamento em longo prazo. Resultados: O Índice de Irregularidade de Little apresentou uma redução estatisticamente significante com o tratamento e permaneceu estável no acompanhamento em longo prazo nos dois grupos. O grupo 1 obteve um aumento significativo na distância entre os primeiros prémolares inferiores com o tratamento e permaneceu estável no acompanhamento em longo prazo. No grupo 2, a distância entre os segundos prémolares inferiores aumentou significativamente com o tratamento e se manteve estável no acompanhamento em longo prazo. A comparação intergrupos em todos os estágios (T1, T2 e T3) não apresentou diferenças estatisticamente significantes entre os grupos. O grupo 1 apresentou uma diminuição significante na distância intercaninos no acompanhamento em longo prazo comparado ao grupo 2. Conclusões: Não houve diferença na quantidade de recidiva do apinhamento anteroinferior com as
contenções 3x3 fixas coladas apenas em caninos e coladas em todos os dentes anteriores inferiores. Assim, ambas as contenções podem ser recomendadas. No entanto, o grupo 1 mostrou uma diminuição na distância intercaninos no pós-tratamento em longo prazo.

**Palavras Chave:** Contenção Ortodôntica; Estabilidade em longo prazo; Recidiva; Apinhamento
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1 INTRODUCTION
1 INTRODUCTION

Orthodontic treatment has as its primary objective the correction of malocclusions. Retention is the phase of orthodontic treatment that aims to maintain the teeth in the correct position after active treatment and counteract relapse. (THILANDER, 2000) Without retention there is a tendency for the teeth to return to their initial position. (LITTLEWOOD; MILLETT; DOUBLEDAY; BEARN et al., 2016) There is consensus in the orthodontic literature that some occlusal changes will inevitably occur after treatment. Therefore, orthodontic retainers are ideally suited to maintain dental alignment. (LITTLE, 1999)

Throughout life, there are also changes in normal occlusion, such as arch length decreased and mandibular incisor crowding. (BISHARA; TREDER; DAMON; OLESEN, 1996; PROFFIT; JR; W, 2002) Thilander stated that the occlusion is the result of a developmental process that continues with significant individual variations. (THILANDER, 2000) During life, the dental arches decrease gradually due to a slow physiologic mesial migration of the dentition. In the maxilla, however, no change in the arch perimeter was found between the ages of 5 and 31 years (measured mesial to the permanent first molars), while a decrease of 4 mm was seen simultaneously in the mandible. (THILANDER, 2009)

The etiology of anteroinferior crowding after orthodontic treatment is multifactorial. Some of them are directly related to orthodontic treatment, such as: increased intercanine width; (GLENN; SINCLAIR; ALEXANDER, 1987; KUFTINEC; STOM, 1975) change in the shape of the dental arches; (WEINBERG; SADOWSKY, 1996) excessive protrusion of incisors; (LITTLE; WALLEN; RIEDEL, 1981; TWEED, 1944) lack of harmony of occlusion; (THILANDER, 2000) professional skill; (THILANDER, 2000) failure to remove the causes of malocclusion; (SADOWSKY; SAKOLS, 1982) retainer time. (LITTLE, 1999; THILANDER, 2000)

Retention strategies usually include removable and fixed retainers. (LITTLEWOOD; MILLETT; DOUBLEDAY; BEARN et al., 2006) In the lower arch fixed retainers in the anterior segment are a valid option for managing the significant relapse rate in this area. (ZACHRISSON, 1977) Two different fixed canine-to-canine
retainers can be used in the mandible, bonded only to the canines or a retainer bonded to each of the mandibular incisors and canines. (PROFFIT; JR; W, 2002; ZACHRISSON, 1997) They are independent of patient cooperation, nearly invisible, and easy to fabricate, but they need regular check-ups, because occasional failures caused by wire fractures or bond failures can occur. Studies have shown that bonded retainers represent an efficient and reliable retention appliance for long-term use, prevent posttreatment changes caused by relapse or the natural aging process in the alignment of the incisors. (RENKEMA; RENKEMA; BRONKHORST; KATSAROS, 2011; STEINNES; JOHNSON; KEROSUO, 2017; ZACHRISSON, 2007)

Systematic reviews and original studies investigated the benefits and damage associated with fixed and removable retainers, focused on stability and clinical performance of both types of retainers, considering the different materials, design of the appliances. (BAHIJE; ENNAJI; BENYAHIA; ZAOU, 2018; BUZATTA; SHIMIZU; SHIMIZU; PACHÊCO-PEREIRA et al., 2017; LITTLEWOOD; KANDASAMY; HUANG, 2017; LITTLEWOOD; MILLET; DOUBLEDAY; BEARN et al., 2016; PADMOS; FUDALEJ; RENKEMA, 2018) Another systematic review evaluated the difference between fixed orthodontic retainers bonded to all teeth and those bonded only to the canines, but only the periodontal condition and bonding failures were presented. (AL-MOGHRABI; PANDIS; FLEMING, 2016) A few studies reported the effectiveness the two types of fixed canine-to-canine retainers in stability of mandibular anterior teeth alignment. (ARTUN; SPADAFORE; SHAPIRO, 1997; MODA; DA SILVA BARROS; FAGUNDES; NORMANDO et al., 2019; SCHÜTZ-FRANSSON; LINDSTEN; BJERKLIN; BONDEMARK, 2017; STEINNES; JOHNSON; KEROSUO, 2017)

Therefore, the purpose of this study is to evaluate the stability of the mandibular anterior teeth alignment by comparing two forms of bonding of the fixed canine-to-canine retainer, bonding only to the canines and all the six mandibular anterior teeth, with 5 years follow-up.
The article presented in this Dissertation was formatted according to the American Journal of Orthodontics and Dentofacial Orthopedics instructions and guidelines for article submission.
COMPARISON OF THE TOOTH ALIGNMENT STABILITY USING CANINE-TO-CANINE RETAINERS BONDED IN TWO DIFFERENT FORMS

ABSTRACT

Objective: Evaluate the stability of the mandibular anterior teeth alignment by comparing two forms of bonding of the fixed canine-to-canine retainer, bonded only to the canines and bonded to each of the mandibular incisors and canines, with 5 years follow-up. Material and Methods: 43 patients (22 female, 21 male) with Class I and Class II malocclusion, were divided into 2 groups: Group 1: 25 patients with retainer bonded only to the canines. Group 2: 18 patients with retainer bonded to the all mandibular anterior teeth. Dental casts were obtained and digitized at pretreatment (T1), posttreatment (T2) and at a mean of 5 years long-term posttreatment (T3). The following measurements were obtained: Little Irregularity Index, intercanine, inter premolar and intermolar widths. The intergroup comparisons of the variables at pretreatment, posttreatment and long-term posttreatment stages and the treatment and long-term posttreatment changes were performed with independent t test. Results: The mandibular irregularity index showed a statistically significant decrease with treatment and remained stable in the long-term posttreatment follow-up. In the group 1, there was a significantly increase in the mandibular inter first premolars width with treatment and it was stable in the long-term posttreatment. In the group 2, the mandibular inter second premolars width showed a significantly increase with treatment and it remained stable in the long-term. The intergroup comparison at all stages (T1, T2 and T3) showed no statistically significant differences between the groups. Group 1 showed a greater decrease in the mandibular intercanine width than group 2 in the long-term posttreatment phase. Conclusions: There was no difference in the amount of relapse of anterior crowding with fixed canine-to-canine retainers bonded only to the canines and bonded all the mandibular anterior teeth. Thus, both retainers can be recommended. However, the canine group showed a decrease in the mandibular intercanine width in long term posttreatment.

Keywords: Orthodontic retainer; Long-term stability; Relapse; Crowding.
INTRODUCTION

Orthodontic treatment has as its primary objective the correction of malocclusions. Retention is the phase of orthodontic treatment that aims to maintain the teeth in the correct position after active treatment and counteract relapse. Without retention there is a tendency for the teeth to return to their initial position. There is consensus in the orthodontic literature that some occlusal changes will inevitably occur after treatment. Therefore, orthodontic retainers are ideally suited to maintain dental alignment.

Throughout life, there are also changes in normal occlusion, such as arch length decreased and mandibular incisor crowding. Many studies have demonstrated a high relapse rate of the alignment of the mandibular anterior teeth after orthodontic treatment and retention. A long-term follow-up study found that postretention crowding and incisor irregularity increased more frequently in the mandible than in the maxilla. The etiology of anteroinferior crowding after orthodontic treatment is multifactorial. Some of them are directly related to orthodontic treatment, such as: increased intercanine width; change in the shape of the dental arches; excessive protrusion of incisors; lack of harmony of occlusion; professional skill; failure to remove the causes of malocclusion; retainer time.

Retention strategies usually include removable and fixed retainers. In the lower arch fixed retainers in the anterior segment are a valid option for managing the significant relapse rate in this area. Two different fixed canine-to-canine retainers can be used in the mandible, bonded only to the canines or a retainer bonded to each of the mandibular incisors and canines. They are independent of patient cooperation, nearly invisible, and easy to fabricate, but they need regular check-ups, because occasional failures caused by wire fractures or bond failures can occur. Studies have shown that bonded retainers represent an efficient and reliable retention appliance for long-term use, prevent posttreatment changes caused by relapse or the natural aging process in the alignment of the incisors.

Systematic reviews and original studies investigated the benefits and damage associated with fixed and removable retainers, focused on stability and clinical performance of both types of retainers, considering the different materials, design of the appliances. Another systematic review evaluated the difference between fixed orthodontic retainers bonded to all teeth and those bonded only to the canines,
but only the periodontal condition and bonding failures were presented.\textsuperscript{25} A few studies reported the effectiveness the two types of fixed canine-to-canine retainers in stability of mandibular anterior teeth alignment.\textsuperscript{19,26-28}

Therefore, the purpose of this study is to evaluate the stability of the mandibular anterior teeth alignment by comparing two forms of bonding of the fixed canine-to-canine retainer, bonding only to the canines and all the six mandibular anterior teeth, with 5 years follow-up.

**MATERIAL AND METHODS**

This study was approved by the ethical committee of Bauru Dental School, University of São Paulo, Brazil (protocol number: 22081719.9.0000.5417; decision number: 3.959.594).

The sample size calculation was based on an alpha significance level of 5% and 80% test power to detect a mean difference of 0.85 mm, with a standard deviation of 0.89 for the Little irregularity index.\textsuperscript{29} Thus, the sample size calculation showed the need for 16 subjects in each group.

**Sample characteristics**

The sample comprised the dental casts of 43 patients (22 female, 21 male) with Class I and Class II malocclusion divided into 2 groups depending on which kind of mandibular retainer was used, treated at the Department of Orthodontics, Bauru Dental School, University of São Paulo, Brazil. Dental casts were obtained at 3 different stages: pretreatment (T1), posttreatment (T2), and at a mean of 5 years long-term posttreatment (T3). The inclusion criteria were based on the following characteristics: Class I or Class II malocclusion treated without extraction; all permanent teeth erupted up to the first molars at pretreatment; complete orthodontic treatment with full maxillary and mandibular fixed appliances; no tooth agenesis or anomalies; mandibular fixed canine-to-canine retainers (conventional plain retainer) worn for at least 5 years posttreatment; presence of documentation of the 3 times evaluated with dental casts in good condition for evaluation.
Group 1 comprised in 25 patients (13 female, 12 male) with retainer bonded only to the canines (Figure 1a). Mean mandibular anterior crowding at pretreatment was 3.42mm (SD, 1.94). The mean age was 13.42 years (SD, 1.51) at the pretreatment, 16.48 years (SD, 1.48) at the posttreatment and 22.08 years (SD, 1.43) at the long-term posttreatment. Mean treatment time and long-term posttreatment time was 3.06 years (SD, 1.56) and 5.60 years (SD, 1.36), respectively. Ten patients presented Class I and 15 had Class II malocclusions.

Group 2 comprised 18 patients (9 female, 9 male) with retainer bonded all the mandibular anterior teeth (Figure 1b). Mean initial mandibular anterior crowding was 3.31mm (SD, 2.19). The mean age was 13.01 years (SD, 2.94) at the pretreatment, 16.63 years (SD, 1.95) at the posttreatment and 21.94 years (SD, 1.43) at the long-term posttreatment. Mean treatment time and long-term posttreatment time was 3.62 years (SD, 2.94) and 5.31 years (SD, 0.77), respectively. Four patients presented Class I and 14 had Class II malocclusions.

All retainers were custom-made in the laboratory and were bonded with composite. Patients in both groups underwent annual controls to observe possible bonding failures and relapse at the long-term posttreatment. The mean posttreatment long-term was 5.48 years (SD, 1.15).

Methods

All dental casts were digitized using a R700 3-dimensional scanner (3Shape, Copenhagen, Denmark). Dental casts measurements were performed using the OrthoAnalyzer 3-dimensional software (3Shape A/S, Copenhagen, Denmark). The following measurements were obtained for each set of dental casts at 3 different stages (T1, T2 and T3). All measurements are linear, in millimeters, and were performed in mandibular arch by a single calibrated examiner (J.Q.F.).

- Little Irregularity Index (Figure 2a): the sum of the linear displacements of the anatomic contact points of each incisor from the adjacent tooth anatomic contact point.\(^{30}\)
- Intercanine width (Figure 2b): linear distance between the cusp tip to cusp tip of the mandibular canines.\(^{31}\)
- Interpremolar width (Figure 2b): linear distance between the cusp tip to cusp tip of the mandibular first and second premolars.\textsuperscript{31}
- Intermolar width (Figure 2b): linear distance between the cusp tip to cusp tip of the mandibular first molars.\textsuperscript{31}

Treatment changes were obtained from T2-T1 values and long-term posttreatment changes, from T3-T2 values.

**Error study**

The pretreatment, posttreatment and long-term posttreatment dental casts of 17 patients were randomly selected, retraced and remeasured by the same examiner (J.Q.F.) after a month interval. The intraclass correlation coefficient (ICC) was used for test reliability of the measurements.\textsuperscript{32}

**Statistical analysis**

The normality of data was verified by the Shapiro-Wilk test.

The intergroup comparability of the ages, treatment and long-term posttreatment times was performed with independent t tests and the sex distribution and type of malocclusion was compared with chi-square tests.

The intragroup comparison of the pretreatment, posttreatment and long-term posttreatment stages was performed with repeated measures ANOVA and Tukey tests when necessary.

The intergroup comparisons of the variables at pretreatment, posttreatment and long-term posttreatment stages and the treatment and long-term posttreatment changes were performed with independent t tests.

The statistical analysis was performed with Statistica software (version 12.0, Statsoft, Tulsa, Okla, USA), and the results were considered significant at p<0.05.
RESULTS

Intraclass correlation coefficients (ICCs) of the variables varied from 0.89 to 0.98, indicating excellent intra-rater agreement.\(^{33}\)

The groups were comparable regarding ages at all stages (T1, T2 and T3), treatment time, long-term posttreatment time, sex distribution and type of malocclusion (Table I).

In the canine group, there was a significantly increase in the mandibular inter first premolars width with treatment and it was stable in the long-term posttreatment (Table II). In the all teeth group, the mandibular inter second premolars width showed a significantly increase with treatment and it remained stable in the long-term (Table II). The mandibular irregularity index showed a statistically significant decrease with treatment and remained stable in the long-term posttreatment follow-up (Table II).

The intergroup comparison at all stages (T1, T2 and T3) showed no statistically significant differences between the groups (Table III).

Intergroup comparison of the treatment changes (T2-T1) was similar between the groups (Table IV). The canine group showed a greater decrease in the mandibular intercanine width than the all teeth group in the long-term posttreatment phase (Table IV).

DISCUSSION

The groups were comparable regarding several parameters that could influence comparisons: type of malocclusion, ages at all stages, treatment time, long-term posttreatment time, sex distribution and type of malocclusion (Table I). This manner, achieved orthodontic treatment results could be evaluated with increased reliability. Furthermore, digital dental casts were used in this study and the measurements were performed with digital software. Three-dimensional dental casts’ measurement has been an optimal alternative to plaster dental casts with excellent agreement.\(^{34}\)

Little Irregularity Index\(^{30}\) was used to quantify mandibular incisor crowding. Thereupon, mandibular crowding at T1 was considered minimal 3.42 mm and 3.31
mm in the canine group and all teeth group, respectively (Table II). At T2, anterior crowding was corrected with treatment and had minimal irregularity for both groups: 1.18 mm and 1.12 mm, for canine groups and all teeth groups, respectively (Table II). Mandibular incisors presented stability from T2 to T3, maintain a minimal irregularity: 1.89 mm for canine group and 1.50 mm for all teeth group (Table II).

Interpremolar widths showed significantly increased with treatment in both groups and continued stable in the long-term (Table II). In the canine group, mandibular inter first premolars width increased, while in the all the six teeth group, increased inter second premolars width. These widths were expanded during treatment and stable posttreatment long-term, however, it is recommended to obtain the best treatment stability has been maintain patients’ pretreatment arch form.31,35

Intergroup comparison at T1, T2 and T3 (Table III) showed that both bonded retainers may still be considered as an effective and safe method to stabilize outcomes of orthodontic treatment, maintaining long-term mandibular anterior alignment. Artun et al.26, Steinnes et al.19 and Schütz-Fransson et al.28, also observed that there was no difference in stability between the two types of retainers, those bonded to all teeth or those bonded only to canines. Therefore, mandibular fixed retainer may prevent posttreatment changes caused by relapse or the natural aging process in the alignment of the incisors also in the very long term.19

Canine group showed a change in the long term posttreatment: a decreased in the mandibular intercanine width (Table IV). Schütz-Fransson28 reported similar result, however, presented in yours two groups. Wolf36 noted that changes in tooth position occur even with the patient is using a permanent fixed mandibular retainer after orthodontic treatment. In addition, analyzed in your study with superpositions of the virtual 3D models, that canines underwent the most pronounced rotation and translation.

Perfect stability cannot be expected in the long term, changes have can also be found even in untreated people.37 There are several studies reporting this maturational changes, indicating a decrease in arch length and perimeter and an increase in anterior alignment.38,39 Abdulraheem et Al.40 stated that as about 25% of the displaced incisors can be considered as an effect of natural growth, not a relapse of the orthodontic treatment. Watted41 observed that the irregularity of the anterior
incisors in the mandible increased considerably more in participants without a retainer compared with those who had a fixed retainer in place. This suggests that, although the fixed retainer did not prevent a certain amount of unwanted occlusal changes, it had a significant role in maintaining the alignment of the mandibular anterior teeth. Thus, a permanent fixed lingual retainer in the lower anterior segment is one of the most effective and used technics to stabilize orthodontic treatment outcomes.\textsuperscript{12}

Clinical implications

Orthodontists expect that the treatment results remain stable for many years. However, long-term stability of the mandibular incisors after orthodontic treatment is variable and unpredictable.\textsuperscript{8} With the findings of this study, orthodontists will be able to plan an efficient retention protocol, as well as explain to the patient the changes that may occur in their occlusion along many years posttreatment. The professional can choose the best form of retainer bonding for each patient, warning about their proper care and regular check-ups. In addition, to being aware that, fixed canine-to-canine retainers are efficient in long-term mandibular anterior alignment.\textsuperscript{41}

CONCLUSIONS

Based on the results of this study, it could be concluded that:

- Increased in inter premolar width may occur with orthodontic treatment;
- The canine group showed as change in long term posttreatment, a decrease in the mandibular inter canine width;
- Fixed canine-to-canine retainer bonded only to the canines or bonded to each tooth, can be recommended since both are equally effective during the retention period;
- The fixed canine-to-canine retainers are still the most effective to contain mandibular anterior segment relapses in long-term.
ACKNOWLEDGEMENTS

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FIGURE LEGENDS

Figure 1a. Fixed canine-to-canine retainer bonded only to the canines 1b. Fixed canine-to-canine retainer bonded all the mandibular anterior teeth.

Figure 2a. Mandibular Little Irregularity Index. 2b. Arch dimensions: intercanine, interpremolar and intermolar widths.
Figure 2
Table I. Intergroup comparison of the ages, treatment and long-term posttreatment times (independent t test), sex distribution and type of malocclusion (chi-square test).

| Variables                          | Group 1 – Canines (n=25) | Group 2 – All Teeth (n=18) | P     |
|-----------------------------------|--------------------------|----------------------------|-------|
|                                   | Mean   | SD    | Mean | SD    |         |
| Age T1 (y)                        | 13.42  | 1.51  | 13.01| 2.94  | 0.601   |
| Age T2 (y)                        | 16.48  | 1.48  | 16.63| 1.95  | 0.775   |
| Age T3 (y)                        | 22.08  | 1.43  | 21.94| 1.61  | 0.765   |
| Treatment time (y)                | 3.06   | 1.56  | 3.62 | 1.84  | 0.299   |
| Long-term posttreatment time (y)  | 5.60   | 1.36  | 5.31 | 0.77  | 0.381   |
| Sex                               |         |       |      |       | X²=0.017 |
| Males                             | 12      |       | 9    |       | DF=1    |
| Females                           | 13      |       | 9    |       | 0.897   |
| Type of malocclusion              |         |       |      |       | X²=1.506 |
| Class I                           | 10      |       | 4    |       | DF=1    |
| Class II                          | 15      |       | 14   |       | 0.220   |
Table II. Intragroup comparison of the pretreatment, posttreatment and long-term posttreatment stages of the canine group and the all teeth group (repeated measures ANOVA and Tukey tests).

| Variables (mm) | Pretreatment (T1) | Posttreatment (T2) | Long-term Posttreatment (T3) | P  |
|----------------|-------------------|--------------------|-----------------------------|----|
|                | Mean (SD)         | Mean (SD)          | Mean (SD)                   |    |
| **CANINE GROUP** |                   |                    |                             |    |
| IC             | 26.78 (1.54)      | 26.95 (1.38)       | 26.61 (1.25)                | 0.251 |
| I1PM           | 33.85 (1.98) A    | 34.51 (1.43) B     | 34.42 (1.33) B              | 0.014* |
| I2PM           | 39.60 (2.72)      | 40.00 (1.89)       | 39.67 (1.91)                | 0.451 |
| IM             | 44.32 (2.79)      | 44.32 (2.66)       | 44.03 (2.54)                | 0.647 |
| Little         | 3.42 (1.94) A     | 1.18 (0.83) B      | 1.89 (1.08) B               | 0.000* |
| **ALL TEETH GROUP** |                 |                    |                             |    |
| IC             | 26.85 (1.90)      | 26.26 (1.38)       | 26.21 (1.34)                | 0.319 |
| I1PM           | 34.08 (1.88)      | 35.00 (1.58)       | 34.66 (1.54)                | 0.147 |
| I2PM           | 39.57 (2.05) A    | 40.77 (1.67) B     | 40.34 (1.63) B              | 0.034* |
| IM             | 44.29 (2.36)      | 43.97 (1.73)       | 43.83 (1.56)                | 0.365 |
| Little         | 3.31 (2.19) A     | 1.12 (0.91) B      | 1.50 (1.08) B               | 0.000* |

* Statistically significant at p<0.05

Different letters in the same row indicate the presence of a statistically significant difference between the stages.
Table III. Intergroup comparison of the variables at pretreatment, posttreatment and long-term posttreatment (independent t tests).

| Variables (mm) | Group 1 – Canines (n=25) | Group 2 – All Teeth (n=18) | P  |
|---------------|-------------------------|---------------------------|----|
|               | Mean | SD  | Mean | SD  |     |
| PRETREATMENT T1 |      |     |      |     |     |
| IC T1         | 26.78 | 1.54 | 26.85 | 1.90 | 0.894 |
| I1PM T1       | 33.85 | 1.98 | 34.08 | 1.88 | 0.699 |
| I2PM T1       | 39.60 | 2.72 | 39.57 | 2.05 | 0.962 |
| IM T1         | 44.32 | 2.79 | 44.29 | 2.36 | 0.968 |
| Little T1     | 3.42  | 1.94 | 3.31  | 2.19 | 0.854 |
| POSTTREATMENT T2 |      |     |      |     |     |
| IC T2         | 26.95 | 1.38 | 26.26 | 1.38 | 0.118 |
| I1PM T2       | 34.51 | 1.43 | 35.00 | 1.58 | 0.297 |
| I2PM T2       | 40.00 | 1.89 | 40.77 | 1.67 | 0.177 |
| IM T2         | 44.32 | 2.66 | 43.97 | 1.73 | 0.627 |
| Little T2     | 1.18  | 0.83 | 1.12  | 0.91 | 0.822 |
| LONG-TERM POSTTREATMENT T3 |      |     |      |     |     |
| IC T3         | 26.61 | 1.25 | 26.21 | 1.34 | 0.318 |
| I1PM T3       | 34.42 | 1.33 | 34.66 | 1.54 | 0.587 |
| I2PM T3       | 39.67 | 1.91 | 40.34 | 1.63 | 0.234 |
| IM T3         | 44.03 | 2.54 | 43.83 | 1.56 | 0.765 |
| Little T3     | 1.89  | 1.08 | 1.50  | 1.08 | 0.257 |
Table IV. Intergroup comparison of the variables at pretreatment, posttreatment and long-term posttreatment (independent t tests).

| Variables (mm) | Group 1 – Canines (n=25) | Group 2 – All Teeth (n=18) | P |
|---------------|--------------------------|----------------------------|---|
|               | Mean         | SD            | Mean         | SD           |   |
| TREATMENT CHANGES |             |               |              |              |   |
| IC T2-T1      | 0.17         | 1.19          | -0.59        | 2.44         | 0.187 |
| I1PM T2-T1    | 0.67         | 1.54          | 0.92         | 2.45         | 0.676 |
| I2PM T2-T1    | 0.40         | 2.15          | 1.20         | 2.43         | 0.259 |
| IM T2-T1      | 0.00         | 2.18          | -0.32        | 1.66         | 0.606 |
| Little T2-T1  | -2.24        | 1.85          | -2.18        | 2.21         | 0.928 |
| LONG-TERM POSTTREATMENT CHANGES |             |               |              |              |   |
| IC T3-T2      | -0.34        | 0.38          | -0.06        | 0.16         | 0.006* |
| I1PM T3-T2    | -0.09        | 0.52          | -0.34        | 0.56         | 0.144 |
| I2PM T3-T2    | -0.33        | 0.87          | -0.42        | 0.64         | 0.700 |
| IM T3-T2      | -0.29        | 1.02          | -0.14        | 0.73         | 0.604 |
| Little T3-T2  | 0.71         | 0.82          | 0.38         | 0.45         | 0.136 |

* Statistically significant at p<0.05
3 DISCUSSION
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The groups were comparable regarding several parameters that could influence comparisons: type of malocclusion, ages at all stages, treatment time, long-term follow up evaluation, sex distribution and type of malocclusion (Table I). This manner, achieved orthodontic treatment results could be evaluated with increased reliability. Furthermore, digital dental casts were used in this study and the measurements were performed with digital software. Three-dimensional dental casts’ measurement has been an optimal alternative to plaster dental casts with excellent agreement. (SOUZA; VASCONCELOS; JANSON; GARIB et al., 2012)

Little Irregularity Index was used to quantify mandibular incisor crowding. (LITTLE, 1975) Thereupon, mandibular crowding at T1 was considered minimal 3.42 mm and 3.31 mm in the canine group and all teeth group, respectively (Table II). At T2, anterior crowding was corrected with treatment and had minimal irregularity for both groups: 1.18 mm and 1.12 mm, for canine groups and all teeth groups, respectively (Table II). Mandibular incisors presented stability from T2 to T3, maintain a minimal irregularity: 1.89 mm for canine group and 1.50 mm for all teeth group (Table II).

Interpremolar widths showed significantly increased with treatment in both groups and continued stable in the long-term (Table II). In the canine group, mandibular inter first premolars width increased, while in the all the six teeth group, increased inter second premolars width. These widths were expanded during treatment and stable posttreatment long-term, however, it is recommended to obtain the best treatment stability has been maintain patients' pretreatment arch form. (R; SAMPSON; LITTLE; ÅRTUN et al., 1995; SHAPIRO, 1974)

Intergroup comparison at T1, T2 and T3 (Table III) showed that both bonded retainers may still be considered as an effective and safe method to stabilize outcomes of orthodontic treatment, maintaining long-term mandibular anterior alignment. Artun et al.(ARTUN; SPADAFORA; SHAPIRO, 1997), Steinnes et al.(STEINNES; JOHNSEN; KEROSUO, 2017) and Schutz-Frazon et al.(SCHÜTZ-FRANSSON; LINDSTEN; BJERKLIN; BONDEMARK, 2017), also observed that there
was no difference in stability between the two types of retainers, those bonded to all mandibular anterior teeth or those bonded only to the canines. Mandibular fixed retainer may prevent posttreatment changes caused by relapse or the natural aging process in the alignment of the incisors also in the very long term. (STEINNES; JOHNSEN; KEROSUO, 2017)

Canine group showed a change in the long term posttreatment, as decreased in the mandibular intercanine width (Table IV). Schütz-Fransson reported similar result, however, presented in yours two groups. SCHÜTZ-FRANSSON; LINDSTEN; BJERKLIN; BONDEMARK, 2017) Wolf noted that changes in tooth position occur even with the patient is using a permanent fixed mandibular retainer after orthodontic treatment. In addition, showed in your study with superposition of the virtual 3D models, that the canines underwent the most pronounced rotation and translation. (WOLF; SCHULTE; KÜPPER; BOURAUEL et al., 2016)

Perfect stability cannot be expected in the long term, changes have can also be found even in untreated people. (THILANDER, 2009) There are several studies reporting this maturational changes, indicating a decrease in arch length and perimeter and an increase in anterior alignment. (BURKE; SILVEIRA; GOLDSMITH; YANCEY et al., 1998; RINCHUSE; BUSCH; DIBAGNO; COZZANI, 2014) Abdulraheem et al. stated that as about 25% of the displaced incisors can be considered as an effect of natural growth, not a relapse of the orthodontic treatment. (ABDULRAHEEM; SCHÜTZ-FRANSSON; BJERKLIN, 2020) Therefore, a permanent fixed lingual retainer in the lower anterior segment is one of the most effective and used technics to stabilize orthodontic treatment outcomes. (ZACHRISSON, 1977) Where appropriate, the retention period should be scheduled for a period of years; especially in adults it should be very long or even permanent. (WATTED; WIEBER; TEUSCHER; SCHMITZ, 2001)

Clinical implications

Orthodontists expect that the treatment results remain stable for many years. However, long-term stability of the mandibular incisors after orthodontic treatment is variable and unpredictable. (LITTLE; WALLEN; RIEDEL, 1981) With the findings of this study, orthodontists will be able to plan an efficient retention protocol, as well as
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4 CONCLUSION
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Based on the results of this study, it could be concluded that:

- Increased in inter premolar width may occur with orthodontic treatment: canine group increase in the mandibular inter first premolars width, while the all teeth group, the mandibular inter second premolars width showed a significantly increase;
- The canine group showed a greater decrease in the mandibular intercanine width than the all teeth group in the long-term posttreatment phase;
- Fixed canine-to-canine retainer bonded only to the canines or bonded to each tooth, can be recommended since both are equally effective during the retention period;
- The fixed canine-to-canine retainers are still the most effective to contain mandibular anterior segment relapses in long-term.
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APPENDIX A - DECLARATION OF EXCLUSIVE USE OF THE ARTICLE IN DISSERTATION/THESIS

We hereby declare that we are aware of the article “Comparison of the tooth alignment stability using canine-to-canine retainers bonded in two different forms” will be included in Dissertation of the student Jessica Quereza de Freitas and may not be used in other works of Graduate Programs at the Bauru School of Dentistry, University of São Paulo.

Bauru, January 25th, 2021.

Jessica Quereza de Freitas
Author

Signature

Marcos Roberto de Freitas
Author

Signature

Karina Maria Salvatore de Freitas
Author

Signature

Author

Signature
ANNEX A. Ethics Committee approval, protocol number 22081719.9.0000.5417 (front).
ANNEX A. Ethics Committee approval, protocol number 22081719.9.0000.5417 (verso).
ANNEX A. Ethics Committee approval, protocol number 22081719.9.0000.5417 (front).
ANNEX A. Ethics Committee approval, protocol number 22081719.9.0000.5417 (verso).
ANNEX A. Ethics Committee approval, protocol number 22081719.9.0000.5417 (front).

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### USP - FACULDADE DE ODONTOLOGIA DE BAURU DA USP

| Outros          | Checklist.pdf | 19/09/2019 21:36:47 | Jessica Quereza de Freitas | Aceito |
|-----------------|---------------|----------------------|----------------------------|--------|
| Declaração de Pesquisadores | Compromissodopesquisador.pdf | 19/09/2019 21:36:02 | Jessica Quereza de Freitas | Aceito |
| Declaração de Instituição e Infraestrutura | Documentos1.pdf | 19/09/2019 21:32:30 | Jessica Quereza de Freitas | Aceito |
| Projeto Detalhado / Brochura Investigador | Tesefinal1.pdf | 19/09/2019 21:29:03 | Jessica Quereza de Freitas | Aceito |
| Folha de Rosto | Folhaderosto.pdf | 19/09/2019 21:27:38 | Jessica Quereza de Freitas | Aceito |

### Situação do Parecer:
Aprovado

### Necessita Apreciação da CONEP:
Não

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BAURU, 07 de Abril de 2020

Assinado por:

Juliana Fraga Soares Bombonatti

(Coordenador(a))

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ANNEX B. Patient’s informed consent exoneration (front).

Termo de Consentimento Livre e Esclarecido

O (a) Senhor (a) está sendo convidado (a) participar como voluntário da pesquisa:

“Comparação da estabilidade do alinhamento dos dentes anteriores com o uso de 3x3 colado de duas formas diferentes”, cujos objetivos e justificativas são comparar as duas formas de colagem da contenção inferior, a qual é utilizada após tratamento ortodôntico. Ela pode ser colada em todos os dentes anteriores ou apenas em caninos, desta forma, será feita uma análise para observar qual tipo de colagem desta contenção, pode trazer maior estabilidade após o tratamento ortodôntico realizado.

A busca pela estabilidade após o tratamento ortodôntico é de extrema importância, e ela começa a partir do diagnóstico correto, plano do tratamento e o uso adequado de contenções, após remoção do aparelho ortodôntico. O controle após tratamento também se faz necessário para que seja observado se houve algum tipo de recidiva do caso tratado.

Para a realização desta pesquisa, a pesquisadora irá usar o modelos de gesso que foram feitos no início, fim e controle após cinco anos, de seu tratamento ortodôntico, com as contenções inferiores devidamente instaladas. Os modelos de gesso serão analisados de forma digital, no software OrthoAnalyzer. Portanto, somente serão usados dados do seu prontuário que está guardado aqui no arquivo do Departamento de Odontologia da Faculdade de Odontologia de Bauru. O manuscrito dos seus dados contidos no prontuário e de seus modelos de gesso será feito de maneira sigilosa e cuidadosa. Todos os procedimentos necessários serão feitos para minimizar qualquer risco de divulgação dos seus dados pessoais, realizando sempre a manipulação de seus dados dentro do arquivo em âmbito sigiloso e em sala individual. Nomes e dados pessoais não serão divulgados em nenhum momento, mantendo desta forma o sigilo profissional e a sua privacidade em todas as fases da pesquisa.

Os resultados desta pesquisa permitirão que o tratamento mais vantajoso, eficiente e com menos efeitos colaterais seja apontada para que seja utilizado em futuros pacientes, de maneira individualizada. Garantindo melhores resultados e menor risco de recidivas. Por isso, seu consentimento é muito importante para a pesquisa.

Mesmo com o tratamento ortodôntico finalizado, caso você compare a necessidade de algum tratamento bucal, você será encaminhado para o sistema de Triagem da Faculdade de Odontologia de Bauru para ser posteriormente encaminhado a Departamentos e estará disposto aos melhores métodos preventivos, diagnósticos e terapêuticos que se demonstrarem eficazes, por parte da Instituição patrocinadora. É nossa responsabilidade oferecer remuneração na forma de auxílio alimentação ou transporte, caso se faça necessário. Além disso, é garantida a indenização em casos de danos que ocorram decorrentes dos procedimentos empregados nesta pesquisa.

Novamente, é de extrema importância que você saiba que a sua privacidade será respeitada. Ou seja, o seu nome ou qualquer outro dado que possa, de qualquer forma, identificá-lo, será mantido em sigilo. Você poderá deixar de participar da pesquisa a qualquer momento sem sofrer prejuízos, retirando, então, seu consentimento, sem precisar se justificar. Para qualquer questionamento futuro, você também ficará com uma cópia deste termo de consentimento livre e esclarecido. É assegurado o esclarecimento de dúvidas durante toda pesquisa, bem como será garantido o livre acesso a todas as informações e esclarecimentos adicionais sobre o estudo.

RUBRICA (paciente):

RUBRICA (pesquisador):
ANNEX B. Patient’s informed consent exoneration (verso)
ANNEX B. Patient’s informed consent exoneration (front).

UNIVERSIDADE DE SÃO PAULO
FACULDADE DE ODONTOLOGIA DE BAURU
CLÍNICA DE ORTODONTIA

AUTORIZAÇÃO PARA DIAGNÓSTICO E/OU EXECUÇÃO DE
TRATAMENTO ORTODÔNTICO

Por este instrumento de autorização por mim assinado, dou
pleno consentimento à FACULDADE DE ODONTOLOGIA DE BAURU-
USP para, por intermédio de seus professores, assistentes e alunos
devidamente autorizados, fazer diagnóstico, planejamento e tratamento
em minha pessoa ou meu filho menor de idade

______________________________, de acordo
com os conhecimentos enquadrados no campo dessa especialidade.

Concordo também, que todas radiografias, fotografias,
modelos, desenhos, históricos de antecedentes familiares, resultados de
exames clínico e de laboratório e quaisquer outras informações
concernentes ao planejamento de diagnóstico e/ou tratamento,
constituem propriedade exclusiva desta FACULDADE, à qual dou plenos
direitos de retenção, uso para quaisquer fins de ensino e de divulgação
em jornais e/ou revistas científicas do país e do exterior.

Bauru, ____ de ___________ de 19 ___.

______________________________
Assinatura do paciente ou responsável
R.G. Nº: _______________________

Nome: __________________________
Endereço: _______________________
CEP: ___________________ Telefone: ___________________