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BRUNA ALVES FURQUIM

Cephalometric and dental casts comparison of cases treated with Damon self-ligating or conventional fixed appliances with and without rapid maxillary expansion

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Comparação cefalométrica e de modelos de casos tratados com aparelho autoligável do sistema Damon e aparelhos convencionais com e sem expansão rápida da maxila

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Orientador: Profº. Drº. Marcos Roberto de Freitas

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DEDICATÓRIA

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ABSTRACT

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Cephalometric and dental casts comparison of cases treated with Damon self-ligating or conventional fixed appliances with and without rapid maxillary expansion

Purpose: To compare the changes in the maxillary and mandibular dental arch forms and in incisors position in orthodontic cases treated with Damon and conventional appliances, with and without rapid maxillary expansion (RME). **Methods:** Sample comprised 75 Class I malocclusion patients with mild to moderate crowding treated orthodontically without extractions. The sample was divided into 3 groups: Group 1: 23 patients (mean initial age: 14.65 years) treated with Damon System for a mean period of 2.72 years; Group 2: 24 patients (mean initial age: 13.85 years) treated with RME followed by conventional fixed appliances for a mean period of 2.17 years; Group 3: 28 patients (mean initial age: 13.94 years) treated with conventional fixed appliances for a mean period of 2.20 years. Pretreatment and posttreatment dental casts and cephalograms of each patient were evaluated. Intergroup comparison of the variables was performed by ANOVA and Tukey test. **Results:** The maxillary intercanine, inter-second-premolar and intermolar widths showed a greater increase in Damon and RME groups. In the mandibular arch, the arch widths showed a greater increase in Damon group compared to the other two groups. There was greater protrusion of the maxillary incisors in Damon group than in the other 2 groups. For the mandibular incisors, Damon caused a greater protrusion and proclination when compared to the conventional appliance. **Conclusions:** The maxillary arch form showed similar increases in most of the distances to treatment with Damon and RME plus conventional appliances. The mandibular arch showed a greater increase in most of the measured distances in cases treated with Damon, compared to the conventional appliances with and without RME. Damon caused greater protrusion of the maxillary incisors. In the mandibular incisors, Damon caused a greater protrusion and proclination when compared to conventional appliance only.

KEYWORDS: Orthodontic brackets, Braces, Orthodontics.

RESUMO

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Comparação cefalométrica e de modelos de casos tratados com aparelho autoligável do sistema Damon e aparelhos convencionais com e sem expansão rápida da maxila

Objetivo: Comparar as alterações na posição dos incisivos e na forma dos arcos superior e inferior em casos tratados com o sistema Damon, e com bráquetes convencionais, com e sem a realização de expansão rápida da maxila (ERM). **Metodologia:** A amostra foi composta por 75 pacientes com má oclusão de Classe I, apinhamento suave a moderado, tratados ortodonticamente sem extrações. Grupo 1: 23 pacientes com idade média inicial de 14,65 anos, tratados com aparelhos autoligáveis do Sistema Damon, por um perído médio de 2,72 anos; Grupo 2: 24 pacientes com idade média inicial de 13,85 anos, tratados com ERM seguido por aparelhos fixos convencionais, por um período médio de 2,17 anos; Grupo 3: 28 pacientes com idade média inicial de 13,94 anos, tratados com aparelhos convencionais, por um perído médio de 2,20 anos.Os modelos de gesso e as telerradiografias foram avaliados ao início e ao final do tratamento. A comparação intergrupos das variáveis foi realizada através do teste ANOVA e o teste de Tukey quando necessário. **Resultados:** As distâncias intercaninos, inter-segundos-premolares e intermolares superiores apresentaram um maior aumento nos grupos Damon e ERM. Na arcada inferior, as larguras do arco mostraram um maior aumento no grupo Damon em comparação aos outros dois grupos. Houve uma maior protrusão dos incisivos superiores no grupo Damon em relação aos outros dois grupos. Nos incisivos inferiores, o Damon causou uma maior protrusão e vestibularização quando comparado com o grupo convencional. **Conclusão:** A forma do arco superior mostrou aumentos semelhantes na maioria das distâncias para o tratamento com o aparelho Damon e ERM com aparelhos convencionais. A forma do arco inferior mostrou maior aumento na maioria das distâncias medidas em casos tratados com o aparelho Damon, em comparação aos casos tratados com aparelho convencional, com e sem ERM. O aparelho Damon causou maior protrusão dos incisivos superiores. Nos incisivos inferiores o aparelho Damon causou uma maior protrusão e vestibularização quando comparado apenas com o aparelho convencional.

PALAVRAS-CHAVE: Braquetes Ortodônticos, Aparelhos Ortodônticos, Ortodontia.

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1 INTRODUCTION

1 INTRODUCTION

The concern with the correct dental irregularities exists even before Angle. This interest resulted in inventions of devices for dental movements, maxillary expansion, anchorage control, etc.

With enormous popularity all over the world and being a recent addition, the self-ligating brackets are not new in orthodontics and were first described by Stolzenberg in 1935 with Russell Luck device, aiming to improve clinical efficiency by reducing the time installation of metal bands to brackets (HARRADINE, 2009). The self-ligating brackets are those that do not make use of elastic or metal ligatures, however they have a mechanism that can be opened or closed in order to attach the arch to the bracket (HARRADINE, 2009).

Many good points are attributed to self-ligating systems over conventional ones, such as ensuring perfect fitting of the arch in the channel of the bracket, minimum friction between the arch and the bracket (VOUDOURIS, 1997; DAMON, 1998b; KIM; KIM; BAEK, 2008) longer interval between appointments, (DAMON, 1998b; HARRADINE, 2003) easy and fast handling, more comfort for the patient, easier oral hygiene and less chairtime (HARRADINE, 2003; RINCHUSE; MILES, 2007; SCOTT et al., 2008).

The manufacturer of the Damon system, argues that this device is capable of providing transverse arch increase keeping the teeth perfectly centered in the bone. This ability to reach the transverse development of the maxilla reduces the need for extractions and procedures such as rapid maxillary expansion or surgically assisted expansion. The manufacturer advertises on its website that the gain in the posterior arch width, analyzed in post-treatment CT images, shows transverse arch development and normal alveolar bone on lingual and buccal surfaces (DAMON, 2005).

The Damon philosophy is founded on the theory that when the force application is able to be delivered continuously, the lighter force is needed, and in turn, the biology of tooth movement is maximized. This is possible by the association of superelastic nickel-titanium NiTi archwires and a passive self-ligation system.

Setting the teeth in an "optimal force zone" promotes a physiological adaptation, where the orofacial muscles and the periodontium are not dominated by the orthodontic force, and by doing so, the connective tissue and alveolar bone move together with the teeth (Ormco).

The initial objective proposed by the Damon system is to apply only the necessary force to stimulate cellular activity, but without causing the collapse of the periodontal ligament and blood vessels (DAMON, 1998a).

Conceived by Damon, their brackets promise a lower incisor protrusion, because the control of the mandibular incisor position is mediated by the lip muscles.(DAMON, 1998a; DAMON, 2005)

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. 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 (QUAGLIO; AL, 2009).

According to the philosophy of Andrews, 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 (1975) 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, 2004).

Studies compared the position of the incisors after the phase of alignment and leveling of the teeth and found the occurrence of dental protrusion, when the cases treated with self-ligating system were compared with those patients treated with conventional brackets. Although no statistical significant differences were found between the effects of conventional and self-ligating brackets on the position of the incisors, all studies showed a slight tendency of self-ligating brackets promote minor buccal inclination of the mandibular incisors. It is important to highlight that clinical studies have shown that, during the correction of crowding, all the teeth tend to have a buccal inclination, regardless the type of bracket used in the treatment. However, studies have shown that no statistical significant differences were found on the buccolingual inclination of the maxillary incisors, when conventional brackets were compared to Damon system (PANDIS; POLYCHRONOPOLOU; ELIADES, 2010; VAJARIA et al., 2011; LOMBARDO et al., 2012).

It is suggested that low-friction brackets associated to mild-force archwires promote major expansion on the posterior region of the dental arch, minor alterations on the position of the mandibular incisor and on the intercanine distances (DAMON, 2005). In general, alignment of the teeth in cases treated without extraction occurs in consequence of the transverse expansion of the dental archs and buccal inclination of the incisors (WEINBERG; SADOWSKY, 1996).

According to the literature, intercanine, inter-premolar and intermolar distances increased in both maxillary and mandibular dental archs, in cases treated without extractions, regardless the type of brackets used. The expansion of the posterior region of the dental arch occurs mainly in consequence of the increasing on buccal inclination of the posterior teeth. A strong factor for the determination of the shape of the dental arch was the archwire used. It is explained by the fact that archwires conformed with larger diagrams causes major arch expansion, regardless the type of bracket used (FLEMING et al., 2009; ONG; HO; MILES, 2010; PANDIS et al., 2010; CATTANEO et al., 2011).

It is known that occurs an increase on the shape of the dental arch as a consequence of the expansion of the posterior teeth through the bone, in cases treated with rapid maxillary expansion (GARIB et al., 2006; RUNGCHARASSAENG et al., 2007; BALLANTI et al., 2009), slow expansion (CORBRIDGE et al., 2011) and self-ligating brackets (CATTANEO et al., 2011).

In the literature, there are no studies comparing Damon samples and conventional device with and without rapid expansion. Therefore, it is necessary to compare the changes in the position of the incisors and the arch shapes of cases treated with the Damon System, and the ones with conventional brackets with and without performing rapid maxillary expansion.

This study aims to compare the changes both in the position of the incisors and the dimensions of the arches in cases treated with the Damon self-ligating, and the ones with conventional devices with and without performing rapid maxillary expansion.

2 ARTICLE

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Cephalometric and dental casts comparison of cases treated with Damon self-ligating or conventional fixed appliances with and without rapid maxillary expansion

ABSTRACT

Purpose: To compare the changes in the maxillary and mandibular dental arch forms and in incisors position in orthodontic cases treated with Damon and conventional appliances, with and without rapid maxillary expansion (RME). **Methods:** Sample comprised 75 Class I malocclusion patients with mild to moderate crowding treated orthodontically without extractions. The sample was divided into 3 groups: Group 1: 23 patients (mean initial age: 14.65 years) treated with Damon System for a mean period of 2.72 years; Group 2: 24 patients (mean initial age: 13.85 years) treated with RME followed by conventional fixed appliances for a mean period of 2.17 years; Group 3: 28 patients (mean initial age: 13.94 years) treated with conventional fixed appliances for a mean period of 2.20 years. Pretreatment and posttreatment dental casts and cephalograms of each patient were evaluated. Intergroup comparison of the variables was performed by ANOVA and Tukey test. **Results:** The maxillary intercanine, inter-second-premolar and intermolar widths showed a greater increase in Damon and RME groups. In the mandibular arch, the arch widths showed a greater increase in Damon group compared to the other two groups. There was greater protrusion of the maxillary incisors in Damon group than in the other 2 groups. For the mandibular incisors, Damon caused a greater protrusion and proclination when compared to the conventional appliance. **Conclusions:** The maxillary arch form showed similar increases in most of the distances to treatment with Damon and RME plus conventional appliances. The mandibular arch showed a greater increase in most of the measured distances in cases treated with Damon, compared to the conventional appliances with and without RME. Damon caused greater protrusion of the maxillary incisors. In the mandibular incisors, Damon caused a greater protrusion and proclination when compared to conventional appliance only.

KEYWORDS: Orthodontic brackets, Braces, Orthodontics.

INTRODUCTION

Self-ligating brackets have huge popularity around the world. However this fixed orthodontic appliance system is not new. It was first described by Stolzenberg, in 1935, who used the Russell Lock appliance aiming to improve clinical efficiency by reducing the time of tying the ligatures around the metal brackets[1]. Self-ligating brackets are those which do not require the use of elastic or metal ligatures, however they are composed by a mechanism that can be opened or closed to attach the archwire inside the slot of the bracket[2].

Positive aspects are attributed to self-ligating system compared to conventional brackets, such as total attachment of the archwire inside the slot of the bracket, minimum friction between the archwire and the bracket,[3-5] longer interval between orthodontic visits[3,6] easier handling, major comfort for the patient, facilitated oral hygiene and a shorter chair-side time[6-8].

The manufacturer of Damon system, argues that its appliance is capable of promote transverse increasing of the dental archs 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 surgically assisted or not. Computer tomography exams acquired at post-treatment period suggest that the increasing of the width of the posterior region of the dental archs is characterized by teeth supported with normal buccal and lingual alveolar bone[9].

Maxillary disjunction is an efficient method for correction of transverse maxillary deficiency, however, the rapid maxillary expansion is also indicated to increase the width of the maxillary dental arch in cases of mild to moderate crowding, wherein the extractions are undesirable to obtain space for the alignment and leveling the teeth without the occurrence of a large protrusion of the incisors[10].

According to Damon manufactures, the brackets of 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[9,11].

Studies compared the position of the incisors after the phase of alignment and leveling of the teeth and found the occurrence of dental protrusion, when the cases treated with self-ligating system were compared with those patients treated with conventional brackets. Although no statistical significant differences were found

between the effects of conventional and self-ligating brackets on the position of the incisors, all studies showed a slight tendency of self-ligating brackets promote minor buccal inclination of the mandibular incisors. It is important to highlight that clinical studies have shown that, during the correction of crowding, all the teeth tend to have a buccal inclination, regardless the type of bracket used in the treatment. However, studies have shown that no statistical significant differences were found on the buccolingual inclination of the maxillary incisors, when conventional brackets were compared to Damon system[12-14].

It is suggested that low-friction brackets associated to mild-force archwires promote major expansion on the posterior region of the dental arch, minor alterations on the position of the mandibular incisor and on the intercanine distances[9]. In general, alignment of the teeth in cases treated without extraction occurs in consequence of the transverse expansion of the dental archs and buccal inclination of the incisors[15].

According to the literature, intercanine, inter-premolar and intermolar distances increased in both maxillary and mandibular dental archs, in cases treated without extractions, regardless the type of brackets used. The expansion of the posterior region of the dental arch occurs mainly in consequence of the increasing on buccal inclination of the posterior teeth. A strong factor for the determination of the dental arch form was the archwire used. It is explained by the fact that archwires conformed with larger diagrams causes major arch expansion, regardless the type of bracket used[16-19].

It is known that occurs an increase in dental arch form as a consequence of the expansion of the posterior teeth through the bone, in cases treated with rapid maxillary expansion[20-22], slow expansion[23] and self-ligating brackets[19].

Considering that Damon system is a technique that was recently incorporated in Orthodontics, there are not studies published in the literature that compare samples 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 arches form and in incisor position in cases treated with the Damon self-ligating and conventional appliances with or without rapid maxillary expansion.

MATERIAL AND METHODS

The present study was approved by the Ethics Committee in Research of Bauru Dental School - University of São Paulo under protocol number 23216514.3.0000.5417.

Sample size calculation was performed based on an alpha level of significance of 5% aiming to achieve a power test of 80% to detect a mean difference of 1.39 mm with a standard deviation of 1.66 for the mandibular intercanine and intermolar distances[13]. Thus, the sample size calculation showed the need of a sample comprised by 23 subjects in each group.

The sample was comprised by 75 patients with Class I malocclusion, with mild to moderate crowding before treatment; treated without extractions and presented all permanent teeth until first molars totally erupted and without anomalies of number and form. The participants of the present study were distributed into 3 groups.

Group 1 consisted of 23 patients (12 females; 11 males) treated with self-ligating brackets of Damon System (Damon MX). The patients were treated of Bauru Dental School - USP, had 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 archwire sequencing used for the treatment of these patients was: (1) 0.014-in CuNiTi Damon®, maintained for at least 10 weeks, until the archwire 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 pre-contoured 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.

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 treated 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, treatment protocol 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 diagramming used for group 3, as previously described.

Group 3 was comprised by 28 (21 females; 07 males) patients treated with conventional orthodontic fixed appliances based on Roth's technique. The patients were treated 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 archwire sequencing used was: (1) 0.014" NiTi, (2) 0.016" NiTi, (3) 0.018" NiTi archwires, 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. The stainless steel mandibular archwires were contoured individualized for each patient, based on the mandibular anterior curvature and the intermolar distances found in the patient's pretreatment model. The maxillary SS archwires were contoured adjacent just outside the mandibular archwires.

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. After scanning, the digital dental models obtained at the initial and final phases of the treatment, were exported in .SLT format to the software

OrthoAnalyzer™ 3D (3Shape A / S, Copenhagen, Denmark) to have digital measurements.

The arch dimensions were measured in the maxillary and mandibular dental arches.

Transverse widths of the dental arches were measured using the following measurements (Fig. 1 A and B).

- Intercanines: measured using as reference the distance between the cusp tips;
- Inter-first-premolars: measured at the buccal cusp tips;
- Inter-second-premolars: measured at the buccal cusp tips;
- Intermolars: measured at the mesiobuccal cusp tips;

When the cusp tip was worn, the reference point was the center of the wear facet.

Anteroposterior measurements consisted in the lengths of anterior and posterior dental arch (Fig. 1 C and D).

- Anterior arch length: distance between an imaginary line that passes through the mesial contact points of the first premolars and the most buccal point of the incisal edges of the central incisors;
- Posterior arch length: distance between an imaginary line that passes through the mesial surfaces of the permanent first molars and the most buccal point of the incisal edges of the central incisors.

The measurements related to the transverse and anteroposterior distances were evaluated in both initial and final digital dental models.

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[24]. The measurements were performed positioning the maxillary and mandibular digital dental models in an occlusal view. At this position, the ruler tool of the software 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 (Fig 2).

Lateral cephalograms were obtained at the beginning and at the end of the treatment of each patient. These orthodontic exams were scanned using a scanner compatible with Dolphin Imaging software version 11.5 (Chatsworth, CA, USA). It is

important to highlight that it was necessary adjust the magnification factor of each lateral cephalogram scanned.

Buccolingual inclinations of incisors were measured by the following variables:

- 1-NA (mm): distance between the furthest point of the maxillary central incisor crown and the NA line;
- 1.NA: angle formed by the intersection of the maxillary central incisor long axis and the NA line;
- 1-NB (mm): distance between the furthest point of the crown of the mandibular central incisor and NB line;
- 1.NB: angle formed by the intersection of the mandibular central incisor long axis and the NB line;

Error of the method was performed using 30 pairs of digital dental models and 30 lateral cephalograms 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[27], whereas the systematic error was calculated using Student's T test.

Kolmogorov-Smirnov normality test was performed and showed that the sample had a normal distribution.

Intergroup comparability regarding sex distribution was evaluated using chi-square test. One-way ANOVA was used to assess the compatibility among 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.

Intergroup comparison of the variables measured at the initial and final stages and the 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 Md I1P, 1-NA and 1.NA the random errors ranged from 0.22 mm (1-NB) and 1.19° (1.NB) (Table 1).

There was compatibility among groups regarding sex distribution (Table 2), the initial and final ages of treatment time (Table 3). There was also compatibility among groups as to Little's Irregularity Index in the maxillary and mandibular arches (Table 3).

In the beginning of the treatment, the measurements of the maxillary models were similar in all groups, except for the anterior arch length which was lower in the Damon group than in the other two groups. In the mandibular arch, there was difference among the groups for the posterior arch length, which was greater in the RME group compared to the other two groups. The maxillary incisors were more protruded in the RME group than in the other groups (Table 4).

Observing the treatment-related changes, the intercanine, inter-second-premolar and intermolar distances showed greater increase in the Damon and RME groups compared to the conventional group (Table 5). The inter-first-premolar distance showed greater increase in the Damon group, followed by the RME group and the conventional group, with significant differences among the 3 groups (Table 5). The maxillary anterior arch length increased in the Damon group and slightly decreased in the RME and conventional groups (Table 5). Regarding the mandibular arch variables, the intercanine, inter-first-premolar, inter-second-premolar and intermolar distances showed greater increase in the Damon group compared to the other two groups (Table 5). The Damon group presented greater protrusion of the maxillary incisors in relation to the other two groups (Table 5). As for the mandibular incisors, the Damon group showed greater protrusion and proclination only when compared to the conventional group (Table 5).

At the end of treatment, The maxillary intercanine distance was greater in the Damon group when compared to the other two groups (Table 6). The inter-second-premolar and intermolar distances were greater in the Damon group only when compared to the conventional group (Table 6). In the mandibular arch, the intercanine distance was greater in the Damon group than in the other groups (Table 6). Inter-second-premolar and intermolar distances were greater in Damon and RME groups than in the conventional group (Table 6). The maxillary incisors were more

protruded in the Damon group with significant difference only for the conventional group (Table 6). The mandibular incisors were more protruded and proclined in the Damon group than in the other two groups (Table 6).

DISCUSSION

THE SAMPLE USED

Seventy-five cases divided into three groups comprised the sample for this study, reliable number, since the sample size calculation was performed determining that it would take at least 23 cases for each group to detect a 1.39 mm increase in lateral distance of the maxillary second premolars. The calculation was performed with a 5% significance power.

The sample consisted of dental casts and initial and final lateral cephalograms obtained from subjects treated with the use of self-ligating 3MX™ 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 2), initial and final ages, and treatment time (Table 3).

Some authors have observed, in another study, some changes in the dental arch length with increasing age[25,26]. Thus, it is very important that the three groups have compatible ages so there is no difference in the arch due to age. Therefore, if there is any change in the arch, it will be due to the treatment and not because of age.

There was also compatibility of the groups as to the Little's Irregularity Index in the maxillary and mandibular arches (Table 3). This compatibility is important because the more the crowding, the greater the trend in the increase of the

transverse dimensions of the dental arches. Some authors state that the elimination of crowding in treatments without extraction is significantly related to an increased arch perimeter, protrusion of the incisors and increased intermolar and inter-premolar transverse distances[15]. Other authors who used the Damon appliance in their studies also state that usually cases with crowding treated without extractions result in an increase in transverse distances and lengths of the maxillary and mandibular dental arches[13,18,27]. 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.

Currently, 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[28]. 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[29].

Prior to orthodontic treatment, both the Damon group and the RME and conventional groups had similar forms of the maxillary arch, with only the length of the anterior arch displayed less significant difference in the Damon group than in the other two groups. In the mandibular models, only cases RME group had, the length of increased posterior arch. Prior to treatment, the maxillary incisors were more protruded in the RME group than in the other groups (Table 4). The compatibility among the groups is important at the beginning of the treatment as well, because if the arch form is compatible, the results will be exclusively by changes due to treatment and not some pre-existing arch form.

Thus, a major concern in the conduct of this study was to obtain compatible groups, which make feasible a correct comparison and thus favoring the interpretation and reliability of results.

METHODOLOGY

The Damon system creator mentions that the use of self-ligating brackets liabilities associated with superelastic wires, provides a transversal development of the dental arches, with a smaller protrusion or proclination of the incisors because

the low forces generated are not able to overlap the perioral muscle strength. This transversal development, with a smaller anterior positioning of the incisors, result in less need for dental extractions or procedures as RME or surgically assisted RME. This increase in the width of the dental arches was measured using as reference cusp tips, because it is a precise methodology and widely used in the literature[30-32].

Digital models were used to perform the transversal and anteroposterior measurements instead of using plaster models through OrthoAnalyzer Software - 3Shape. Digital models reduce or solve many problems and difficulties associated with storage, retrieval, reproduction, communication and risk of damage to models[33]. Traditional and digital models offer the same intra-examiner reproducibility in most cases, and for some measures, when transversal sections may help, digital models seem to reproduce an even smaller error[34], 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[35].

The measurements are performed more quickly in digital images when compared to those performed with a digital caliper in dental casts, and demonstrated that the Bolton analysis in the digital model is accurate and can be performed 65 seconds faster than in the plaster models[36]. According to several authors, the use of digital models for quantitative analysis was validated after evidence of high accuracy and reproducibility of measurements[33,35,37-40]. The lengths of the arches were also checked to quantify the anterior movement of the incisors at the end of treatment, in order to confirm or not the theory of action of perioral muscles in containing the incisors[3]. Measurements of the lengths of anterior and posterior arches were taken in the maxillary and mandibular dental arches in order to evaluate the behavior of these variables in the anterior and posterior segments separately[13,41].

The 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[24]. The Little irregularity index was adapted to the maxillary dental arch, as this methodology is used with good acceptability by other authors[42-45].

The use of software for cephalometric analysis has become increasingly popular. When compared to manual technique, the digital cephalometric measurement offers a number of advantages: cephalometric measurements are

performed in a shorter period of time[46]; the image can be enlarged and manipulated without quality loss[47,48]; the angles and distances are calculated automatically, eliminating the possibility of error during manual measurement and data transfer to the computer[49]. Conventional radiographs were obtained for the initial and final documentation and were used to check the change in position of the incisors at the end of treatment. The software used in this study was the Dolphin Imaging software (version 11.5), which is widely used and has high reproducibility, accuracy and precision in the cephalometric measurements used[49,50].

RESULTS

Maxillary Arch Form

The orthodontic treatment with the Damon appliance promoted a greater increase in the maxillary intercanine distance when compared to patients treated with RME and conventional appliance (Table 5).

A larger increase of this distance was already expected in the Damon group compared with the conventional group, without RME, as it had been shown in previous studies[13,52,53]. Now, Ong[17] found a different result when comparing the intercanine width of cases treated with the Damon system and the conventional one, showing a reduction of this distance; however, his treatment was performed with premolar extractions.

With respect to the group treated with RME, there are no studies comparing the arch form of cases treated with self-ligating and RME. Thus, the present results are unprecedented, making it difficult to compare to other studies. In the literature, there are only studies comparing patients treated with RME and cases treated with fixed conventional appliances, which showed that RME caused a greater increase in the intercanine width with treatment[43]. Maltalgliati et al.[54] concluded in their study that there was a greater increase in this distance with treatment using Damon appliance, but not as much as in the inter-premolar widths.

With treatment, the maxillary inter-first-premolar width showed a greater increase in the Damon group, followed by RME group and the conventional group,

with significant differences among the three groups (Table 5). And the inter-second-premolar width in the maxillary arch showed a greater increase in the Damon group than in the other two groups (Table 5).

Vajaria et al.[13] found increased inter-premolar width in both cases, those treated with Damon appliance and those treated with conventional appliance. Canuto et al.[43] also found a significant increase of inter-first-premolar width in both groups, the RME and the conventional. As for the inter-second-premolar width, Canuto et al.[43] found a greater increase in the cases treated with RME than in those treated with conventional appliances. Maltalgliati et al.,[54] in a study comparing cases treated with the Damon appliance, found a greater increase of this distance with treatment.

The Damon appliance promoted a greater increase of the maxillary intermolar width as compared with the cases treated with RME and the conventional appliances (Table 5).

For intermolar width, the results are similar to other studies that also found a greater increase of this distance in cases treated with Damon appliance when compared to patients treated with conventional appliances[13,18,27,53]. Unlike this, a reduction of this distance was found in the study by Ong[17], but this was when evaluating patients treated with premolar extractions. Canuto et al.[43] found a greater increase for intermolar width in the group treated with RME. Maltalgliati et al.,[54] in their study, found a greater increase in this distance at the end of the treatment of cases treated with Damon appliance.

Thus, when comparing the results of this study, the Damon self-ligating appliance is closer to the results of cases treated with RME, showing a significant transverse expansion of the maxillary arch.

With treatment, the cases treated with Damon appliance had a greater increase in the maxillary anterior arch length, while the cases treated with conventional appliances with and without RME showed a slight decrease (Table 5).

Similar to our study, Ong[17] also found a greater increase of the arch length in cases treated with Damon appliance compared to treatment with conventional appliance, even with premolar extraction and the study of Canuto et al.,[43] found a greater increase of the arch length in cases treated with RME compared to patients treated with conventional appliance. This was probably the fact that despite not having significant difference, the Damon group had earlier increased crowding. However, the increase of the arch length should be observed with caution, since it

may indicate an increase of the occurrence of a protrusion of the incisors, and not a lateral transversal expansion of the arch.

At the end of orthodontic treatment it was observed that the maxillary intercanine width of the cases treated with Damon appliance was greater when compared to the cases treated with conventional appliances with and without RME (Table 6). Now, the inter-second-premolar and intermolar widths were greater only in the cases treated with the Damon appliance when compared to patients treated with conventional appliances (Table 6). These greater distances in the Damon group were already expected, as they are due to the greater increase obtained from treatment in this group.

Mandibular Arch Form

Orthodontic treatment with Damon appliance promoted a greater increase in the mandibular intercanine width when compared with the cases treated with conventional appliance and RME (Table 5).

Other studies comparing the Damon system to the conventional one also found a greater increase in mandibular intercanine width in the group treated with self-ligating appliances[13,27,53]. Ong[17] found a decrease of this distance in cases treated with self-ligating appliances, but their study involved the extraction of premolars.

Regarding the inter-first-premolar and inter-second-premolar widths, orthodontic treatment with the Damon appliance generated a greater increase of these distances compared to patients treated with RME and conventional appliances (Table 5).

Vajaria et al.[13] also found a greater increase of this distance in the Damon group compared to the conventional one. In other studies, a greater increase in the inter-second-premolar width was found both in the Damon group and in the conventional group[13,52]. Maltalgliati et al.[54] concluded that there was a further increase of this distance with treatment using the Damon appliance, but slightly less than in the maxillary arch.

Regarding the intermolar width, the cases treated with Damon appliance showed a greater increase in these distances compared to patients treated with RME and conventional appliance (Table 5).

Several studies have also shown a greater increase in cases treated with Damon appliance compared to patients treated with conventional appliance[13,27,52]. However, Scott et al.[53] found a small decrease of this distance in the group treated with Damon appliance and a small increase in the group treated with conventional appliance, but the patients in their study showed to have extractions. Maltalgliati et al.,[54] in the study comparing cases treated with Damon appliance, found a greater increase of this distance with treatment.

There were no significant changes of the mandibular arch length with treatment (Table 5).

At the end of orthodontic treatment, the cases treated with Damon appliance showed greater intercanine width in the mandibular arch in relation to the other 2 groups. Inter-second-premolar and intermolar widths were also greater in the Damon group, but the cases treated with RME also showed this increase, with a significant difference with respect to cases treated with conventional appliances (Table 6).

Most of the differences found between the Damon and the conventional appliances without RME were given mainly by the way of diagramming the arches. The Damon appliance protocol uses wires and diagrams that allow and aimed at the expansion of both the maxillary and mandibular arches. In the conventional appliance protocol diagrams are chosen from the pretreatment mandibular model of the patient, without expanding so much the arch, unlike the objective of the Damon philosophy.

Incisors inclination

The orthodontic treatment with the Damon appliance promoted greater protrusion of the maxillary incisors than the other two groups and greater protrusion and proclination of the mandibular incisors only in relation to the conventional appliance group (Table 5).

Corroborating this study, other studies comparing the Damon system and the conventional one also found a greater protrusion of the mandibular incisors in cases treated with the Damon appliance[13,27,53]. Vajaria et al.,[13] evaluating the self-ligating Damon appliance, found neither greater protrusion nor proclination of the maxillary incisors after treatment. Fleming et al.,[16] in their study comparing the self-ligating to the conventional appliances found a greater proclination of the incisors regardless of the appliance system used. According to Chen et al.,[55] in their systematic review, the proclination of the mandibular incisors with treatment with self-ligating appliances is 1.5° lower than with the use of conventional appliances.

It has been observed by Pandis et al.[27] that when Damon 2 brackets were used there was a mandibular incisor proclination of 7 to 8 degrees associated with alleviation of crowding. According to some authors, the proclination of the mandibular incisor and their advancement are common findings in studies that analyze crowding alleviation. Studies have consistently shown that mandibular incisor advancement along with the lateral expansion occur when crowding is alleviated during nonextraction treatment when no other appliances are used (headgear, distalizers, lip bumpers)[15,16,27].

After orthodontic treatment with the Damon system, it can be observed that the maxillary incisors were more protruded compared to cases treated with conventional appliance without RME. The mandibular incisors were more protruded and proclined for the cases treated with conventional appliance with and without rapid maxillary expansion (Table 6).

CLINICAL CONSIDERATIONS

The correction of crowding without extractions or interproximal stripping inevitably results in dentoalveolar expansion of the dental arches, in transverse and anteroposterior directions, and incisors proclination[15]. The consequences of this type of treatment depend on the type of the fixed appliance used, conventional or self-ligating.

The results of this study showed that, for the maxillary arch, in general, the Damon and the RME groups showed similar changes with treatment, since these two groups actually promote greater arch expansion.

Therefore, in the mandibular arch, the greatest differences were generally in the Damon group compared to the RME and conventional groups. That was somehow expected, as the RME acts directly only in the maxillary arch. Some authors report that the mandibular arch follows the maxillary arch expansion [10], but this study showed that the greatest expansion is really only in the maxillary arch. This study also showed that the mandibular arch expands more with the Damon appliance, whose archwire and diagram allows and aims at the expansion of both the maxillary and mandibular arches.

The Damon appliance promoted the most changes in relation to the conventional appliance without RME mainly due to the type of diagram used. In its protocol, the expanded wires and diagrams aim to promote the expansion of both the maxillary and mandibular arches and, thus, allow the correction of crowding. In the conventional appliance protocol, the diagrams are based on the pretreatment mandibular dental cast of each patient, not altering the arch form.

In cases treated with Damon appliance, it is clear the expansive effect in the dental arches. This can and should be considered in orthodontic planning, since the self-ligating appliances can be very useful when expansion is necessary. However, despite showing similar arch form at the end of treatment, RME and self-ligating appliances present different indications. In the present study, were not included cases with posterior crossbite, i.e., transverse skeletal problems, where the major indication would be to conduct the RME. This way, its indication cannot be neglected, since it has a very important role in the treatment of these skeletal discrepancies in the transverse direction.

CONCLUSIONS

The maxillary arch form showed similar increases in most distances with treatment with the Damon system and with rapid maxillary expansion compared to treatment with conventional appliances.

The mandibular arch form showed the greatest increases in the measured distances in the cases treated with the Damon self-ligating appliance when compared to the cases treated with conventional appliances with and without RME.

The Damon appliance caused greater protrusion of the maxillary incisors in relation to the conventional appliance with and without RME. In the mandibular incisors, the Damon appliance caused a greater protrusion and proclination only in relation to the conventional appliance.

REFERENCES

1. Harradine NW. Historical aspects and evolution of ligation an appliances. In: Self-ligation in orthodontics: an evidence-based approach to biomechanics and treatment 2009.

2. Harradine N. The History and Development of Self-Ligating Brackets. Seminars in orthodontics 2008;14:5-18.

3. Damon D. The rationale, evolution and clinical application of the self-ligating bracket. Clin Orthod Res 1998;1:52-61.

4. Kim TK, Kim KD, Baek SH. Comparison of frictional forces during the initial leveling stage in various combinations of self-ligating brackets and archwires with a custom-designed typodont system. Am J Orthod Dentofacial Orthop 2008;133:187 e 115-124.

5. Voudouris JC. Interactive edgewise mechanisms: form and function comparison with conventional edgewise brackets. Am J Orthod Dentofacial Orthop 1997;111:119-140.

6. Harradine NW. Self-ligating brackets: where are we now? J Orthod 2003;30:262-273.

7. Rinchuse DJ, Miles PG. Self-ligating brackets: present and future. Am J Orthod Dentofacial Orthop 2007;132:216-222.

8. Scott P, Sherriff M, DiBiase AT, Cobourne MT. Perception of discomfort during initial orthodontic tooth alignment usig a self-ligating or conventional bracket system: a randomized clinical trial. Eur J Orthod 2008;30:227-232.

9. Damon DH. Treatment of the face with biocompatible orthodontic. Orthodontics: Current principles and techniques. T. M Graber, R. L. Vanarsdall, Jr., K. W. Vig. Elsevier-Mosby; 2005.

10. Sandstrom R, Klappeer L, Papaconstantinou S. Expansion of the lower arch concurrent with rapid maxillary expansion. Am J Orthod Dentofacial Orthop 1988;94:296-302.

11. Damon DH. The Damon low-friction bracket: a biologically compatible straight-wire system. J Clin Orthod 1998;32:670-680.

12. Pandis N, Polychronopolou A, Eliades T. Active or passive self-ligatind brackets? A randomized controlled trial of comparative efficiency in resolving maxillary anterior crowding in adolescents. Am J Orthod Dentofacial Orthop 2010;137:12 e 11-16; discussion 12-13.

13. Vajaria R, BeGole E, Kusnoto B, Galang MT, Obrez A. Evaluation of incisor position and dental transverse dimensional changes using the Damon System. Angle Orthod 2011;81:647-652.

14. Lombardo L, Ficara P, Maltoni I, Moser L, Guarneri MP, Sicilani G. Comparison of the anterior limit of the dentition in patients treates with self-ligating straigth-wire, conventional straigth-wire and standard edgewise appliances. ISRN Dent 2012:748-758.

15. Weinberg M, Sadowsky C. Resolution of mandibular arch crowding in growing patients with Class I malocclusions treated nonextraction. Am J Orthod Dentofacial Orthop 1996;110:359-364.

16. Fleming PS, DiBiase AT, Sarri G, Lee RT. Comparison of mandibular arch changes during alignment and leveling with 2 preadjusted edgewise appliances. Am J Orthod Dentofacial Orthop 2009;136:340-347.

17. Ong E, Ho C, Miles P. Alignment efficiency and discomfort of three orthodontic archwire sequences: a randomizes clinical trial. J Orthod 2010;38:32-39.

18. Pandis N, Polychronopoulou A, Makou M, Eliades T. Mandibular dental arch changes associated with treatment of crowding using self-ligating and conventional brackets. Eur J Orthod 2010;32:248-253.

19. Cattaneo PM, Treccani M, Carlsson K, Thorgeirsson T, Myrda A, Cevidanes LH et al. Transversal maxillary dento-alveolar changes in patients treates with active and passive self-ligating brackets: a randomized clinical trial using CBCT-scans and digital models. Orthod Craniofac Res 2011;14:222-233

20. Ballanti F, Lione R, Fanucci E, Franchi L, Baccetti T, Cozza P. Immediate and post-retention effects of rapid maxilarry expasion investigated by computed tomography in growing patients. Angle Orthod 2009;79:24-29.

21. Garib DG, Henriques JF, Janson G, Freitas MR, Fernandes AY. Periodontal effects of rapid maxillary expansion with tooth-tissue-borne expanders: a computed tomography evaluation. Am J Orthod Dentofacial Orthop 2006;129:749-758.

22. Rungcharassaeng K, Caruso JM, Kan JYK, Taylor G. Factors affecting bucal bone changes of maxillary posterior teeth after rapid maxillary expansion. Am J Orthod Dentofacial Orthop 2007;132:428. e421. e428.

23. Corbridge JK, Campbell PM, Taylor R, Ceen RF, Buschang PH. Transverse dentoalveolar changes after show maxillary expansion. Am J Orthod Dentofacial Orthop 2011;140:317-325.

24. Little R. The Irregularity index: a quatitative score of mandibular anterior alignment. Am J Orthod 1975;5:554-563.

25. Moorrees C, Gron A, Lebret L, Yen P, Frohlicj F. Growth studies of the dentition: A review. Am J Orthod Dentofacial Orthop 1969;44:129-141.

26. Araújo A, Buschang P. Transversal growth and development of the jaws - news opportunities for mandibular expansion. Revista Dental Press Ortodontia e Ortopedia Facial 2004;9:122-136.

27. Pandis N, Polychronopolou A, Eliades T. Self-ligating vs conventional brackets in treatment of madibular crowding: a prospective clinical trial of treatment duration and dental effects. Am J Orthod Dentofacial Orthop 2007;132:208-215.

28. Damon D. Damon system: the workbook 2004.

29. Lenza M. Braquetes autoligáveis - futuro da Ortodontia? R Dental Press Ortodon Ortop Facial 2008;13:3.

30. Kim E, Gianelly AA. Extraction vs nonextraction: arch widths and smile esthetics. Angle Orthod 2003;73:354-358.

31. Isik F, Sayinsu K, Nalbantgil D, Arun T. A comparative study of dental arch widths: extraction and non-extraction treatment. Eur J Orthod 2005;27:585-589.

32. Germec-Cakan D, Tander TU, Akan S. Arch-width and perimeter changes in patients with borderline Class I malocclusion treated with extractions or without extractions with air-rotor stripping. Am J Orthod Dentofacial Orthop 2010;137:734 e 731-737 discussion -735.

33. Leifert MF, Leifert MM, Efstratiadis SS, Cangialosi TJ. Comparison of Space analysis evaluations with dental models and plaster dental casts. Am J Orthod Dentofacial Orthop 2009;136:16 e 11-14; discussion.

34. Mangiacapra R, Butti AC, Salvato A, Biagi R. Tradicional plaster casts and dental digital models: intra-examiner reability of measurements. Prog Orthod 2009;10:48-53.

35. Sousa MV, Vasconcelos EC, Janson G, Garib D, Pinzan A. Accuracy and reproducibility of 3-dimensional digital model measurements. Am J Orthod Dentofacial Orthop 2012;142:269-273.

36. Mullen SR, Martin CA, Ngan P, Gladwin M. Accuracy of space analysis with emodels and palster models. Am J Orthod Dentofacial Orthop 2007;132:346-352.

37. Braumann B, al e. Three-dimensional analysis of morphological changes in the maxilla of patients with cleft lip and palate. Cleft Palate Craniofac J 2002;39:1-11.

38. Kusnoto B, Evans C. Reability of a 3D surface laser scanner for orthodontic applications. Am J Orthod Dentofacial Orthop 2002;122:342-388.

39. Costalos P, Sarraf K, Cangialosi T, Efstratiadis S. Evaluation of the accuracy of digital model analysis for the American Board of Orthodontics objective grading system for dental casts. Am J Orthod Dentofacial Orthop 2005;128:624-629.

40. Abizadeh N, Moles D, O'Neill J, Noar J. Digital versus plaster study models: How acurate and reproducible are they? J Orthod 2012;39:151-159.

41. Miyake H, Ryu T, Himuro T. Effects on the dental arch form using a preajusted appliance with premolar extraction in Class I crowding. Angle Orthod 2008;78:1043-1049.

42. Erdinc AE, Nanda RS, Isiksal E. Relapse of anterior crowdinf in patients treated with extraction and nonextraction of premolars. Am J Orthod Dentofacial Orthop 2006;129:775-784.

43. Canuto LF, Freitas MRd, Janson G, Freitas KMd, Martins PP. Influence of rapid palatal expansion on maxillary incisor alignment stability. Am J Orthod Dentofacial Orthop 2010;137:164 e 161-166; discussion -165.

44. Akyalcin S, Erdinc AE, Dincer B, Nanda RS. Do long-term changes in relative maxillary arch width affect buccal-corridor ratios in extraction and nonextraction treatment? Am J Orthod Dentofacial Orthop 2011;139:356-361.

45. Wahab RM, Idris H, Yacob H, Ariffin SH. Comparison of self- and conventional-ligating brackets in the alignment stage. Eur J Orthod 2012;34:176-181.

46. Tsorovas G, Karsten AL. A comparison of hand-tracing and cephalometric analysis computer programs with and without advanced features--accuracy and time demands. Eur J Orthod 2010;32:721-728.

47. Jackson Ph, Dickson Gc, Birnie Dj. Digital image processing of cephalometric radiographs: a preliminary report. British Journal of Orthodontics. Oxford 1985;12:122-132.

48. Sayinsu K, Isik F, Trakyali G, Arun T. An evaluation of the errors in cephalometric measurements on scanned cephalometric images and conventional tracings. Eur J Orthod 2007;29:105-108.

49. Sandler Pj. Reproducibility Of Cephalometric Measurements. Br J Orthod 1988;15:105-110.

50. Power G. Et Al. Dolphin Imaging Software: An Analysis Of The Accuracy Of Cephalometric Digitization And Orthognathic Prediction. Int. J. Oral Maxillofac. Surg. 2005;34:619-626.

51. Houston WJ. The analysis of errors in orthodontic measurements. Am J Orthod 1983;83:382-390.

52. Fleming PS, DiBiase AT, Sarri G, Lee RT. Pain experience during initial alignment with a self-ligating and a conventional fixed orthodontic appliance system. A randomized controlled clinical trial. Angle Orthod 2009;79:46-50.

53. Scott P, DiBiase AT, Shrerriff M, Cobourne MT. Alignment efficiency of Damon3 self-ligating and conventional orthodontic bracket systems: a randomized clinical trial. Am J Orthod Dentofacial Orthop 2008;134:470 e 471-478.

54. Maltagliati L, Myahira Y, Fatorri L, Filho LC, Cardoso M. Transversal changes in dental arches from non-extraction treatment with self ligating brackets. Dental Press J Orthod 2013;18:39-45.

55. Chen SS, -H, al e, al e. Systematic review of self-ligating brackets. American Journal of Orthodontics and Dentofacial Orthopedics. Am J Orthod Dentofacial Orthop 2010;137:726 e 721-726 e 718.

Figure legends:

Fig. 1 – A and B Maxillary and Mandibular measurements of the transverse widths; **C and D** Maxillary and mandibular measurements of anteroposterior distances.

Fig. 2 - Degree of crowding measured by the Little's Irregularity Index.

Fig. 1

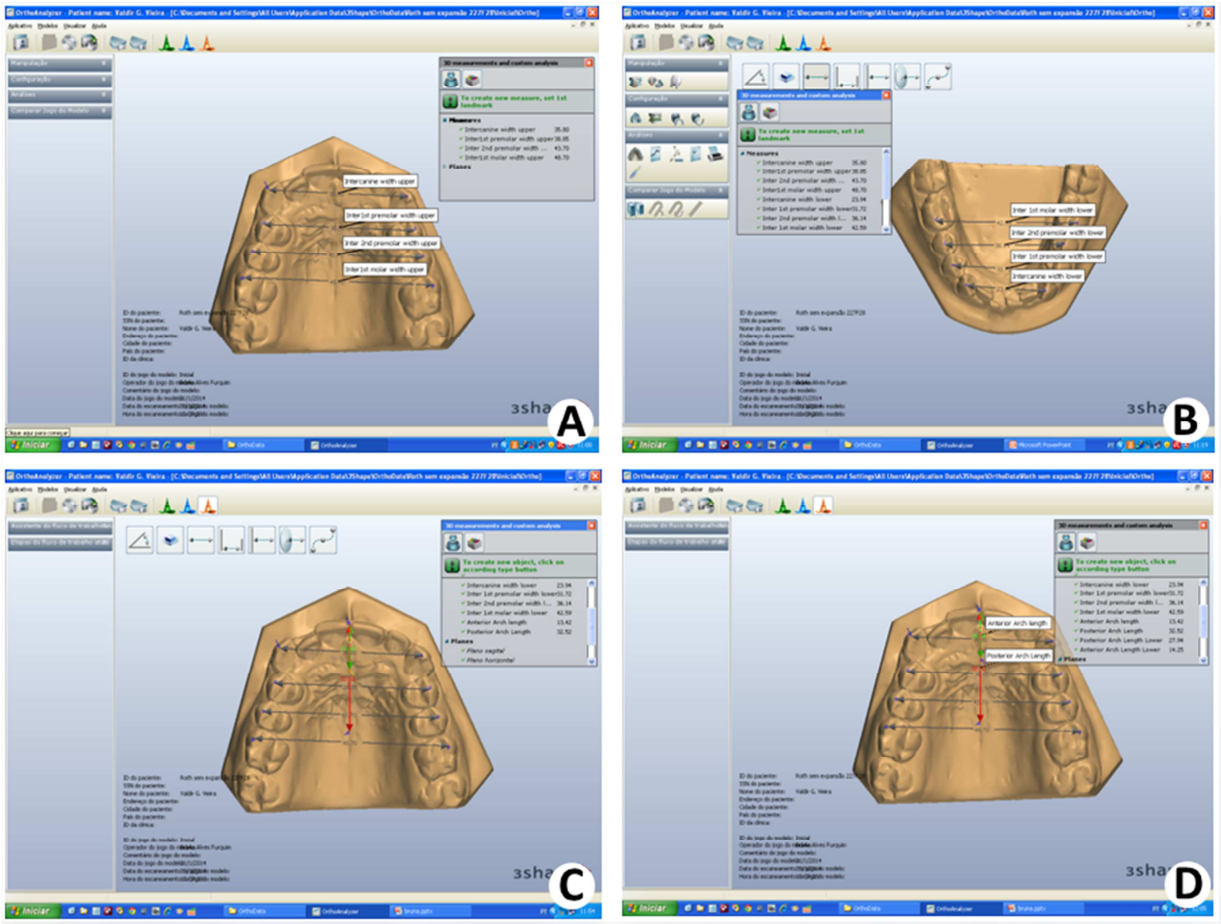

Fig. 2

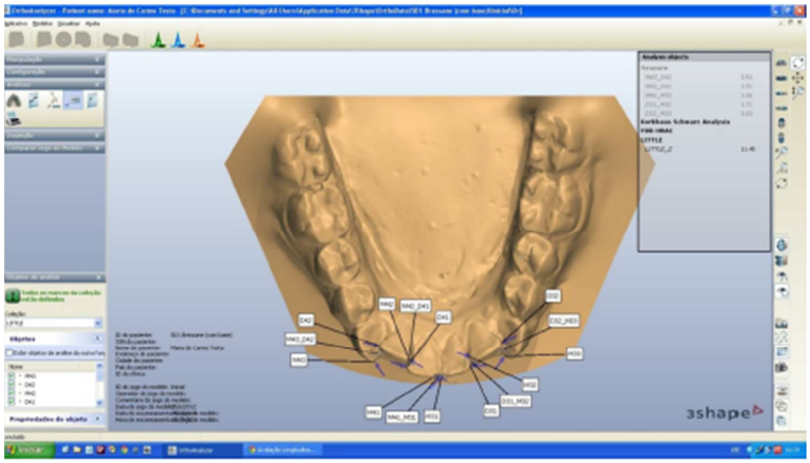

Table 1. Results of the casual and systematic errors (Dahlberg's formula and dependent t tests, respectively)(n=30).

Variables	1st Measurement		2nd Measurement		Dahlberg	P
	Mean	S.D.	Mean	S.D.		
Maxillary dental casts variables						
Mx IIL (mm)	13.58	4.59	14.33	5.06	1.08	0.055
Mx IC (mm)	35.55	1.99	35.38	2.08	0.39	0.105
Mx I1P (mm)	42.62	3.16	42.73	3.21	0.41	0.301
Mx I2P (mm)	48.06	3.11	48.07	3.03	0.34	0.929
Mx IM (mm)	52.22	3.06	52.32	3.19	0.39	0.345
Mx AAL (mm)	16.39	2.66	16.55	2.87	1.06	0.580
Mx PAL (mm)	33.17	3.04	33.21	3.17	1.14	0.879
Mandibular dental casts variables						
Md IIL (mm)	8.60	3.94	8.61	4.03	0.71	0.967
Md IC (mm)	27.27	1.99	27.31	1.86	0.34	0.611
Md I1P (mm)	35.48	2.89	35.71	2.81	0.43	**0.047***
Md I2P (mm)	41.26	3.16	41.41	3.11	0.37	0.120
Md IM (mm)	46.17	3.49	46.07	3.59	0.49	0.443
Md AAL (mm)	13.87	2.68	13.90	2.78	0.60	0.884
Md PAL (mm)	28.96	2.16	28.86	2.55	0.66	0.581
Cephalometric variables						
1-NA (mm)	6.21	1.71	6.52	1.66	0.54	**0.020***
1.NA (º)	28.70	4.05	29.59	3.81	0.97	**0.000***
1-NB (mm)	7..68	2.54	7.65	2.48	0.22	0.695
1.NB (º)	32.49	5.38	32.96	5.28	1.19	0.136

* Statistically significant for P<0.05.

Table 2. Intergroup comparison of sex distribution (chi-square test).

Sex / Group	Females	Males	Total
Group 1 – Damon	12	11	23
Group 2 - Conventional + RME	14	10	24
Group 3 – Conventional	21	7	28
Total	47	28	75
X^2 =3.09	**DF= 2**		**P=0.212**

Table 3. Intergroup comparison of the initial and final ages, treatment time and Little irregularity index at pretreatment stage (one-way ANOVA).

Variables	Group 1 Damon N=23	Group 2 Conventional + RME N=24	Group 3 Conventional N=28	P
	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	
Initial age (years)	14.65 (1.34)	13.85 (1.83)	13.94 (2.87)	0.388
Final age (years)	17.37 (1.18)	16.02 (1.80)	16.15 (3.02)	0.073
Treatment time (years)	2.72 (0.81)	2.17 (0.52)	2.20 (1.10)	0.053
Mx LII (mm)	12.52 (3.86)	12.23 (4.15)	10.83 (4.69)	0.319
Md LII (mm)	9.22 (2.85)	7.46 (2.16)	8.06 (2.35)	0.051

Table 4. Intergroup comparison at pretreatment stage (T1)(one-way ANOVA and Tukey tests).

Variables	Group 1 Damon N=23	Group 2 Conventional + RME N=24	Group 3 Conventional N=28	P
	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	
Maxillary dental casts variables				
Mx IC (mm)	35.07 (2.61)	34.23 (2.63)	35.07 (3.72)	0.546
Mx I1P (mm)	40.20 (2.64)	40.69 (2.22)	41.30 (2.80)	0.331
Mx I2P (mm)	45.88 (3.44)	45.56 (2.30)	46.38 (3.38)	0.628
Mx IM (mm)	50.37 (3.79)	50.47 (2.69)	51.37 (3.13)	0.473
Mx AAL (mm)	13.70 (2.02) ^{A}	17.21 (3.05) ^{B}	16.61 (3.38) ^{B}	**0.000***
Mx PAL (mm)	30.50 (2.95)	32.50 (2.88)	30.98 (3.32)	0.072
Mandibular dental casts variables				
Md IC (mm)	26.50 (2.28)	26.79 (2.75)	26.45 (2.24)	0.865
Md I1P (mm)	33.20 (2.98)	34.47 (2.14)	33.94 (2.18)	0.213
Md I2P (mm)	38.81 (3.06)	39.89 (2.60)	39.05 (2.78)	0.389
Md IM (mm)	43.90 (3.32)	45.68 (3.24)	44.19 (2.87)	0.116
Md AAL (mm)	12.37 (2.73)	13.42 (2.36)	12.97 (2.68)	0.392
Md PAL (mm)	26.76 (2.51) ^{A}	29.14 (1.71) ^{B}	27.05 (3.13) ^{A}	**0.003***
Cephalometric variables				
1-NA (mm)	5.16 (1.50) ^{A}	6.49 (2.18) ^{B}	5.07 (2.15) ^{A}	**0.024***
1.NA (º)	27.65 (4.50)	30.83 (5.99)	26.87 (7.06)	0.055
1-NB (mm)	5.67 (2.38)	5.52 (2.00)	5.77 (2.42)	0.924
1.NB (º)	27.61 (4.85)	26.51 (7.78)	30.04 (7.24)	0.169

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

Variables	Group 1 Damon N=23	Group 2 Conventional + RME N=24	Group 3 Conventional N=28	P
	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	
Maxillary dental casts variables				
Mx IC (mm)	1.95 (2.17) ^{A}	1.38 (1.92) ^{A}	-0.05 (2.84) ^{B}	**0.011***
Mx I1P (mm)	4.65 (1.64) ^{A}	3.37 (1.90) ^{B}	2.09 (1.74) ^{C}	**0.000***
Mx I2P (mm)	4.19 (2.59) ^{A}	3.89 (2.00) ^{A}	1.51 (1.75) ^{B}	**0.000***
Mx IM (mm)	3.41 (1.21) ^{A}	2.69 (2.58) ^{A}	0.20 (1.58) ^{B}	**0.000***
Mx AAL (mm)	2.30 (2.17) ^{A}	-0.28 (2.73) ^{B}	-0.15 (3.24) ^{B}	**0.003***
Mx PAL (mm)	1.86 (3.44)	-0.01 (3.57)	0.41 (2.25)	0.105
Mandibular dental casts variables				
Md IC (mm)	1.57 (2.00) ^{A}	0.12 (2.02) ^{B}	0.44 (1.36) ^{B}	**0.020***
Md I1P (mm)	3.59 (1.82) ^{A}	1.60 (1.92) ^{B}	1.56 (1.82) ^{B}	**0.000***
Md I2P (mm)	3.69 (1.83) ^{A}	2.12 (2.22) ^{B}	1.67 (1.78) ^{B}	**0.001***
Md IM (mm)	2.67 (1.43) ^{A}	0.66 (2.21) ^{B}	0.26 (1.27) ^{B}	**0.000***
Md AAL (mm)	2.05 (3.76)	1.28 (3.41)	1.01 (1.90)	0.479
Md PAL (mm)	0.36 (5.20)	-0.14 (2.88)	1.25 (2.10)	0.353
Cephalometric variables				
1-NA (mm)	1.63 (1.55) ^{A}	-0.38 (2.33) ^{B}	0.33 (1.57) ^{B}	**0.001***
1.NA (º)	1.90 (2.52)	-1.42 (6.47)	0.79 (5.46)	0.131
1-NB (mm)	2.60 (1.22) ^{A}	1.47 (1.16) ^{AB}	1.11 (0.75) ^{B}	**0.000***
1.NB (º)	7.74 (3.82) ^{A}	4.57 (8.01) ^{AB}	2.60 (3.88) ^{B}	**0.006***

* 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 6. Intergroup comparison of the posttreatment stage (T2)(one-way ANOVA and Tukey tests).

Variables	Group 1 Damon N=23	Group 2 Conventional + RME N=24	Group 3 Conventional N=28	P
	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	
Maxillary dental casts variables				
Mx IC (mm)	37.02 (2.00) ^{A}	35.61 (2.04) ^{B}	35.02 (1.90) ^{B}	**0.002***
Mx I1P (mm)	44.86 (3.32)	44.07 (1.97)	43.39 (2.19)	0.064
Mx I2P (mm)	50.08 (3.40) ^{A}	49.46 (1.92) ^{AB}	47.90 (2.73) ^{B}	**0.017***
Mx IM (mm)	53.78 (3.32) ^{A}	53.16 (2.40) ^{AB}	51.57 (2.82) ^{B}	**0.021***
Mx AAL (mm)	16.01 (1.41)	16.92 (2.15)	16.45 (2.47)	0.341
Mx PAL (mm)	32.36 (2.56)	32.49 (2.71)	31.39 (3.47)	0.352
Mandibular dental casts variables				
Md IC (mm)	28.08 (1.75) ^{A}	26.91 (1.72) ^{B}	26.90 (1.91) ^{B}	**0.044***
Md I1P (mm)	36.80 (1.88)	36.07 (1.86)	35.55 (1.82)	0.067
Md I2P (mm)	42.50 (2.41) ^{A}	42.01 (2.09) ^{A}	40.72 (2.21) ^{B}	**0.017***
Md IM (mm)	46.58 (3.06) ^{A}	46.35 (2.56) ^{A}	44.45 (2.40) ^{B}	**0.009***
Md AAL (mm)	14.42 (2.22)	14.71 (3.48)	13.98 (2.29)	0.623
Md PAL (mm)	27.12 (4.50)	29.00 (3.00)	28.31 (2.95)	0.191
Cephalometric variables				
1-NA (mm)	6.79 (1.65) ^{A}	6.11 (2.20) ^{AB}	5.40 (1.95) ^{B}	**0.049***
1.NA (º)	29.55 (4.62)	29.40 (7.15)	27.66 (5.55)	0.444
1-NB (mm)	8.27 (1.99) ^{A}	7.00 (1.62) ^{B}	6.89 (2.38) ^{B}	**0.039***
1.NB (º)	35.36 (3.55) ^{A}	31.09 (5.03) ^{B}	32.65 (6.52) ^{B}	**0.023***

* 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 SAMPLE USED

Seventy-five cases divided into three groups comprised the sample for this study, reliable number, since the sample size calculation was performed determining that it would take at least 23 cases for each group to detect a 1.39 mm increase in lateral distance of the maxillary second premolars. The calculation was performed with a 5% significance power.

The sample consisted of dental casts and initial and final lateral cephalograms obtained from subjects treated with the use of self-ligating 3MX™ 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 2), initial and final ages, and treatment time (Table 3).

Some authors have observed, in another study, some changes in the dental arch length with increasing age (MOORREES et al., 1969; ARAÚJO; BUSCHANG, 2004). Thus, it is very important that the three groups have compatible ages so there is no difference in the arch due to age. Therefore, if there is any change in the arch, it will be due to the treatment and not because of age.

There was also compatibility of the groups as to the Little's Irregularity Index in the maxillary and mandibular arches (Table 3). This compatibility is important because the more the crowding, the greater the trend in the increase of the transverse dimensions of the dental arches. Some authors state that the elimination of crowding in treatments without extraction is significantly related to an increased arch perimeter, protrusion of the incisors and increased intermolar and inter-premolar

transverse distances (WEINBERG; SADOWSKY, 1996). Other authors who used the Damon appliance in their studies also state that usually cases with crowding treated without extractions result in an increase in transverse distances and lengths of the maxillary and mandibular dental arches (PANDIS; POLYCHRONOPOLOU; ELIADES, 2007; PANDIS et al., 2010; VAJARIA et al., 2011). 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.

Currently, 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 (DAMON, 2004). 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 (LENZA, 2008).

Prior to orthodontic treatment, both the Damon group and the RME and conventional groups had similar forms of the maxillary arch, with only the length of the anterior arch displayed less significant difference in the Damon group than in the other two groups. In the mandibular models, only cases RME group had, the length of increased posterior arch. Prior to treatment, the maxillary incisors were more protruded in the RME group than in the other groups (Table 4). The compatibility among the groups is important at the beginning of the treatment as well, because if the arch form is compatible, the results will be exclusively by changes due to treatment and not some pre-existing arch form.

Thus, a major concern in the conduct of this study was to obtain compatible groups, which make feasible a correct comparison and thus favoring the interpretation and reliability of results.

METHODOLOGY

The Damon system creator mentions that the use of self-ligating brackets liabilities associated with superelastic wires, provides a transversal development of the dental arches, with a smaller protrusion or proclination of the incisors because the low forces generated are not able to overlap the perioral muscle strength. This transversal development, with a smaller anterior positioning of the incisors, result in

less need for dental extractions or procedures as RME or surgically assisted RME. This increase in the width of the dental arches was measured using as reference cusp tips, because it is a precise methodology and widely used in the literature (KIM; GIANELLY, 2003; ISIK et al., 2005; GERMEC-CAKAN; TANDER; AKAN, 2010).

Digital models were used to perform the transversal and anteroposterior measurements instead of using plaster models through OrthoAnalyzer Software - 3Shape. Digital models reduce or solve many problems and difficulties associated with storage, retrieval, reproduction, communication and risk of damage to models (LEIFERT et al., 2009). Traditional and digital models offer the same intra-examiner reproducibility in most cases, and for some measures, when transversal sections may help, digital models seem to reproduce an even smaller error (MANGIACAPRA et al., 2009), 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 (SOUSA et al., 2012).

The measurements are performed more quickly in digital images when compared to those performed with a digital caliper in dental casts, and demonstrated that the Bolton analysis in the digital model is accurate and can be performed 65 seconds faster than in the plaster models (MULLEN et al., 2007). According to several authors, the use of digital models for quantitative analysis was validated after evidence of high accuracy and reproducibility of measurements (BRAUMANN; AL, 2002; KUSNOTO; EVANS, 2002; COSTALOS et al., 2005; LEIFERT et al., 2009; ABIZADEH et al., 2012; SOUSA et al., 2012). The lengths of the arches were also checked to quantify the anterior movement of the incisors at the end of treatment, in order to confirm or not the theory of action of perioral muscles in containing the incisors (DAMON, 1998). Measurements of the lengths of anterior and posterior arches were taken in the maxillary and mandibular dental arches in order to evaluate the behavior of these variables in the anterior and posterior segments separately (MIYAKE; RYU; HIMURO, 2008; VAJARIA et al., 2011).

The 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 (LITTLE, 1975). The Little irregularity index was adapted to the maxillary dental arch, as this

methodology is used with good acceptability by other authors (ERDINC; NANDA; ISIKSAL, 2006; CANUTO et al., 2010; AKYALCIN et al., 2011; WAHAB et al., 2012).

The use of software for cephalometric analysis has become increasingly popular. When compared to manual technique, the digital cephalometric measurement offers a number of advantages: cephalometric measurements are performed in a shorter period of time (TSOROVAS; KARSTEN, 2010); the image can be enlarged and manipulated without quality loss (JACKSON; DICKSON; BIRNIE, 1985; SAYINSU et al., 2007); the angles and distances are calculated automatically, eliminating the possibility of error during manual measurement and data transfer to the computer (SANDLER, 1988). Conventional radiographs were obtained for the initial and final documentation and were used to check the change in position of the incisors at the end of treatment. The software used in this study was the Dolphin Imaging software (version 11.5), which is widely used and has high reproducibility, accuracy and precision in the cephalometric measurements used (SANDLER, 1988; POWER, 2005).

ERROR OF THE METHOD

In order to verify the intraexaminer error, 30 pairs of models and 30 lateral cephalograms were chosen randomly.

The calculation of errors in methodology enables the interpretation of data obtained based on the limitations found, considering the most reliable results. In this study, the measurements of the models and the cephalometric points were performed by a single examiner to ensure greater reliability. The systematic error arises when, over time, the examiner changes the measurement technique unconsciously. For the evaluation of this error, the paired t-test was applied. Among the eighteen variables analyzed, only three showed systematic error (Md I1P, 1-NA and 1.NA), with small differences between measurements, 35.48 mm and 35.71 mm, 6.21 mm and 6.52 and 28.70 degrees and 29.59 degrees, respectively, which does not interfere in the final results and conclusions of this study. The formula proposed by Dahlberg[27] was applied to estimate the magnitude of random errors. The random error ranged from 0.22 mm in the variable 1-NB to 1.19 in the variable 1.NB (Table 1). The largest source of random errors, according to Houston(HOUSTON, 1983), arises from the difficulty of identifying a particular point or the inaccuracy in the

definition of certain points. The greater significance of random errors refers to its power to increase the standard deviation of the mean measurements obtained. Because the errors are quite small, it is concluded that the standard deviations found are due to the variability of groups.

RESULTS

Maxillary Arch Form

The orthodontic treatment with the Damon appliance promoted a greater increase in the maxillary intercanine distance when compared to patients treated with RME and conventional appliance (Table 5).

A larger increase of this distance was already expected in the Damon group compared with the conventional group, without RME, as it had been shown in previous studies (SCOTT et al., 2008; FLEMING et al., 2009b; VAJARIA et al., 2011). Now, Ong (ONG; HO; MILES, 2010) found a different result when comparing the intercanine width of cases treated with the Damon system and the conventional one, showing a reduction of this distance; however, his treatment was performed with premolar extractions.

With respect to the group treated with RME, there are no studies comparing the arch form of cases treated with self-ligating and RME. Thus, the present results are unprecedented, making it difficult to compare to other studies. In the literature, there are only studies comparing patients treated with RME and cases treated with fixed conventional appliances, which showed that RME caused a greater increase in the intercanine width with treatment (CANUTO et al., 2010). Maltalgliati et al. (MALTAGLIATI et al., 2013) concluded in their study that there was a greater increase in this distance with treatment using Damon appliance, but not as much as in the inter-premolar widths.

With treatment, the maxillary inter-first-premolar width showed a greater increase in the Damon group, followed by RME group and the conventional group, with significant differences among the three groups (Table 5). And the inter-second-premolar width in the maxillary arch showed a greater increase in the Damon group than in the other two groups (Table 5).

Vajaria et al. (VAJARIA et al., 2011) found increased inter-premolar width in both cases, those treated with Damon appliance and those treated with conventional appliance. Canuto et al. (CANUTO et al., 2010) also found a significant increase of inter-first-premolar width in both groups, the RME and the conventional. As for the inter-second-premolar width, Canuto et al. (CANUTO et al., 2010) found a greater increase in the cases treated with RME than in those treated with conventional appliances. Maltalgliati et al., (MALTAGLIATI et al., 2013) in a study comparing cases treated with the Damon appliance, found a greater increase of this distance with treatment.

The Damon appliance promoted a greater increase of the maxillary intermolar width as compared with the cases treated with RME and the conventional appliances (Table 5).

For intermolar width, the results are similar to other studies that also found a greater increase of this distance in cases treated with Damon appliance when compared to patients treated with conventional appliances (PANDIS; POLYCHRONOPOLOU; ELIADES, 2007; SCOTT et al., 2008; PANDIS et al., 2010; VAJARIA et al., 2011). Unlike this, a reduction of this distance was found in the study by Ong (ONG; HO; MILES, 2010), but this was when evaluating patients treated with premolar extractions. Canuto et al. (CANUTO et al., 2010) found a greater increase for intermolar width in the group treated with RME. Maltalgliati et al., (MALTAGLIATI et al., 2013) in their study, found a greater increase in this distance at the end of the treatment of cases treated with Damon appliance.

Thus, when comparing the results of this study, the Damon self-ligating appliance is closer to the results of cases treated with RME, showing a significant transverse expansion of the maxillary arch.

With treatment, the cases treated with Damon appliance had a greater increase in the maxillary anterior arch length, while the cases treated with conventional appliances with and without RME showed a slight decrease (Table 5).

Similar to our study, Ong (ONG; HO; MILES, 2010) also found a greater increase of the arch length in cases treated with Damon appliance compared to treatment with conventional appliance, even with premolar extraction and the study of Canuto et al., (CANUTO et al., 2010) found a greater increase of the arch length in cases treated with RME compared to patients treated with conventional appliance. This was probably the fact that despite not having significant difference, the Damon

group had earlier increased crowding. However, the increase of the arch length should be observed with caution, since it may indicate an increase of the occurrence of a protrusion of the incisors, and not a lateral transversal expansion of the arch.

At the end of orthodontic treatment it was observed that the maxillary intercanine width of the cases treated with Damon appliance was greater when compared to the cases treated with conventional appliances with and without RME (Table 6). Now, the inter-second-premolar and intermolar widths were greater only in the cases treated with the Damon appliance when compared to patients treated with conventional appliances (Table 6). These greater distances in the Damon group were already expected, as they are due to the greater increase obtained from treatment in this group.

Mandibular Arch Form

Orthodontic treatment with Damon appliance promoted a greater increase in the mandibular intercanine width when compared with the cases treated with conventional appliance and RME (Table 5).

Other studies comparing the Damon system to the conventional one also found a greater increase in mandibular intercanine width in the group treated with self-ligating appliances (PANDIS; POLYCHRONOPOLOU; ELIADES, 2007; SCOTT et al., 2008; VAJARIA et al., 2011). Ong (ONG; HO; MILES, 2010) found a decrease of this distance in cases treated with self-ligating appliances, but their study involved the extraction of premolars.

Regarding the inter-first-premolar and inter-second-premolar widths, orthodontic treatment with the Damon appliance generated a greater increase of these distances compared to patients treated with RME and conventional appliances (Table 5).

Vajaria et al. (VAJARIA et al., 2011) also found a greater increase of this distance in the Damon group compared to the conventional one. In other studies, a greater increase in the inter-second-premolar width was found both in the Damon group and in the conventional group (FLEMING et al., 2009b; VAJARIA et al., 2011). Maltalgliati et al. (MALTAGLIATI et al., 2013) concluded that there was a further increase of this distance with treatment using the Damon appliance, but slightly less than in the maxillary arch.

Regarding the intermolar width, the cases treated with Damon appliance showed a greater increase in these distances compared to patients treated with RME and conventional appliance (Table 5).

Several studies have also shown a greater increase in cases treated with Damon appliance compared to patients treated with conventional appliance (PANDIS; POLYCHRONOPOLOU; ELIADES, 2007; FLEMING et al., 2009b; VAJARIA et al., 2011). However, Scott et al. (SCOTT et al., 2008) found a small decrease of this distance in the group treated with Damon appliance and a small increase in the group treated with conventional appliance, but the patients in their study showed to have extractions. Maltalgliati et al., (MALTAGLIATI et al., 2013) in the study comparing cases treated with Damon appliance, found a greater increase of this distance with treatment.

There were no significant changes of the mandibular arch length with treatment (Table 5).

At the end of orthodontic treatment, the cases treated with Damon appliance showed greater intercanine width in the mandibular arch in relation to the other 2 groups. Inter-second-premolar and intermolar widths were also greater in the Damon group, but the cases treated with RME also showed this increase, with a significant difference with respect to cases treated with conventional appliances (Table 6).

Most of the differences found between the Damon and the conventional appliances without RME were given mainly by the way of diagramming the arches. The Damon appliance protocol uses wires and diagrams that allow and aimed at the expansion of both the maxillary and mandibular arches. In the conventional appliance protocol diagrams are chosen from the pretreatment mandibular model of the patient, without expanding so much the arch, unlike the objective of the Damon philosophy.

Incisors inclination

The orthodontic treatment with the Damon appliance promoted greater protrusion of the maxillary incisors than the other two groups and greater protrusion and proclination of the mandibular incisors only in relation to the conventional appliance group (Table 5).

Corroborating this study, other studies comparing the Damon system and the conventional one also found a greater protrusion of the mandibular incisors in cases

treated with the Damon appliance (PANDIS; POLYCHRONOPOLOU; ELIADES, 2007; SCOTT et al., 2008; VAJARIA et al., 2011). Vajaria et al.,(VAJARIA et al., 2011) evaluating the self-ligating Damon appliance, found neither greater protrusion nor proclination of the maxillary incisors after treatment. Fleming et al., (FLEMING et al., 2009a) in their study comparing the self-ligating to the conventional appliances found a greater proclination of the incisors regardless of the appliance system used. According to Chen et al., (CHEN et al., 2010) in their systematic review, the proclination of the mandibular incisors with treatment with self-ligating appliances is 1.5° lower than with the use of conventional appliances.

It has been observed by Pandis et al. (PANDIS; POLYCHRONOPOLOU; ELIADES, 2007) that when Damon 2 brackets were used there was a mandibular incisor proclination of 7 to 8 degrees associated with alleviation of crowding. According to some authors, the proclination of the mandibular incisor and their advancement are common findings in studies that analyze crowding alleviation. Studies have consistently shown that mandibular incisor advancement along with the lateral expansion occur when crowding is alleviated during nonextraction treatment when no other appliances are used (headgear, distalizers, lip bumpers) (WEINBERG; SADOWSKY, 1996; PANDIS; POLYCHRONOPOLOU; ELIADES, 2007; FLEMING et al., 2009a).

After orthodontic treatment with the Damon system, it can be observed that the maxillary incisors were more protruded compared to cases treated with conventional appliance without RME. The mandibular incisors were more protruded and proclined for the cases treated with conventional appliance with and without rapid maxillary expansion (Table 6).

4 CONCLUSION

4 CONCLUSION

The intercanine, inter-second-premolar and intermolar widths showed greater increase in the Damon and RME groups when compared to the conventional group. The inter-first-premolar width showed greater increase in the Damon group, followed by the RME group and the conventional group, with significant differences among the 3 groups. The maxillary anterior arch length had an increase in the Damon group and showed a slight decrease in the RME and conventional groups.

In the mandibular arch, the intercanine, inter-first-premolar, inter-sencond-premolar and intermolar widths showed greater increase in the Damon group when compared to the other two groups.

There was greater protrusion of the maxillary incisors in the Damon group when compared to the conventional group with and without RME. In the mandibular incisors, the Damon appliance caused a greater protrusion and proclination only when compared to the conventional appliance.

REFERENCES

1. Ormco Corporation. Ormco

2. Ballanti F, Lione R, Fanucci E, Franchi L, Baccetti T, Cozza P. Immediate and post-retention effects of rapid maxilarry expasion investigated by computed tomography in growing patients. Angle Orthod. 2009 79(1):24-9.

3. Cattaneo PM, Treccani M, Carlsson K, Thorgeirsson T, Myrda A, Cevidanes LH, et al. Transversal maxillary dento-alveolar changes in patients treates with active and passive self-ligating brackets: a randomized clinical trial using CBCT-scans and digital models. Orthod Craniofac Res. 2011 14(4):222-33

4. Corbridge JK, Campbell PM, Taylor R, Ceen RF, Buschang PH. Transverse dentoalveolar changes after show maxillary expansion. Am J Orthod Dentofacial Orthop. 2011 140(3):317-25.

5. Damon D. The rationale, evolution and clinical application of the self-ligating bracket. Clin Orthod Res. 1998a 1(1):52-61.

6. Damon DH. The Damon low-friction bracket: a biologically compatible straight-wire system. J Clin Orthod. 1998b 32(11):670-80.

7. Damon DH. Treatment of the face with biocompatible orthodontic. Orthodontics: Current principles and techniques. T. M Graber, R. L. Vanarsdall, Jr., K. W. Vig. 4th Edition ed: Elsevier-Mosby; 2005.

8. Fleming PS, DiBiase AT, Sarri G, Lee RT. Comparison of mandibular arch changes during alignment and leveling with 2 preadjusted edgewise appliances. Am J Orthod Dentofacial Orthop. 2009 136(3):340-7.

9. Garib DG, Henriques JF, Janson G, Freitas MR, Fernandes AY. Periodontal effects of rapid maxillary expansion with tooth-tissue-borne expanders: a computed tomography evaluation. Am J Orthod Dentofacial Orthop. 2006 129(6):749-58.

10. Harradine NW. Self-ligating brackets: where are we now? J Orthod. 2003 30(3):262-73.

11. Harradine NW. Historical aspects and evolution of ligation an appliances. In: Self-ligation in orthodontics: an evidence-based approach to biomechanics and treatment. 2009

12. Kim TK, Kim KD, Baek SH. Comparison of frictional forces during the initial leveling stage in various combinations of self-ligating brackets and archwires with a custom-designed typodont system. Am J Orthod Dentofacial Orthop. 2008 133(2):187 e 15-24.

13. Lombardo L, Ficara P, Maltoni I, Moser L, Guarneri MP, Sicilani G. Comparison of the anterior limit of the dentition in patients treates with self-ligating straigth-wire, conventional straigth-wire and standard edgewise appliances. ISRN Dent. 2012 2012):748-58.

14. Ong E, Ho C, Miles P. Alignment efficiency and discomfort of three orthodontic archwire sequences: a randomizes clinical trial. J Orthod. 2010 38(1):32-9.

15. Pandis N, Polychronopolou A, Eliades T. Active or passive self-ligatind brackets? A randomizade controlled trial of comparative efficiency in resolving maxillary anterior crowding in adolescents. Am J Orthod Dentofacial Orthop. 2010 137(1):12 e 1-6; discussion -3.

16. Pandis N, Polychronopoulou A, Makou M, Eliades T. Mandibular dental arch changes associated with treatment of crowding using self-ligating and conventional brackets. Eur J Orthod. 2010 32(3):248-53.

17. Quaglio CL, al e. Classe II divisão 1 associada à deficiência transversal maxilar. Tratamento com disjuntor tipo Hyrax e aparelho de Herbst: relato de caso clínico. Revista Dental Press Ortodontia e Ortopedia Facial. 2009 14(5):

18. Rinchuse DJ, Miles PG. Self-ligating brackets: present and future. Am J Orthod Dentofacial Orthop. 2007 132(2):216-22.

19. Rungcharassaeng K, Caruso JM, Kan JYK, Taylor G. Factors affecting bucal bone changes of maxillary posterior teeth after rapid maxillary expansion. Am J Orthod Dentofacial Orthop. 2007 132(4):428. e1. e.

20. Scott P, DiBiase AT, Shrerriff M, Cobourne MT. Alignment efficiency of Damon3 self-ligating and conventional orthodontic bracket systems: a randomized clinical trial. Am J Orthod Dentofacial Orthop. 2008 134(4):470 e 1-8.

21. Vajaria R, BeGole E, Kusnoto B, Galang MT, Obrez A. Evaluation of incisor position and dental transverse dimensional changes using the Damon System. Angle Orthod. 2011 81(4):647-52.

22. Voudouris JC. Interactive edgewise mechanisms: form and function comparison with conventional edgewise brackets. Am J Orthod Dentofacial Orthop. 1997 111(2):119-40.

23. Weinberg M, Sadowsky C. Resolution of mandibular arch crowding in growing patients with Class I malocclusions treated nonextraction. Am J Orthod Dentofacial Orthop. 1996 110(4):359-64.

24. Zanelato RC. A individualização de torque para os caninos no aparelho pré-ajustado. R Clín Ortodon Dental Press. 2004 3(3):00-.

25. Abizadeh N, Moles D, O'Neill J, Noar J. Digital versus plaster study models: How acurate and reproducible are they? J Orthod. 2012 Sep;39(3):151-9.

26. Akyalcin S, Erdinc AE, Dincer B, Nanda RS. Do long-term changes in relative maxillary arch width affect buccal-corridor ratios in extraction and nonextraction treatment? Am J Orthod Dentofacial Orthop. 2011 Mar;139(3):356-61.

27. Araújo A, Buschang P. Transversal growth and development of the jaws - news opportunities for mandibular expansion. Revista Dental Press Ortodontia e Ortopedia Facial. 2004 May;9(3):122-36.

28. Braumann B, al e. Three-dimensional analysis of morphological changes in the maxilla of patients with cleft lip and palate. Cleft Palate Craniofac J. 2002 39(1):1-11.

29. Canuto LF, Freitas MRd, Janson G, Freitas KMd, Martins PP. Influence of rapid palatal expansion on maxillary incisor alignment stability. Am J Orthod Dentofacial Orthop. 2010 Feb;137(2):164 e 1-6; discussion -5.

30. Chen SS, -H, al e, al e. Systematic review of self-ligating brackets. American Journal of Orthodontics and Dentofacial Orthopedics. Am J Orthod Dentofacial Orthop. 2010 137(6):726 e 1- e 18.

31. Costalos P, Sarraf K, Cangialosi T, Efstratiadis S. Evaluation of the accuracy of digital model analysis for the American Board of Orthodontics objective grading system for dental casts. Am J Orthod Dentofacial Orthop. 2005 Nov;128(5):624-9.

32. Damon D. The rationale, evolution and clinical application of the self-ligating bracket. Clin Orthod Res. 1998 1(1):52-61.

33. Damon D. Damon system: the workbook. 2004

34. Erdinc AE, Nanda RS, Isiksal E. Relapse of anterior crowdinf in patients treated with extraction and nonextraction of premolars. Am J Orthod Dentofacial Orthop. 2006 Jun;129(6):775-84.

35. Fleming PS, DiBiase AT, Sarri G, Lee RT. Comparison of mandibular arch changes during alignment and leveling with 2 preadjusted edgewise appliances. Am J Orthod Dentofacial Orthop. 2009a 136(3):340-7.

36. Fleming PS, DiBiase AT, Sarri G, Lee RT. Pain experience during initial alignment with a self-ligating and a conventional fixed orthodontic appliance system. A randomized controlled clinical trial. Angle Orthod. 2009b 79(1):46-50.

37. Germec-Cakan D, Tander TU, Akan S. Arch-width and perimeter changes in patients with borderline Class I malocclusion treated with extractions or without extractions with air-rotor stripping. Am J Orthod Dentofacial Orthop. 2010 Jun;137(6):734 e 1-7 discussion -5.

38. Houston WJ. The analysis of errors in orthodontic measurements. Am J Orthod. 1983 83(5):382-90.

39. Isik F, Sayinsu K, Nalbantgil D, Arun T. A comparative study of dental arch widths: extraction and non-extraction treatment. Eur J Orthod. 2005 Dec;27(6):585-9.

40. Jackson Ph, Dickson Gc, Birnie Dj. Digital image processing of cephalometric radiographs: a preliminary report. British Journal of Orthodontics. Oxford. 1985 12(3):122-32.

41. Kim E, Gianelly AA. Extraction vs nonextraction: arch widths and smile esthetics. Angle Orthod. 2003 Aug;73(4):354-8.

42. Kusnoto B, Evans C. Reability of a 3D surface laser scanner for orthodontic applications. Am J Orthod Dentofacial Orthop. 2002 Oct;122(4):342-88.

43. Leifert MF, Leifert MM, Efstratiadis SS, Cangialosi TJ. Comparison of Space analysis evaluations with dental models and plaster dental casts. Am J Orthod Dentofacial Orthop. 2009 Jul;136(1):16 e 1-4; discussion.

44. Lenza M. Braquetes autoligáveis - futuro da Ortodontia? R Dental Press Ortodon Ortop Facial. 2008 13(6):3.

45. Little R. The Irregularity index: a quatitative score of mandibular anterior alignment. Am J Orthod. 1975 Nov;5(68):554-63.

46. Maltagliati L, Myahira Y, Fatorri L, Filho LC, Cardoso M. Transversal changes in dental arches from non-extraction treatment with self ligating brackets. Dental Press J Orthod. 2013 May-June;18(3):39-45.

47. Mangiacapra R, Butti AC, Salvato A, Biagi R. Tradicional plaster casts and dental digital models: intra-examiner reability of measurements. Prog Orthod. 2009 10(2):48-53.

48. Miyake H, Ryu T, Himuro T. Effects on the dental arch form using a preajusted appliance with premolar extraction in Class I crowding. Angle Orthod. 2008 Nov;78(6):1043-9.

49. Moorrees C, Gron A, Lebret L, Yen P, Frohlicj F. Growth studies of the dentition: A review. Am J Orthod Dentofacial Orthop. 1969 Chicago;44(129-41.

50. Mullen SR, Martin CA, Ngan P, Gladwin M. Accuracy of space analysis with emodels and palster models. Am J Orthod Dentofacial Orthop. 2007 Sep;132(3):346-52.

51. Ong E, Ho C, Miles P. Alignment efficiency and discomfort of three orthodontic archwire sequences: a randomizes clinical trial. J Orthod. 2010 38(1):32-9.

52. Pandis N, Polychronopolou A, Eliades T. Self-ligating vs conventional brackets in treatment of madibular crowding: a prospective clinical trial of treatment duration and dental effects. Am J Orthod Dentofacial Orthop. 2007 132(2):208-15.

53. Pandis N, Polychronopoulou A, Makou M, Eliades T. Mandibular dental arch changes associated with treatment of crowding using self-ligating and conventional brackets. Eur J Orthod. 2010 32(3):248-53.

54. Power G. Et Al. Dolphin Imaging Software: An Analysis Of The Accuracy Of Cephalometric Digitization And Orthognathic Prediction. Int J Oral Maxillofac Surg. 2005 34(6):619-26.

55. Sandler Pj. Reproducibility Of Cephalometric Measurements. Br J Orthod. 1988 15(2):105-10.

56. Sayinsu K, Isik F, Trakyali G, Arun T. An evaluation of the errors in cephalometric measurements on scanned cephalometric images and conventional tracings. Eur J Orthod. 2007 29(105-8.

57. Scott P, DiBiase AT, Shrerriff M, Cobourne MT. Alignment efficiency of Damon3 self-ligating and conventional orthodontic bracket systems: a randomized clinical trial. Am J Orthod Dentofacial Orthop. 2008 134(4):470 e 1-8.

58. Sousa MV, Vasconcelos EC, Janson G, Garib D, Pinzan A. Accuracy and reproducibility of 3-dimensional digital model measurements. Am J Orthod Dentofacial Orthop. 2012 Aug;142(2):269-73.

59. Tsorovas G, Karsten AL. A comparison of hand-tracing and cephalometric analysis computer programs with and without advanced features--accuracy and time demands. Eur J Orthod. 2010 Jun 16;32(6):721-8.

60. Vajaria R, BeGole E, Kusnoto B, Galang MT, Obrez A. Evaluation of incisor position and dental transverse dimensional changes using the Damon System. Angle Orthod. 2011 81(4):647-52.

61. Wahab RM, Idris H, Yacob H, Ariffin SH. Comparison of self- and conventional-ligating brackets in the alignment stage. Eur J Orthod. 2012 Apr;34(2):176-81.

62. Weinberg M, Sadowsky C. Resolution of mandibular arch crowding in growing patients with Class I malocclusions treated nonextraction. Am J Orthod Dentofacial Orthop. 1996 110(4):359-64.