**UNIVERSIDADE DE SÃO PAULO**
**FACULDADE DE ODONTOLOGIA DE BAURU**

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# Comparison of dental inclination in digital models of cases treated with self-ligating or conventional fixed appliances with and without rapid maxillary expansion

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# Comparação das inclinações dentarias em modelos digitais de casos tratados com aparelho autoligável do sistema Damon e aparelhos convencionais com e sem expansão rápida da maxila

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 Ciência Odontológicas Aplicadas, na área de concentração Ortodontia.

Orientador: Profº. Drº. Marcos Roberto de Freitas

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# ABSTRACT

## Comparison of dental inclination in digital models of cases treated with self-ligating or conventional fixed appliances with and without rapid maxillary expansion

**Introduction:** This study aimed to compare the buccolingual inclination of the anterior and posterior teeth in subjects treated with self-ligating or conventional fixed appliances with and without rapid maxillary expansion. **Methods:** Seventy-one subjects with Class I malocclusion were divided in 3 groups. Group 1 comprised 24 subjects (17 females; 7 males, mean age of 13.94 $\pm$ 2.87), treated with Roth prescription, Group 2 comprised 24 subjects (14 females; 10 males, mean age of 13.85 $\pm$ 1.83) treated with Rapid Maxillary Expansion followed by conventional appliances using Roth prescription and Group 3 comprised 23 patients (12 females; 11 males, mean age of 14.75 $\pm$ 1.34) treated with Damon system. Intergroup changes comparison were performed using one-way ANOVA **Results:** Significant differences between groups were found for the buccolingual inclinations of: left maxillary lateral incisor, right mandibular lateral incisor and canine, left mandibular posterior teeth and right mandibular molar. **Conclusion:** The left maxillary lateral incisor showed palatal inclination in Damon Group and buccal inclination in RME and conventional groups. Right mandibular lateral incisor and canine showed greater buccal inclination in Damon group than in RME group. Damon group showed greater posterior mandibular buccal inclination in most teeth during treatment than conventional and RME groups.



**Keywords:** Orthodontic brackets, orthodontics, dental models

## RESUMO

**Introdução:** Este estudo teve como objetivo comparar as inclinações bucolinguais dos dentes anteriores e posteriores em indivíduos tratados com aparelhos fixos auto-ligaveis ou convencionais com e sem expansão rápida da maxila. **Métodos:** Setenta e um indivíduos com má oclusão de Classe I foram divididos em 3 grupos. O grupo 1 foi constituído por 24 sujeitos (17 do sexo feminino, 7 do sexo masculino, com idade média de 13,94 + 2,87) tratados com prescrição Roth, o grupo 2 foi constituído por 24 sujeitos (14 do sexo feminino, 10 do sexo masculino, idade média de 13,85 ± 1,83) tratados com Expansão Rapida da Maxila (ERM) seguido de aparelho convencional de prescrição Roth e o Grupo 3 foi constituído por 23 pacientes (12 do sexo feminino, 11 do sexo masculino, com idade média de 14,75 + 1,34) tratados com o sistema Damon. A comparação das alterações intergrupo foi realizada utilizando o teste ANOVA. **Resultados:** Foram encontradas diferenças significativas nas inclinações vestibulares intergrupo do: incisivo lateral superior esquerdo, incisivo lateral inferior direito e canino, dentes posteriores inferiores esquerdos e molar inferior direito. **Conclusão:** O incisivo lateral superior esquerdo apresentou inclinação palatina no Grupo Damon e inclinação vestibular nos grupos ERM e convencional. O incisivo lateral inferior direito eo canino do mesmo lado apresentaram maior inclinação vestibular no grupo Damon do que no grupo ERM. Damon mostrou maior inclinação vestibular na mandibular na maioria dos dentes posteriores durante o tratamento comparado com os grupos convencional e ERM.



**Palavra-chave:** Aparelho ortodôntico, ortodontia, modelos dentais

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# 1 Introduction

# 1 INTRODUCTION

New bracket systems with different ligating features have been manufactured by almost every orthodontic company in the last decade. Different passive and active self-ligating brackets have been introduced with claims of reduced friction, light forces, efficient sliding mechanics, and easy clinical application. No studies support a significant difference between self-ligating and conventional brackets with regard to efficiency (WAHAB et al., 2012; PAPAGEORGIOU et al., 2014). These bracket systems differ with respect to clip properties, wire types, and sequences and prescription (SHIVAPUJA; BERGER, 1994; HARRADINE, 2003; CHEN et al., 2010).

The Damon self-ligating system introduced broad archwires and a passive clip with the claim of posterior expansion with bodily movement or minimal tipping of the teeth (DAMON, 1998). The results of previous studies indicated greater intermolar arch width increases in the Damon groups than in the conventional bracket groups (PANDIS; STRIGOU; ELIADES, 2006; VAJARIA et al., 2011). Furthermore, a recent study showed that broader forms of copper-nickel-titanium and stainless steel archwires in the Damon group could expand the maxillary arch as much as the conventional straightwire system combined with the quad-helix appliance (ATIK; CIGER, 2014). In contrast, several studies have shown no differences between the Damon passive self-ligating system and conventional brackets with respect to transverse arch dimensional changes (WES FLEMING et al., 2008; CATTANEO et al., 2011).

According to the philosophy of Andrews, Roth began the second generation of preadjusted brackets in 1976, incorporating the same overcorrection of the optimum position of the teeth. Roth believed in relapsing movement towards the setting of the teeth to the correct positions. In order to produce a universal prescription that could be used in a large number of patients (ROTH, 1976), Roth changed some values of brackets prescription of the original Straight-Wire system. The suggested new prescription excluded the necessity of making folds in the final wires to achieve a slight overcorrection position at the end of the orthodontic therapy. From these positions, slightly overcorrected, the teeth would settle in their normal positions, not orthodontic, and with high percentage of regularity. In short, the prescription was designed for the

final positions of the teeth, obtained at the end of the fixed appliance therapy (ZANELATO et al., 2004).

It may be admitted that at present, orthopedic maxillary expansion is a therapeutic approach inserted with coherence in orthodontic practice, regardless of the occlusal development stage, provided that the maxillary atresia is part of the morphological deviation. Lateral repositioning of the maxillary with increased bone mass is a fact, with marked changes in the morphology of the dental arch, bringing indisputable positive aspects in mechanotherapy for maxillary deficiencies. The maxillary expansion is an efficient method, which presents post-treatment stability to the transverse maxillary deficiency correction. This method was introduced by Angell, in 1860, with a device made of gold, having a screw arranged transversely to the palate. Years later, the Hyrax expander was started by Biederman, with some modifications. It is tooth-supported and constructed with rigid wires. The expander screw is placed as close to the palate as possible, so that the force approaches the maxillary center of resistance, and fixed by bands (QUAGLIO et al., 2009). The Hyrax expander facilitates cleaning, preventing the development of tissue irritation that results from the interposition of food between the palate and acrylic, as it may occur with the Haas machine. The absence of acrylic also prevents the compression of the palate vessels, which would cause the tissue necrosis due to the force that the maxillary expander exerts. While the tooth-muco-supported unit divides its force between teeth and palate, Hyrax tooth-supported apparatus, distributes the supporting teeth, trying to compensate for the lack of acrylic with the proximity of the wires and the palate expander screw. Rapid maxillary expansions using a maxillary expander provide a greater separation of the sutures in the anterior region and lower in the posterior region. The palatine processes move downwards resulting in a repositioning of the upper dental base on the lower. Clinically, this separation can be seen by the appearance of a diastema between the maxillary central incisors, based on apical divergence and convergence of these coronary teeth. This diastema diminishes or closes completely a few months later, after the repositioning of the crown and the root (ARAUGIO et al., 2013).

Crown inclination (buccolingual inclination of the crown, crown torque) is one of Andrews' six keys to normal occlusion (ANDREWS, 1972; ANDREWS, 1976), and the critical factor for the prescription of pre-adjusted appliance. Several reports

measured the inclination manually on study model (VARDIMON; LAMBERTZ, 1986). Inclination is defined as the tangent angle between oclusal plane long axis teeth point.

As manual procedure has difficulty to define tangent angle with the eye, it may lead to human error. With the recent advances in laser scanners and computers, it is now possible to scan the three-dimensional (3D) model shapes accurately (KURODA et al., 1996; ARAI; ISHIKAWA, 1999). Although several methods were described to reduce human error (SEBATA, 1980; UGUR; YUKAY, 1997), little has been reported on measuring inclination with laser scanner and computer (CHIASHI; ARIA; NAKAHARA, 2004).

However, the results in the literature do not provide a clear comparison of these bracket systems in terms of incisor and molar inclinations because different archwire types and sequences are used in each system. The main purpose of this study was evaluate cases treated with the Damon self-ligating, and the ones with conventional devices with and without performing rapid maxillary expansión in terms of tooth inclination changes in mandibular and maxillary archs.

# 2 Article

# 2 ARTICLE

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 dental inclination in digital models of cases treated with self-ligating or conventional fixed appliances with and without rapid maxillary expansion


## ABSTRACT

**Introduction:** This study aimed to compare the buccolingual inclination of the anterior and posterior teeth in subjects treated with self-ligating or conventional fixed appliances with and without rapid maxillary expansion. **Methods:** Seventy-one subjects with Class I malocclusion were divided in 3 groups. Group 1 comprised 24 subjects (17 females; 7 males, mean age of 13.94 ± 2.87), treated with Roth prescription, Group 2 comprised 24 subjects (14 females; 10 males, mean age of 13.85 ± 1.83) treated with Rapid Maxillary Expansion followed by conventional appliances using Roth prescription and Group 3 comprised 23 patients (12 females; 11 males, mean age of 14.75 ± 1.34) treated with Damon system. Intergroup changes comparison were performed using one-way ANOVA **Results:** Significant differences between groups were found for the buccolingual inclinations of: left maxillary lateral incisor, right mandibular lateral incisor and canine, left mandibular posterior teeth and right mandibular molar. **Conclusion:** The left maxillary lateral incisor showed palatal inclination in Damon Group and buccal inclination in RME and conventional groups. Right mandibular lateral incisor and canine showed greater buccal inclination in Damon group than in RME group. Damon group showed greater posterior mandibular buccal inclination in most teeth during treatment than conventional and RME groups.


Keywords: Orthodontic brackets, orthodontics, dental models

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## INTRODUCTION

The biggest challenge in orthodontics is the relationship between esthetics and function, because in addition to the esthetic improvements that both aim for in patients, orthodontists have another major goal, which is to obtain a stabilized and functional occlusion.

Andrews, in 1972, classified the buccolingual inclination as one of the six keys to normal occlusion and recommended this maxillary and mandibular torque of each tooth in his brackets' prescription. These values were obtained from the sample of 120 patients with ideal occlusion, which he used to idealize the first preset device.[1]

The vast majority of brackets prescriptions derived from natural occlusions, or clinical experience of the authors, where the angle and torque of the teeth were obtain from the average values found in researches. These torque recommendations are appropriated in most cases; however, these values may be influence by some variables, such as the shape of the dental arch; the morphology of the buccal surface; the vertical position of the bracket in the buccal and dental irruption position. Therefore, orthodontists have to identify these individual variations and perform the necessary torque compensation to position teeth properly.

Roth began the second generation of preset brackets in 1976, incorporating the same overcorrection of the optimum position of the teeth. Roth believed in relapsing movement towards the setting of the teeth to the correct positions. In order to produce a universal prescription that could be used in a large number of patients, Roth in 1976 changed some values of brackets prescription of the original Straight-Wire system.[2] The suggested new prescription excluded the necessity of making folds in the final wires to achieve a slight overcorrection position at the end of the orthodontic therapy. From these positions, slightly overcorrected, the teeth would settle in their normal positions, not orthodontic, and with the high percentage of regularity. In short, the prescription was designed for the final positions of the teeth, obtained at the end of the fixed appliance therapy.

The manufacturer of Damon system, argues that its appliance is capable of promote transverse increase of the dental arches maintaining the teeth perfectly centered in the alveolar process. This ability to promote a major transverse development of the maxilla would reduce the need of extractions and rapid maxillary expansion. Computer tomography exams acquired at posttreatment period suggest that the increasing of the width of the posterior region of the dental arches is characterized by teeth supported with normal buccal and lingual alveolar bone.[3] According to Damon, the brackets of this orthodontic system would promote a minor protrusion of the incisors, because the control of the position of the mandibular incisors are mediated by the labial muscles.[3,4]

Rapid maxillary expansion is considered a coherent therapeutic procedure in orthodontic practice only if there is a maxillary atresia, regardless the stage of occlusal development that the patient presents. Maxillary disjunction is an efficient method for correction of transverse maxillary deficiency, creating a tooth inclination of posterior teeth, however, the rapid maxillary expansion is also indicated to increase the width of the maxillary dental arch in cases of mild to moderate crowding, where in the extractions are undesirable to obtain space for the alignment and leveling the teeth without the occurrence of a large protrusion of the incisors.[5]

Considering that Damon system is a technique that was recently incorporated in Orthodontics, there is not studies published in the literature that compare teeth inclination in cases treated with Damon system and conventional brackets with and without rapid maxillary expansion. Thus, the aim of the present study was to compare the changes in maxillary and mandibular dental inclinations in anterior and posterior teeth in cases treated with the Damon self-ligating and conventional appliances with and without rapid maxillary expansion.

## MATERIAL AND METHODS

The Ethics Committee in Research of Bauru Dental School - University of São Paulo under protocol number 44953015.7.0000.5417, approved the present study.

Sample size calculation was performed based on an alpha level of significance of 5% (0.05) and a beta of 20% (0.2) aiming to achieve a power test of 80% to detect a mean difference of 1,23 degrees with a standard deviation of 2,01 degrees for the molar and pre-molar inclination.[6] Thus, the sample size calculation showed the need of a sample comprised by 22 subjects in each group.

The sample was comprised by 71 patients with Class I malocclusion, who were diagnosed with mild to moderate crowding; treated without extractions; and presented all permanent teeth until permanent first molars totally erupted in the oral cavity and without anomalies of number and form. The participants of the present study were equally distributed into three groups.

Group 1 was comprised by 24 (17 females; 07 males) patients treated with conventional orthodontic fixed appliances based on Roth's technique. The patients were graduate students of Bauru Dental School - USP, with initial age of 13.94 years (SD = 2.87), final age of 16.15 years (SD = 3.02) and treatment time of 2.20 years (SD = 1.10). The sequence of archwires used for the treatment of these patients was: (1) 0.014" NiTi archwire, (2) 0.016" NiTi archwire, (3) 0.018" NiTi archwire, which was maintained until the correction of any crowding and rotations, (4) 0.016" stainless steel archwire (5) 0.018" stainless steel archwire, (6) 0.020" stainless steel archwire, and, finally, (7) 0.019"x0.025" rectangular stainless steel archwire. Interlandi's diagram was used to individualize the dental arch form of each patient. Interlandi's diagram is composed by acetate sheets and have radii of curvature that varies from 18 to 26 mm.

Group 2 consisted of 24 patients (14 females; 10 males) treated with rapid maxillary expansion followed by conventional orthodontic fixed appliances based on Roth's technique. The rapid maxillary expansion was indicated aiming to correct the crowding. None of these patients was diagnosed with posterior crossbites. These individuals were undergraduate students of Bauru Dental School - USP, with initial age of 13.85 years (SD = 1.83), final age of 16.02 years (SD = 1.80) and treatment time of 2.17 years (SD = 0.52). In this group, the sequence of procedures performed in the treatment was: (1) rapid maxillary expansion using Hyrax or Haas expander during a period of one week, with protocol of activation based on turns of ¼ of round at morning and ¼ of round at night, until observe the opening of the midpalatal suture with the appearing of a diastema in the region of maxillary anterior teeth. After the period of activation of this appliance, the screw was fixed to disable the possibility of more activations occur. (2) After the period of activation, the Hyrax expander was used as a retention appliance during 4-6 months. (3) When the retention period finished, the orthodontic fixed appliance was installed and it was used the same sequence of archwires and diagram used for group 1, as described above.

Group 3 consisted of 23 patients (12 females; 11 males) treated with self-ligating brackets of Damon System (Damon MX). The patients were treated for undergraduate

students at Bauru Dental School - USP, with initial age of 14.65 years (SD = 1.34), final age of 17.37 years (SD = 1.18) and treatment time of 2.72 years (SD =0.81). The sequence of archwires used for the treatment of these patients was: (1) 0.014" CuNiTi Damon®, maintained for at least 10 weeks, until the archwire shows be completely passive in the slot of the bracket; (2) 0.014"x0.025" CuNiTi Damon®, maintained for at least 8 weeks until observe an alignment that would allow the complete insertion of the following archwire in the slot of the bracket and the closing of its lid; (3) 0.019"x0.025" rectangular-stainless steel archwire, which was conformed aiming to maintain the dental arch form obtained after the insertion of the 0.014"x 0.025" CuNiTi Damon® archwire.

The arch form of the Damon System presents a diagram expressively wider than the other traditional archwire of the orthodontic market. Considering that Damon archwires have both incisal curvature and posterior transverse distances increased, it is possible to affirm that Damon system provides major expansion, mainly in the area of the premolars due to the Damon's arch form be greatly expanded in this area. This effect occurs because the archwires are precontoured and superelastic, and, because that, they have the same arch form and only one diagram to the maxillary and mandibular dental arches of all the patients.

## Methods

### Digital models

The initial and final dental casts of each patient were digitized using the 3Shape R700 3D scanner (3Shape A / S, Copenhagen, Denmark). For this purpose, the dental casts were fixed to a plate and positioned on a platform that has a tri-axial drive system. Thus, the dental casts were tilted, rotated and translated, while laser beams were projected on the dental casts and two cameras captured the images.

The time for reproduction of the images lasts few minutes, and the maxillary and mandibular digital dental models are captured separately. In a microcomputer coupled to the scanner, the image was saved in .SLT format, which is compatible with Windows operating system and specific software for the manipulation of threedimensional images. After scanning, the digital dental models obtained at the initial and final phases

of the treatment, were measured by digital method using the software OrthoAnalyzerTM 3D (3Shape A / S, Copenhagen, Denmark).

**Little Index**

Degree of crowding was measured only in the initial digital dental model of each patient, aiming to assess the sample compatibility. Crowding was measured by the Little's Irregularity Index.[7] The measurements were performed positioning the maxillary and mandibular digital dental models in an occlusal view. At this position, was created a occlusal plane, based on three points: tip of the buccal cusp of the first permanent molar and one point in the incisal edge of the right central incisor and the procedure was repeated in the mandibular arch (Fig. 1); a feature of the software that simulates a caliper was used to calculate the five distances between the contact points of the anterior teeth. The sum of these distances resulted in the value of the Little's Irregularity Index.

**Crown Inclination**

The bucco-lingual inclination were measure creating a occlusal plane based on three points as described above, therefore the measure tool were activated with the model in occlusal view, then were marked two points, the first in the distal part of the crown and the second in the mesial part (Fig. 2). Formerly the model was collocated in the lateral view and the preparing tool was activated to measure the axis of the crown (Fig. 3). For the last is activated the inclination tool and the program show the inclination in degrees of the tooth. The procedure has been repeated in all teeth.
The measurement was make in the initial and final patient model to compare the inclination before and after treatment (Fig. 4).

**Statistical method**

**Error Study**

Error of the method was performed using 20 pairs of digital dental models and that were randomly selected and re-measured at an interval of 30 days from the first

measurement. Random error was calculated using Dahlberg's formula[8], whereas the systematic error was calculated using Student's T test.

The formula used to calculate the causal error was: $SE^2 = \Sigma (d^2 / 2N)^2$ where D is the difference between 1st and 2nd measurements and N is the total number of cases used for evaluation. To evaluate the systematic error by applying the test "t" test, it will be used the significance level of 5% ($p < 0.05$).

**Statistical analysis**

Kolmogorov-Smirnov normality test was performed and showed that the sample had a normal distribution. Thus, parametric tests were used.[9]

Comparability between the groups regarding sex distribution was evaluated using chi-square test. One-way ANOVA was used to assess the comparability between the groups regarding the initial and final ages, treatment time and the Little's Irregularity Index for the maxillary and mandibular dental arches. Tukey test was used, when necessary.

Intragroup comparison of the variables measured at the initial and final tooth inclination changes, was performed with Dependent "t" test.

Intergroup comparison of the variables measured at the initial and final stages and changes with treatment, was performed with one-way ANOVA test and the Tukey test when necessary.

All statistical tests were performed using Statistica software (Statistica for Windows - Release 5.0 - Copyright StatSoft, Inc. 1995), with a significance level to $p < 0.05$.

**RESULTS**

There was significant systematic error in the variables 23, 35 and 32, the random errors ranged from 0.54º in the variable 21 to 2.70 in the variable 34 (Table I).

There was comparability among groups regarding initial and final ages of treatment time (Table II). There was also comparability among groups as to Little's Irregularity Index in the maxillary and mandibular arches (Table II).

**Anterior Inclination**

Intragroup changes comparison, Group 1 showed significant buccal inclination in the maxillary canines after treatment (Table III). In Group 2 just the left maxillary canine showed significant buccal inclination with treatment (Table IV). Group 3 showed significant buccal inclination in the right maxillary canine, mandibular canines and in the mandibular lateral incisor after treatment; left maxillary lateral incisor showed a significant palatal inclination after treatment (Table V).

Intergroup comparison of initial stage (T1) showed greater buccal inclination in the left lateral incisor in Damon Group when compared to conventional group (Table VI).

Intergroup comparison of final stage (T2) showed that the right central incisor and the left lateral incisor were more buccally inclinated in the RME group when compared to Damon Group (Table VII). Damon Group presented the right mandibular canine more buccally inclinated than RME group (Table VII).

Intergroup changes comparison (T2-T1) indicated that, in the Damon group, left maxillary lateral incisor showed palatal inclination and conventional and RME groups showed buccal inclination of this tooth (Table VIII). In Damon Group, right lateral incisor presented buccal inclination and in conventional and RME groups, this tooth had lingual inclination (Table VIII). The right mandibular canine in Damon group had buccal inclination and was significantly different from RME group, in which this tooth presented lingual inclination (Table VIII).

**Posterior Inclination**

Intragroup comparison of initial and final stages of the conventional group showed that there was significant buccal inclination in the maxillary first premolars, left maxillary second premolar, right mandibular first premolar and left mandibular second premolar after treatment (Table III). Group 2, treated with RME, showed a significant buccal inclination in the first and second maxillary premolars and in right mandibular premolars after treatment (Table IV). Group 3, treated with Damon system, showed a significant buccal inclination in all of posterior teeth except for the right maxillary first molar after treatment (Table V).

Intergroup comparison of initial stage (T1) showed greater buccal inclination in left second premolar and first molar in conventional and RME groups, when compared to Damon (Table VI).

Intergroup comparison of final stage (T2) showed that the left maxillary first molar was more buccally inclinated in the Damon group in comparison to RME Group (Table VII).

Intergroup comparison of treatment changes (T2-T1) showed that, in the Damon group, the left mandibular premolars showed greater buccal inclination when compared to conventional and RME groups (Table VIII). Regarding mandibular molars, Damon Group showed greater buccal inclination than RME and conventional groups (Table VIII).

## DISCUSSION

### Sample

Seventy-one cases divided into three groups comprised the sample for this study, reliable number, since the sample calculation was performed determining that it would take at least 22 cases for each group. The calculation was performed with an 80% significance power.

The sample consisted of dental casts obtained from subjects treated with the use of self-ligating 3XM™ Damon appliances and conventional fixed appliances (Roth prescription) with and without previous RME. The pairs of dental casts should present the occlusal surfaces well copied, without positive or negative bubbles so that reliable and reproducible measurements could be performed. The dental casts were scanned so as to facilitate their manipulation and measurements.

### Compatibility

There was compatibility among the groups regarding sex distribution (Table II), initial and final ages and treatment time (Table II).

Some authors have observed, in another study, some changes in the dental inclinations with increasing age.[10-12] Thus, it is important that the three groups have

compatible ages so there is no difference in the inclination due to age. Therefore, if there is any change in the inclinations, it will be due to the treatment and not because of age.

There was also compatibility of the groups regarding the Little Irregularity Index in the maxillary and mandibular arches (Table II). This compatibility is important because the more the crowding, the greater will be the increase of the transverse dimensions of the dental arches.

It has been reported that the elimination of crowding in nonextraction treatment is significantly related to an increased arch perimeter and protrusion of the incisors.[13] Other authors who used the Damon appliance in their studies also state that usually cases with crowding treated nonextraction result in an increase in transverse distances of the maxillary and mandibular dental arches.[14,15] Therefore, in order to obtain reliable results, which show that difference by the appliance and not only by the amount of crowding, the compatibility of samples is required.

Many manufacturers have indicated in their promotional materials the use of self-ligating brackets associated with orthodontic wires of more expansive format for any type of malocclusion or patient's facial pattern. In cases of severe crowding the use of this system would result in an expansion of the arches, increased buccal inclination of the incisors, in order to align and level all the teeth as a result of the lack of a diagnosis and treatment plan, generating the prognosis of uncertain stability.

The compatibility among the groups was important at the beginning of the treatment, because if the sample is compatible, the results will be changes due to the treatment.

**Methodology**

Digital models were used to perform the oclusal plane and crown inclination measurements instead of using plaster models through OrthoAnalyser Software-3Shape. Digital models reduce many problems associated with storage, retrieval, reproduction and risk of damage to models.[15]

Traditional and digital models offer the same intraexaminer reproducibility in most cases, and for some measures, when transversal sections may help, digital models seem to reproduce an even smaller error, and there are no statistically

significant differences between measurements made directly on the plaster model and digital models for linear measurements such as width and length of the dental arch.[16,17]

According to several authors, the use of digital models for quantitative analysis was validated after evidence of high accuracy and reproducibility of measurements.[15,17-19] Measurements of the teeth inclinations were taken in both arches in order to evaluate the behavior of these variables after treatment.[6,20] Studies showing the reliability of the method which compared the inclinations between dental plaster models and digital dental models, concluding that there is no significant difference between two methods.[21-23]

The maxillary and mandibular crowding was measured by Little Irregularity Index, methodology enshrined in literature, which allows the quantification of this intra-arch malocclusion. Only the numeric value obtained in the measurements was used, not being assigned scores as the ones described in the original study.[7] The accentuated inclination of molar and premolars, reduces intermolar distances, which can generate anterior crowding. The Little irregularity index was adapted to the maxillary dental arch, as this methodology is used with good acceptability by other authors.[24-27]

## Results

The term inclination of teeth was first proposed in the six keys by Andrews.[1] Most studies focused on the labiolingual inclination of anterior teeth, which seems important to an esthetic profile.[9,28] In recent years, the buccolingual inclination of posterior teeth has become intriguing to researchers for its important role in smile esthetics and interdigitated occlusion. Studies show that posterior teeth with palatal or lingual inclination would increase the negative corridor and consequently decrease the fullness of a smile. Due to this, buccolingual inclination is another important transverse characteristic of occlusion.[29] However, there is little information available on the inclination in all teeth, even less comparing self-ligating with conventional appliance with and without RME.

Buccal inclination was found in the majority of teeth with the treatment (Table VIII), this could be due the dental crowding.

When intragroup changes were evaluated, the Damon group showed significant buccal inclination in the majority of teeth compared to the ERM and conventional

groups (Tables III, IV and V). These results are contrary to the Damon theory, which defend the dental body movement concept.[30] Additionally, the Damon group showed smaller buccal inclination of maxillary canines compared with the other groups, it was as expected because the Damon prescription has a smaller torque canine.[31]

The orthodontic treatment with Damon appliance did not promoted a greater anterior buccal inclination, when compared to patients treated with conventional appliance with and without RME (Table VIII). Although not significantly difference, in general,the anterior buccolingual inclination was greater with the Damon appliance.[26,32] It has been reported that the posttreatment incisor inclinations did not differ significantly between the Damon group and conventional group.[32] Was reported not difference in the mean of the two angles measured for the Self-ligating bracket and conventional bracket[33], which also coincides with our results.

Although labial inclination of mandibular incisor was reported when Damon brackets were used, these changes were not significant.[33] Similar results were found in the current study for the mandibular central incisors.[34] However, the Damon group showed greater labial inclination of mandibular lateral incisors when compared with the ERM and conventional groups. This could be explained due to the differences in the methodology used to measure the teeth inclination, wire gap in the bracket slot and the degree of dental crowding.[35-37]

Studies reported buccolingual inclination of the molar teeth in 75% of rapid maxillary expansion measured immediately after expansion.[38] Other study showed only a minimal buccolingual inclination of the molars after rapid expansion.[39] In this study there, no difference in the inclination of the upper posterior teeth in the group RME compared with the others groups, therefore we can consider necessary the use of RME to the expansion of maxillary but inappropriate to correct the changes of the inclination, because the arch-wire can achieve this aim.[40,41] Additionally, the variation in the teeth that received bands in our sample may have influenced the results because minimized the mean buccal inclination of permanent molars.

Final inclinations of the mandibular posterior teeth were similar among groups at the end of treatment (Table VII). Similar results were reported when Damon system was compared with other prescription.[42,43] However, greater posterior teeth inclination changes with treatment were found in the Damon group for the left mandibular teeth and right mandibular molar (Table VIII). This could be explained due to the greater

lingual inclination tendency that the mandibular posterior teeth presented in the Damon group (Table VI).

It could be thought that the greater buccal inclination obtained with treatment for these mandibular posterior teeth, may case some type of gingival recession. Periodontal evaluation was not performed since this was not the focus of the current study. Additionally, it has been reported that orthodontic treatment alone rarely promotes this type of problem in patients without periodontal disease.[44] However, this issue should be further studied.

Regarding posterior teeth buccal inclination, stability in long-term is a concern because the posterior mandibular tooth should be lingually inclined to support the forces of mastication,[45] and the relationship between occlusal contact and tooth displacement produces different patterns of occlusal contact, especially bucco-lingual, as well as mesio-distal displacements of the molars. Thus, it has been reported that masticatory pressure affects the inclination of the teeth in the long-term.[46] The stability of the occlusal results of the subjects in the Damon group could be argued because of the greater mandibular posterior teeth buccal inclination changes observed with treatment (Table VIII). However, a greater buccal inclination tendency of the maxillary posterior teeth was observed for this group, as well. Therefore, all patients finished with an adequate posterior transversal relationship and this may help to achieve stability. Additionally, some studies showed that posterior teeth buccal inclination helps to achieve stability in Class II and III malocclusions and that in the long-term the posterior mandibular inclination increases because of the wear effect and this could help to obtain better teeth intercuspation with time.[47,48]

A potential criticism regarding true equivalence of our 3 groups is differences in bracket prescription values between the appliances. Damon brackets have a specific prescription, different to the Roth one. Prescription values in torque were identical for mandibular incisors, this might explain why the incisor proclination did not differ significantly between the groups.[2,30] There were some differences in torque values for mandibular canines and premolars. The torque values varied significantly between prescriptions for the canines and the second premolars, but the orthodontic treatment performed in this investigation used 0.019 X 0.025” in stainless steel archwire as the last one; therefore, these differences in the prescription values of the mentioned teeth might have not a major effect in our results.

## CONCLUSIONS

The left maxillary lateral incisor showed palatal inclination in Damon Group and buccal inclination in RME and conventional groups. Right mandibular lateral incisor and canine showed greater buccal inclination in Damon group than in RME group.

Damon group showed greater posterior mandibular buccal inclination in most teeth during treatment than conventional and RME groups.

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## FIGURE LEGENDS

**Fig. 1** Training of occlusal plane

**Fig. 2** Dial the width of the crown

**Fig. 3** Marking the long axis of clinical crown

**Fig. 4** Measure of the crown inclination

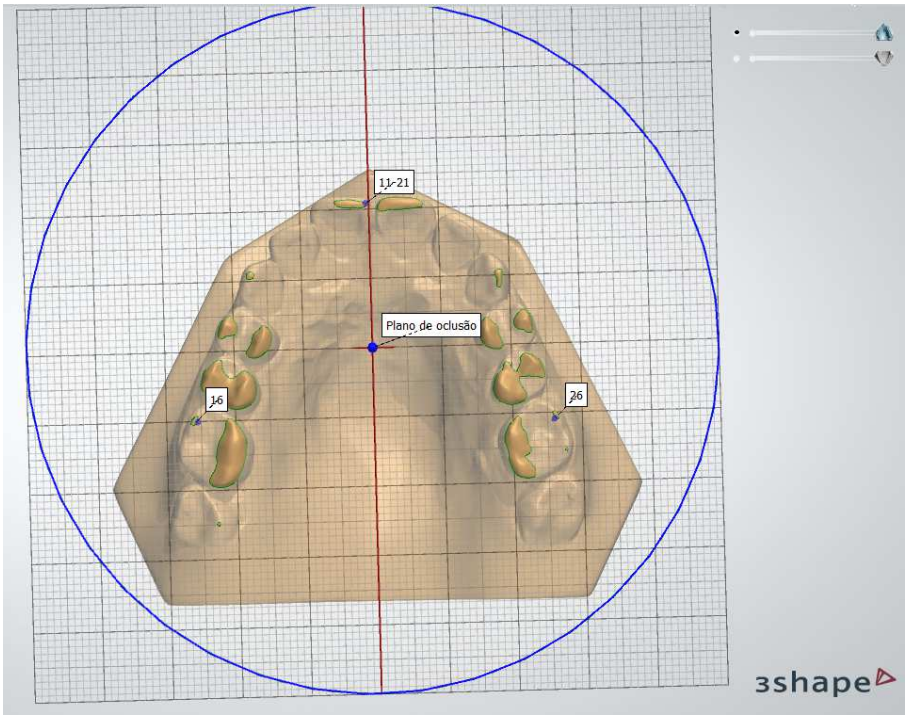


**Fig 1.**

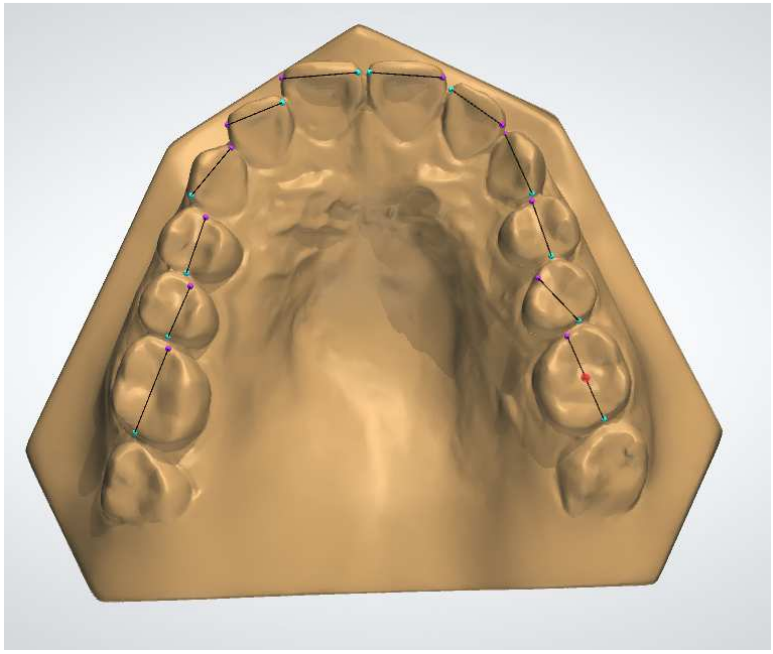

**Fig 2.**

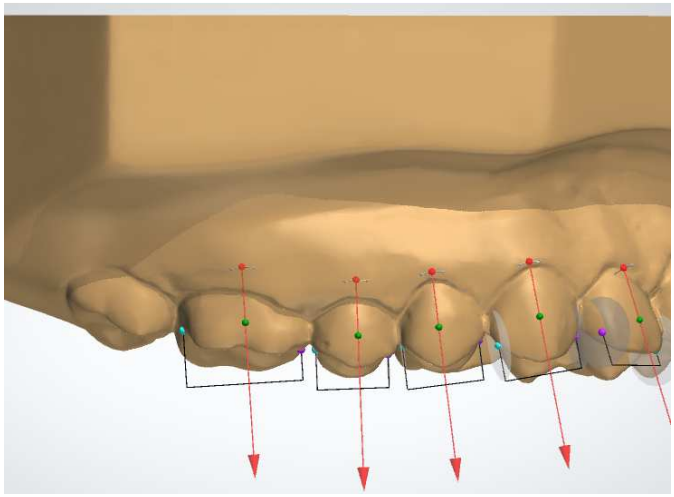

**Fig 3.**

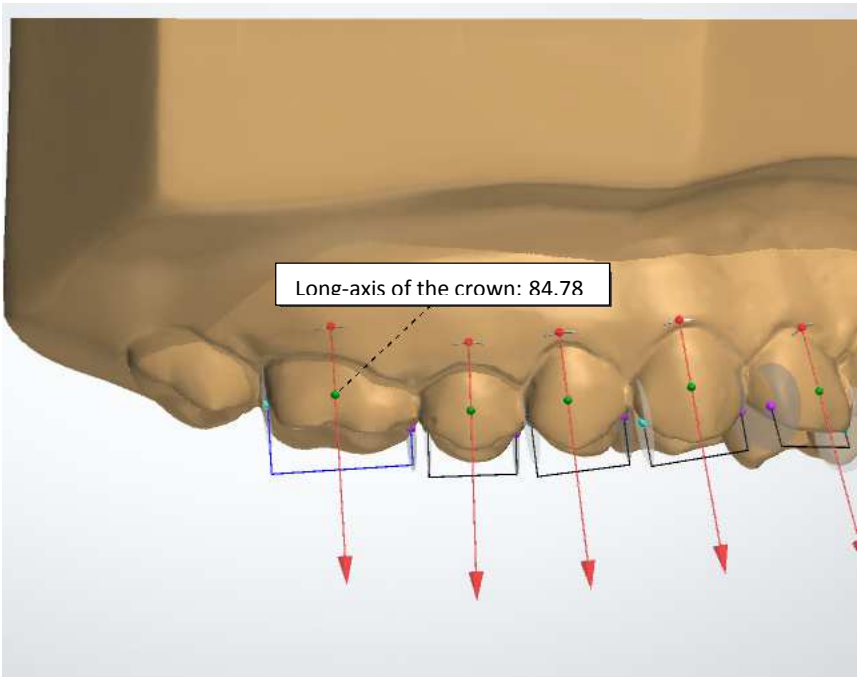


**Fig 4.**

**Table I.** Results of the casual and systematic errors (Dahlberg's formula and dependent t tests, respectively)(n=30).

| V (º) | 1st Measurement | | 2nd Measurement | | | |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | Dalhberg | p |
| 16 | 76.71 | 4.77 | 76.69 | 4.88 | 0.76 | 0.943 |
| 15 | 77.61 | 7.25 | 77.87 | 7.1 | 0.8 | 0.435 |
| 14 | 80 | 6.3 | 80.33 | 6.9 | 1.51 | 0.625 |
| 13 | 80.78 | 4.17 | 80.94 | 3.61 | 0.86 | 0.654 |
| 12 | 78.47 | 4.31 | 78.61 | 3.86 | 1.02 | 0.745 |
| 11 | 79.05 | 4.97 | 78.5 | 5.04 | 0.77 | 0.063 |
| 21 | 78.33 | 7.15 | 78.26 | 7.27 | 0.5 | 0.744 |
| 22 | 76.46 | 5.54 | 75.9 | 6.41 | 1.7 | 0.426 |
| 23 | 79.36 | 4.62 | 80.62 | 4.4 | 1.5 | 0.027* |
| 24 | 81.86 | 6.09 | 80.63 | 6.11 | 1.82 | 0.083 |
| 25 | 78.9 | 6.95 | 78.46 | 7.28 | 0.92 | 0.235 |
| 26 | 79.59 | 4.82 | 78.33 | 2.9 | 2.16 | 0.149 |
| 36 | 51.76 | 7.32 | 51.41 | 6.72 | 1.15 | 0.466 |
| 35 | 60.34 | 7.92 | 58.57 | 6.1 | 2.32 | 0.048* |
| 34 | 63.73 | 10.83 | 62.24 | 10.11 | 2.7 | 0.168 |
| 33 | 71.05 | 9.51 | 71.25 | 9.25 | 1.04 | 0.649 |
| 32 | 79.65 | 8.58 | 78.91 | 9.03 | 0.97 | 0.042* |
| 31 | 80.57 | 7.42 | 80.65 | 7.87 | 0.9 | 0.831 |
| 41 | 80.71 | 5.43 | 80.18 | 5.93 | 0.85 | 0.115 |
| 42 | 79.91 | 8.56 | 79.37 | 9.13 | 1.46 | 0.367 |
| 43 | 74.62 | 8.3 | 73.28 | 8.23 | 1.87 | 0.068 |
| 44 | 63.69 | 7.52 | 62.92 | 7.13 | 1.29 | 0.138 |
| 45 | 57.84 | 11.92 | 58.91 | 11.85 | 1.79 | 0.139 |
| 46 | 52.99 | 9.06 | 52.49 | 8.63 | 0.86 | 0.145 |

* Statistically significant for P<0.05.

**Table II.** Intergroup comparison of the initial and final ages, treatment time and Little irregularity index at pretreatment stage (one-way ANOVA).

| Variables | Group 1 Conventional n=24 | Group 2 Conventional + RME n =24 | Group 3 Damon n=23 | p |
|---|---|---|---|---|
| | Mean (S.D.) | Mean (S.D.) | Mean (S.D.) | |
| Initial age | 13.94 (2.87) | 13.85 (1.83) | 14.65 (1.34) | 0.388 |
| Final age | 16.15 (3.02) | 16.02 (1.80) | 17.37 (1.18) | 0.073 |
| Treatment time | 2.20 (1.10) | 2.17 (0.52) | 2.72 (0.81) | 0.053 |
| Mx LII (mm) | 10.83 (4.69) | 12.23 (4.15) | 12.52 (3.86) | 0.319 |
| Md LII (mm) | 8.06 (2.35) | 7.46 (2.16) | 9.22 (2.85) | 0.051 |

**Table III.** Intragroup comparison of initial and final inclination (Dependent t test)

| CONVENTIONAL | | | |
|---|---|---|---|
| V(°) | INITIAL | FINAL | P |
| | Mean (SD) | Mean (SD) | |
| 16 | 76.95 (5.72) | 76.50 (5.82) | 0.641 |
| 15 | 76.45 (6.08) | 79.60 (6.65) | 0.052 |
| 14 | 75.59 (7.99) | 81.75 (5.22) | 0.001* |
| 13 | 78.16 (6.21) | 81.08 (5.04) | 0.040* |
| 12 | 76.48 (9.19) | 78.35 (3.96) | 0.245 |
| 11 | 78.74 (8.41) | 79.11 (4.62) | 0.830 |
| 21 | 78.12 (9.28) | 80.32 (5.27) | 0.251 |
| 22 | 75.24 (7.22) | 78.58 (6.50) | 0.066 |
| 23 | 76.71 (7.54) | 81.11 (5.17) | 0.013* |
| 24 | 77.71 (7.30) | 81.68 (4.65) | 0.007* |
| 25 | 76.28 (6.43) | 79.81 (6.07) | 0.003* |
| 26 | 77.38 (6.98) | 78.17 (5.82) | 0.595 |
| 36 | 55.53 (8.35) | 54.30 (7.63) | 0.499 |
| 35 | 59.69 (9.24) | 63.10 (9.27) | 0.043* |
| 34 | 63.66 (9.36) | 66.28 (9.03) | 0.237 |
| 33 | 72.75 (8.25) | 72.61 (6.86) | 0.949 |
| 32 | 77.61 (7.51) | 80.31 (8.58) | 0.234 |
| 31 | 80.39 (6.60) | 79.10 (8.81) | 0.589 |
| 41 | 79.93 (5.34) | 79.35 (8.87) | 0.800 |
| 42 | 77.92 (7.61) | 78.27 (9.30) | 0.869 |
| 43 | 71.68 (8.08) | 75.28 (7.82) | 0.133 |
| 44 | 61.05 (5.93) | 68.13 (9.30) | 0.004* |
| 45 | 57.71 (11.05) | 61.98 (9.93) | 0.103 |
| 46 | 54.98 (8.07) | 55.29 (8.83) | 0.864 |

* Statistically significant for $p<0.05$

**Table IV.** Intragroup comparison of initial and final inclination (Dependent t test)

| RAPID MAXILLARY EXPANSION (RME) | | | |
|---|---|---|---|
| V(°) | INITIAL | FINAL | P |
| | Mean (SD) | Mean (SD) | |
| 16 | 77.91 (6.14) | 75.99 (5.54) | 0.160 |
| 15 | 75.70 (7.42) | 81.33 (4.71) | 0.000* |
| 14 | 78.11 (5.67) | 81.89 (4.02) | 0.004* |
| 13 | 77.04 (7.67) | 80.79 (5.13) | 0.060 |
| 12 | 78.38 (6.51) | 78.09 (5.01) | 0.839 |
| 11 | 80.08 (5.57) | 80.57 (3.85) | 0.651 |
| 21 | 80.38 (4.16) | 80.20 (4.31) | 0.861 |
| 22 | 78.16 (4.72) | 80.24 (3.86) | 0.124 |
| 23 | 77.88 (4.90) | 82.22 (5.79) | 0.002* |
| 24 | 76.77 (4.61) | 82.36 (4.44) | 0.000* |
| 25 | 75.21 (6.89) | 81.17 (4.88) | 0.001* |
| 26 | 76.12 (6.81) | 76.25 (5.00) | 0.913 |
| 36 | 57.70 (6.65) | 58.52 (7.34) | 0.668 |
| 35 | 60.38 (6.22) | 63.35 (7.28) | 0.171 |
| 34 | 64.66 (6.68) | 68.94 (8.87) | 0.071 |
| 33 | 76.04 (7.81) | 73.50 (8.80) | 0.303 |
| 32 | 80.50 (6.05) | 80.20 (8.06) | 0.897 |
| 31 | 80.33 (6.98) | 79.80 (8.21) | 0.821 |
| 41 | 81.75 (5.95) | 79.38 (7.57) | 0.265 |
| 42 | 80.15 (5.57) | 78.00 (7.36) | 0.357 |
| 43 | 75.42 (6.94) | 73.64 (9.26) | 0.471 |
| 44 | 63.41 (6.01) | 67.77 (8.81) | 0.035* |
| 45 | 56.72 (6.85) | 63.25 (9.07) | 0.012* |
| 46 | 56.18 (5.56) | 55.96 (6.85) | 0.883 |

* Statistically significant for $p<0.05$

**Table V.** Intragroup comparison of initial and final inclination (Dependent t test)

| DAMON | | | |
|---|---|---|---|
| V(°) | INITIAL | FINAL | P |
| | Mean (SD) | Mean (SD) | |
| 16 | 78.04 (6.44) | 76.88 (4.82) | 0.348 |
| 15 | 76.84 (6.26) | 82.15 (5.32) | 0.001* |
| 14 | 76.28 (6.10) | 82.56 (3.51) | 0.000* |
| 13 | 77.79 (7.39) | 82.99 (3.58) | 0.011* |
| 12 | 75.94 (5.65) | 75.81 (4.06) | 0.916 |
| 11 | 77.46 (5.69) | 76.99 (4.23) | 0.732 |
| 21 | 78.76 (5.33) | 77.29 (3.92) | 0.220 |
| 22 | 79.96 (6.26) | 75.86 (4.45) | 0.037* |
| 23 | 78.68 (7.64) | 82.36 (5.38) | 0.063 |
| 24 | 76.88 (6.18) | 82.88 (6.31) | 0.005* |
| 25 | 77.04 (5.10) | 82.41 (3.63) | 0.000* |
| 26 | 77.19 (5.93) | 80.44 (4.22) | 0.009* |
| 36 | 50.13 (7.58) | 55.95 (7.75) | 0.007* |
| 35 | 54.52 (6.02) | 64.86 (6.61) | 0.000* |
| 34 | 59.85 (7.25) | 71.72 (7.59) | 0.000* |
| 33 | 70.76 (7.62) | 75.70 (6.79) | 0.038* |
| 32 | 77.33 (8.05) | 82.30 (5.79) | 0.051 |
| 31 | 81.78 (8.56) | 81.32 (4.91) | 0.852 |
| 41 | 80.93 (8.01) | 82.09 (4.22) | 0.625 |
| 42 | 76.42 (9.20) | 83.12 (3.18) | 0.012* |
| 43 | 72.77 (8.03) | 79.59 (4.90) | 0.008* |
| 44 | 63.54 (6.71) | 70.70 (8.85) | 0.012* |
| 45 | 54.19 (7.18) | 64.76 (5.89) | 0.000* |
| 46 | 50.55 (8.61) | 56.56 (7.84) | 0.007* |

* Statistically significant for $p<0.05$

**Table VI.** Intergroup comparison of initial stage (T1) (one-way ANOVA and Tukey tests).

| INITIAL MEASUREMENTS | | | | |
|---|---|---|---|---|
| V(°) | CONVENTIONAL | RME | DAMON | P |
| | Mean (SD) | Mean (SD) | Mean (SD) | |
| 16 | 76.95 (5.72) | 77.91 (6.14) | 78.04 (6.44) | 0.810 |
| 15 | 76.45 (6.08) | 75.70 (7.42) | 76.84 (6.26) | 0.853 |
| 14 | 75.59 (7.99) | 78.11 (5.67) | 76.28 (6.10) | 0.438 |
| 13 | 78.16 (6.21) | 77.04 (7.67) | 77.79 (7.39) | 0.868 |
| 12 | 76.48 (9.19) | 78.38 (6.51) | 75.94 (5.65) | 0.535 |
| 11 | 78.74 (8.41) | 80.08 (5.57) | 77.46 (5.69) | 0.468 |
| 21 | 78.12 (9.28) | 80.38 (4.16) | 78.76 (5.33) | 0.518 |
| 22 | 75.24 (7.22) $^{A}$ | 78.16 (4.72) $^{AB}$ | 79.96 (6.26) $^{B}$ | 0.049* |
| 23 | 76.71 (7.54) | 77.88 (4.90) | 78.68 (7.64) | 0.640 |
| 24 | 77.71 (7.30) | 76.77 (4.61) | 76.88 (6.18) | 0.856 |
| 25 | 76.28 (6.43) | 75.21 (6.89) | 77.04 (5.10) | 0.643 |
| 26 | 77.38 (6.98) | 76.12 (6.81) | 77.19 (5.93) | 0.796 |
| 36 | 55.53 (8.35) $^{B}$ | 57.70 (6.65) $^{B}$ | 50.13 (7.58) $^{A}$ | 0.007* |
| 35 | 59.69 (9.24) $^{B}$ | 60.38 (6.22) $^{B}$ | 54.52 (6.02) $^{A}$ | 0.029* |
| 34 | 63.66 (9.36) | 64.66 (6.68) | 59.85 (7.25) | 0.136 |
| 33 | 72.75 (8.25) | 76.04 (7.81) | 70.76 (7.62) | 0.105 |
| 32 | 77.61 (7.51) | 80.50 (6.05) | 77.33 (8.05) | 0.289 |
| 31 | 80.39 (6.60) | 80.33 (6.98) | 81.78 (8.56) | 0.780 |
| 41 | 79.93 (5.34) | 81.75 (5.95) | 80.93 (8.01) | 0.639 |
| 42 | 77.92 (7.61) | 80.15 (5.57) | 76.42 (9.20) | 0.284 |
| 43 | 71.68 (8.08) | 75.42 (6.94) | 72.77 (8.03) | 0.256 |
| 44 | 61.05 (5.93) | 63.41 (6.01) | 63.54 (6.71) | 0.332 |
| 45 | 57.71 (11.05) | 56.72 (6.85) | 54.19 (7.18) | 0.416 |
| 46 | 54.98 (8.07) | 56.18 (5.56) | 50.55 (8.61) | 0.050 |

* Statistically significant for P<0.05

Different letters in a row indicate the presence of a statistically significant difference among the groups, indicated by the Tukey test.

**Table VII.** Intergroup comparison of final stage (T2) (one-way ANOVA and Tukey tests).

| FINAL MEASUREMENTS | | | | |
|---|---|---|---|---|
| V(°) | CONVENTIONAL | RME | DAMON | P |
| | Mean (SD) | Mean (SD) | Mean (SD) | |
| 16 | 76.50 (5.82) | 75.99 (5.54) | 76.88 (4.82) | 0.871 |
| 15 | 79.60 (6.65) | 81.33 (4.71) | 82.15 (5.32) | 0.330 |
| 14 | 81.75 (5.22) | 81.89 (4.02) | 82.56 (3.51) | 0.818 |
| 13 | 81.08 (5.04) | 80.79 (5.13) | 82.99 (3.58) | 0.280 |
| 12 | 78.35 (3.96) | 78.09 (5.01) | 75.81 (4.06) | 0.139 |
| 11 | 79.11 (4.62) $^{AB}$ | 80.57 (3.85) $^{B}$ | 76.99 (4.23) $^{A}$ | 0.032* |
| 21 | 80.32 (5.27) | 80.20 (4.31) | 77.29 (3.92) | 0.068 |
| 22 | 78.58 (6.50) $^{AB}$ | 80.24 (3.86) $^{B}$ | 75.86 (4.45) $^{A}$ | 0.029* |
| 23 | 81.11 (5.17) | 82.22 (5.79) | 82.36 (5.38) | 0.708 |
| 24 | 81.68 (4.65) | 82.36 (4.44) | 82.88 (6.31) | 0.750 |
| 25 | 79.81 (6.07) | 81.17 (4.88) | 82.41 (3.63) | 0.255 |
| 26 | 78.17 (5.82) $^{AB}$ | 76.25 (5.00) $^{A}$ | 80.44 (4.22) $^{B}$ | 0.039* |
| 36 | 54.30 (7.63) | 58.52 (7.34) | 55.95 (7.75) | 0.180 |
| 35 | 63.10 (9.27) | 63.35 (7.28) | 64.86 (6.61) | 0.745 |
| 34 | 66.28 (9.03) | 68.94 (8.87) | 71.72 (7.59) | 0.131 |
| 33 | 72.61 (6.86) | 73.50 (8.80) | 75.70 (6.79) | 0.413 |
| 32 | 80.31 (8.58) | 80.20 (8.06) | 82.30 (5.79) | 0.624 |
| 31 | 79.10 (8.81) | 79.80 (8.21) | 81.32 (4.91) | 0.640 |
| 41 | 79.35 (8.87) | 79.38 (7.57) | 82.09 (4.22) | 0.401 |
| 42 | 78.27 (9.30) | 78.00 (7.36) | 83.12 (3.18) | 0.050 |
| 43 | 75.28 (7.82) $^{AB}$ | 73.64 (9.26) $^{A}$ | 79.59 (4.90) $^{B}$ | 0.046* |
| 44 | 68.13 (9.30) | 67.77 (8.81) | 70.70 (8.85) | 0.535 |
| 45 | 61.98 (9.93) | 63.25 (9.07) | 64.76 (5.89) | 0.583 |
| 46 | 55.29 (8.83) | 55.96 (6.85) | 56.56 (7.84) | 0.874 |

* Statistically significant for P<0.05

Different letters in a row indicate the presence of a statistically significant difference among the groups, indicated by the Tukey test.

**Table VIII.** Intergroup comparison of the treatment changes (T2-T1) (one-way ANOVA and Tukey tests).

| | TREATMENT CHANGES | | | |
|---|---|---|---|---|
| V(°) | CONVENTIONAL | RME | DAMON | P |
| | Mean (SD) | Mean (SD) | Mean (SD) | |
| 16 | -0.10 (4.56) | -1.91 (6.16) | -1.15 (5.23) | 0.525 |
| 15 | 2.85 (7.48) | 5.63 (5.66) | 5.31 (5.54) | 0.285 |
| 14 | 5.51 (8.02) | 3.77 (5.47) | 6.28 (6.24) | 0.469 |
| 13 | 2.37 (6.66) | 3.74 (8.84) | 5.19 (7.97) | 0.514 |
| 12 | 1.83 (7.48) | -0.28 (6.40) | -0.12 (5.30) | 0.487 |
| 11 | 0.99 (8.01) | 0.49 (5.02) | -0.47 (5.95) | 0.764 |
| 21 | 1.92 (9.00) | -0.18 (4.92) | -1.46 (5.01) | 0.258 |
| 22 | 4.05 (7.94) $^{A}$ | 2.08 (6.09) $^{A}$ | -4.10 (7.96) $^{B}$ | 0.002* |
| 23 | 3.17 (8.42) | 4.34 (5.72) | 3.67 (8.09) | 0.873 |
| 24 | 2.40 (7.15) | 5.59 (4.44) | 6.00 (8.26) | 0.164 |
| 25 | 1.99 (5.82) | 5.95 (6.85) | 5.37 (4.57) | 0.060 |
| 26 | 0.05 (7.06) | 0.12 (5.26) | 3.24 (4.82) | 0.154 |
| 36 | -1.26 (8.57) $^{A}$ | 0.82 (8.84) $^{A}$ | 5.81 (8.39) $^{B}$ | 0.032* |
| 35 | 1.45 (8.25) $^{A}$ | 2.96 (9.82) $^{A}$ | 10.34 (9.49) $^{B}$ | 0.007* |
| 34 | 3.34 (10.09) $^{A}$ | 4.28 (10.55) $^{AB}$ | 11.87 (10.43) $^{B}$ | 0.021* |
| 33 | -0.69 (10.45) | -2.53 (11.24) | 4.93 (9.62) | 0.071 |
| 32 | 1.80 (10.75) | -0.29 (10.51) | 4.97 (10.34) | 0.286 |
| 31 | -2.39 (11.11) | -0.52 (10.81) | -0.46 (10.69) | 0.801 |
| 41 | -1.59 (10.73) | -2.36 (9.70) | 1.16 (10.17) | 0.520 |
| 42 | -0.20 (10.22) $^{A}$ | -2.15 (10.70) $^{A}$ | 6.70 (10.52) $^{B}$ | 0.024* |
| 43 | 3.23 (11.18) $^{AB}$ | -1.78 (11.39) $^{A}$ | 6.81 (9.97) $^{B}$ | 0.046* |
| 44 | 7.66 (10.15) | 4.36 (9.07) | 7.15 (11.19) | 0.512 |
| 45 | 4.35 (12.01) | 6.53 (11.15) | 10.57 (8.97) | 0.187 |
| 46 | 0.98 (8.45) $^{A}$ | -0.22 (6.98) $^{A}$ | 6.00 (8.61) $^{B}$ | 0.040* |

* Statistically significant for P<0.05

Different letters in a row indicate the presence of a statistically significant difference among the groups, indicated by the Tukey test.

# 3 Discussion

# 3 DISCUSSION

The term tooth inclination was first used in the six keys of normal occlusion proposed by Andrews.(ANDREWS, 1972) Most studies focused on the labiolingual inclination of the anterior teeth, which seems important because of its association with an esthetic profile.(CAO et al., 2011) In the last years, the buccolingual inclination of the posterior teeth has achieved importance due to its role in smile esthetics and interdigitated occlusion. Studies show that posterior teeth with palatal or lingual inclination would increase the negative corridor and consequently decrease the fullness of a smile. Due to this, buccolingual inclination is another important transverse characteristic of occlusion and for a final smile attractiveness.(ZACHRISSON, 2003) However, there is little information available on the inclination in all teeth, and it has not been reporting comparisons between self-ligating with conventional appliance with and without RME.

Regarding to the methodology of the current study, all variables were assessed using measurements performed on digital dental models. The three-dimensional analyses of dental models started with the digital revolution occurred in the 90s, and nowadays, it has been widely used in the development of orthodontic researches because it enables the demarcation of points, the drawing of lines and the performing of linear and angular measurements(RHEUDE et al., 2005; WHETTEN et al., 2006). Therefore, the three-dimensional analyses of digital dental models allow assessment with high accuracy and reproducibility of measurements that were difficult to perform manually in conventional dental models, such as palatal volume, inclination and angulations of teeth.(SANTORO et al., 2003; ZILBERMAN; HUGGARE; PARIKAKIS, 2003; QUIMBY et al., 2004)

According to several authors, the use of digital models for quantitative analysis was validated after evidence of high accuracy and reproducibility of the measurements(KUSNOTO; EVANS, 2002; LEIFERT et al., 2009; MANGIACAPRA et al., 2009; ABIZADEH et al., 2012). Measurements of the teeth inclinations were taken in both arches in order to evaluate the behavior of these variables during and after treatment.(GHISLANZONI et al., 2013; DE MEDEIROS ALVES et al., 2015) Studies comparing the reliability of inclination measurements performed in dental plaster

models and digital dental models, reported that there is no significant difference between the two methods.(GHAHFEROKHI et al., 2002; KODAKA et al., 2010; NOURI et al., 2014)

The results of the current study showed that patients in the three groups presented buccal inclination with the treatment in the majority of teeth, with more significant changes in the Damon group. All groups achieve adequate occlusion and esthetic smile. However, because of the greater buccal inclination in posterior mandibular teeth presented in the Damon group, it seems important to investigate the periodontal final status of the patients as the stability of the obtained results.

# 4 Conclusions

# 4 CONCLUSIONS

In Damon group, left maxillary lateral incisor showed palatal inclination and conventional and RME groups showed buccal inclination. In Damon Group, the right lateral incisor presented buccal inclination the opposite to other two groups. In Damon group, the right mandibular canine had a significant buccal inclination, different from RME group, in which this tooth presented lingual inclination.

In Damon group, the left mandibular premolars showed greater buccal inclination when compared to conventional and RME groups. Regarding mandibular molars, Damon Group showed greater buccal inclination than RME and conventional groups.

The little difference of inclination between the Damon System and Conventional prescription suggest that no difference exist between both appliances. This parameter should be considered by orthodontist for the achievement an effective and better orthodontic treatment.

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# Appendix

# APPENDIX

**APÊNCIDE A - DECLARAÇÃO DE USO EXCLUSIVO DE ARTIGO EM DISSERTAÇÃO/TESE**

**DECLARATION OF EXCLUSIVE USE OF THE ARTICLE IN DISSERTATION/THESIS**

We hereby declare that we are aware of the article COMPARISON OF DENTAL INCLINATION IN DIGITAL MODELS OF CASES TREATED WITH SELF-LIGATING OR CONVENTIONAL FIXED APPLIANCES WITH AND WITHOUT RAPID MAXILLARY EXPANSION will be included in Dissertation of the student Ricardo Martin Rengifo Vásquez and may not be used in other works of Graduate Programs at the Bauru School of Dentistry, University of São Paulo.

Bauru, 29 de novembro 2016 .

Ricardo Martin Rengifo Vásquez
Author _____ Signature

Marcos Roberto de Freitas
Author _____ Signature

Karina Maria Salvatore Freitas
Author _____ Signature

Guilherme Janson
Author _____ Signature

# Annexes

# ANNEXES

FACULDADE DE ODONTOLOGIA DE BAURU-USP

## PARECER CONSUBSTANCIADO DO CEP

**DADOS DO PROJETO DE PESQUISA**

**Título da Pesquisa:** COMPARAÇÃO DAS INCLINAÇÕES DENTÁRIAS EM MODELOS DIGITAIS DE CASOS TRATADOS COM APARELHOS AUTOLIGÁVEIS E APARELHOS CONVENCIONAIS COM E SEM EXPANSÃO RÁPIDA DA MAXILA

**Pesquisador:** Ricardo Martin Rengifo Vásquez

**Área Temática:**

**Versão:** 3

**CAAE:** 44953015.7.0000.5417

**Instituição Proponente:** Universidade de São Paulo - Faculdade de Odontologia de Bauru

**Patrocinador Principal:** Financiamento Próprio

**DADOS DO PARECER**

**Número do Parecer:** 1.173.033

**Data da Relatoria:** 29/07/2015

**Apresentação do Projeto:**

Idem ao Parecer 1.113.771

**Objetivo da Pesquisa:**

Idem ao Parecer 1.113.771

**Avaliação dos Riscos e Benefícios:**

Riscos: Pesquisa retrospectiva em modelos de estudos em gesso.

Beneficios: Pesquisas sobre as inclinações dentárias, tanto em oclusão normal, como em casos tratados ortodonticamente são muito escassos na literatura por ser uma técnica com abordagem mais recente, ainda não há estudos comparando as inclinações dos dentes em casos tratados com aparelhos autoligaveis, com expansão e com aparelho convencional sem expansão. Sendo assim, este trabalho se propõe a comparar as alterações nas inclinações dentarias em casos tratados com bráquetes autoligáveis, bráquetes convencionais com e sem a realização de expansão rápida da maxila, e assim comparar se vale a pena o paciente passar pela dolorosa expansão maxilar ou pode ser tratado tranquilamente com aparelhos autoligaveis.

**Endereço:** DOUTOR OCTAVIO PINHEIRO BRISOLLA 75 QUADRA 9
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FACULDADE DE ODONTOLOGIA DE BAURU-USP

Continuação do Parecer: 1.173.033

**Comentários e Considerações sobre a Pesquisa:**

Idem ao Parecer 1.113.771

**Considerações sobre os Termos de apresentação obrigatória:**

Na análise prévia, foi solicitado que:

1- O autor deveria ter incluído o nome do orientador nas informações no plataforma no item de componentes da equipe, o que não foi realizado.

Pendência ATENDIDA.

2- O autor deveria ou ter justificado adequadamente a dispensa do TCLE ou ter incluído TCLE/ termo de assentimento. Nesta nova versão, o autor assinalou que não houve dispensa de TCLE porém nãoapresentou esta documentação. Nada foi mencionado sobre o termo de assentimento, uma vez que a pesquisa envolverá pacientes a partir de 12 anos.

O pesquisador esclarece que será usados os modelos de estudo sob guarda do Departamento de Ortodontia:
"O estudo é restrospectivo, já tem a amostra e os modelos no acervo da faculdade. Este estudo é continuação de um outro estudo já finalizado e vai utilizar a mesma amostra. Por tanto o estudo não vai precisar mais do paciente, só dos modelos que estão no acervo da faculdade."

Pendência ATENDIDA.

**Recomendações:**

**Conclusões ou Pendências e Lista de Inadequações:**

Nennhuma no momento

**Situação do Parecer:**

Aprovado

**Necessita Apreciação da CONEP:**

Não

**Considerações Finais a critério do CEP:**

Esse projeto foi considerado APROVADO na reunião extraordinária do CEP de 29.07.2015, com base nas normas éticas da Resolução CNS 466/12. Ao término da pesquisa o CEP-FOB/USP exige a

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Continuação do Parecer: 1.173.033

apresentação de relatório final. Os relatórios parciais deverão estar de acordo com o cronograma e/ou parecer emitido pelo CEP. Alterações na metodologia, título, inclusão ou exclusão de autores, cronograma e quaisquer outras mudanças que sejam significativas deverão ser previamente comunicadas a este CEP sob risco de não aprovação do relatório final. Quando da apresentação deste, deverão ser incluídos todos os TCLEs e/ou termos de doação assinados e rubricados, se pertinentes.

BAURU, 06 de Agosto de 2015

**Assinado por:**
**Izabel Regina Fischer Rubira Bullen**
**(Coordenador)**

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