RESEARCH ARTICLE

Comparison of Changes in Dental Arch Dimensions in Cases Treated with Conventional Appliances and Self-Ligating Damon System

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Abstract:

Proposition:

The objective of this study was to compare changes in maxillary and mandibular dental arch dimensions in cases treated nonextraction with conventional appliances and self-ligating Damon System.

Materials and Methods:

initial (T1) and final (T2) dental casts of 45 patients with Class I malocclusion treated nonextraction, with slight to moderate crowding, divided into two groups. Group 1: 21 patients treated with self-ligating Damon appliances, at a mean initial age of 18.37 years and mean treatment time of 2.11 years. Group 2: 24 patients treated with conventional appliances, at a mean initial age of 19.50 years and mean treatment time of 1.99 years. The model analysis was performed; Little irregularity index was used to evaluate crowding and arch form was evaluated by measurements in maxillary and mandibular arches including intercanine, interpremolar (first and second premolars) and intermolar distances and arch length. The intragroup comparison was performed with dependent t or Wilcoxon tests and intergroup comparison, with independent t or Mann Whitney tests.

Results:

In intergroup comparison of treatment changes (T2-T1) the Damon group presented an increase in maxillary transversal dimensions significantly greater than the conventional group. The change in maxillary arch length did not show difference between the groups. Regarding the mandibular arch, the Damon group presented a significantly greater increase in intercanine and inter first premolars than the conventional group. In The mandibular arch length, the greater and significant increase was observed in the groups of patients treated with conventional appliances.

Conclusions:

The treatment with the Damon appliances resulted in a significantly greater increase of maxillary arch dimensions when compared to conventional appliances. Mandibular intercanine and interpremolar distances also presented greater increase in Damon than conventional appliances. The increase in mandibular arch length was greater in conventional than in Damon group.

Keywords: Corrective orthodontics, Dental arch, Damon appliances, Mandibular intercanine, Orthodontic appliance design, Treatment outcomes.

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1. INTRODUCTION

The self-ligating appliances, introduced in the 1930s by Stolzenberg, are bracket systems that do not use ligatures, featuring a built-in mechanical device for closing the slot [1]. The primary advantage of self-ligating brackets is the possibility of generating less friction with the orthodontic wire during tooth movement, allowing orthodontic movements to be achieved with the application of lighter forces, causing less damage to adjacent tissues, besides the less time of chair released in the appointments. However, self-ligating bracket systems have some disadvantages, such as higher cost, possible breakage of the clip or the slide, more occlusal interferences and lip discomfort, and difficulty in finishing the cases [2].

In all types of treatment, the widths of the arches increase during alignment with or without extractions. The greater changes occur in the area of premolars, followed by the area of canines and, finally, in the region of molars [3].

The use of low-friction brackets such as the Damon System, associated with wires of lighter forces produces a greater expansion in the posterior region of the arch, with less alteration in the intercanine distance and position of the mandibular incisor than the conventional appliances [4, 5].

There are papers in the literature that evaluated the changes in the transversal measurements of the dental arches in the conventional appliances and the self-ligating system. Most showed that there was no statistically significant difference between the appliances, as both increased the transverse dimensions of the arches, with increased intercanine and intermolar distances, besides proclination and protrusion of the mandibular incisors in both systems, with the self-ligating appliances presenting greater changes in the intermolar distance [6, 7].

Due to the lack of studies comparing the changes with the conventional appliances and the self-ligating Damon System, this work intends to show changes in the dental arches after orthodontic treatment with the two mentioned techniques.

2. MATERIALS AND METHODS

2.1. Materials

This study was approved by the research ethics committee of the UNINGA University Center, Maringá, Brazil, and all patients signed informed consent.

The sample calculation was based on an alpha significance level of 5% (0.05) and a beta of 20% (0.2) to achieve 80% test power in order to detect a mean difference of 1.46mm with a standard deviation of 1.66 for the mandibular intercanine and intermolar distances [8], evidencing that 21 patients would be necessary for each group.

Initial and final dental casts were selected from 45 patients with previous orthodontic treatment performed at the Darwin Dentistry Institute, Cuiabá, Brasil. The sample was divided into 2 groups, 21 of which were treated with the self-ligating Damon System (Ormco) and 24 with conventional Straight-Wire (A Company) appliances. Individuals selected should have complete permanent denture to first molars, Class I malocclusion, slight to moderate crowding, and non-extraction in the treatment plan. Class II and III malocclusions and complex cases were excluded from the sample.

2.1.1. Group 1

21 patients of both genders (10 female and 11 male) with initial mean age 18.37 years (SD 6.99), final mean age of 20.48 years (SD 7.26) and treatment time of 2.11 years (SD 0.62) treated with the self-ligating Damon Mx System. The wires used were 0.014 "(CuNiTi), 0.014" x 0.025 "(CuNiTi), 0.018" x 0.025 "(CuNiTi), 0.017" x 0.025 "(TMA), 0.019" x 0.025"(stainless steel), coordinated form of each patient. The diagram was done individually after alignment of the dental arches with the 0.014 "x 0.025" (CuNiTi) wire, with reference to the bite registry in wax 7, and then attached to the patient's chart.

2.1.2. Group 2

24 patients of both genders (15 female and 9 male) with initial mean age 19.50 years (SD 7.16), final mean age of 21.49 years (SD 7.01), and mean treatment time of 1.99 years (dp 0.55) treated with conventional Straight-Wire (A Company) slot 0.022 ". The wire sequence used in orthodontic treatment was 0.014 "(NiTi), 0.016" (NiTi), 0.016 "(steel), 0.018" (steel), 0.020 "(steel) and 0.019" x 0.025 "(steel). The diagram was made from the WALA border, an anatomical structure constituted by the outermost spatial prominence of the buccal aspect of the mandible, from the

initial dental cast [9].

2.2. Methods

In the initial and final dental casts of each case, the following variables were evaluated (Fig. (**1**)): intercanine (A, IC), interpremolar (first (B, I1PM) and second premolars (B', I2PM)), and intermolar distances (first molars (C, IM)) and arch length (D+E, AL).
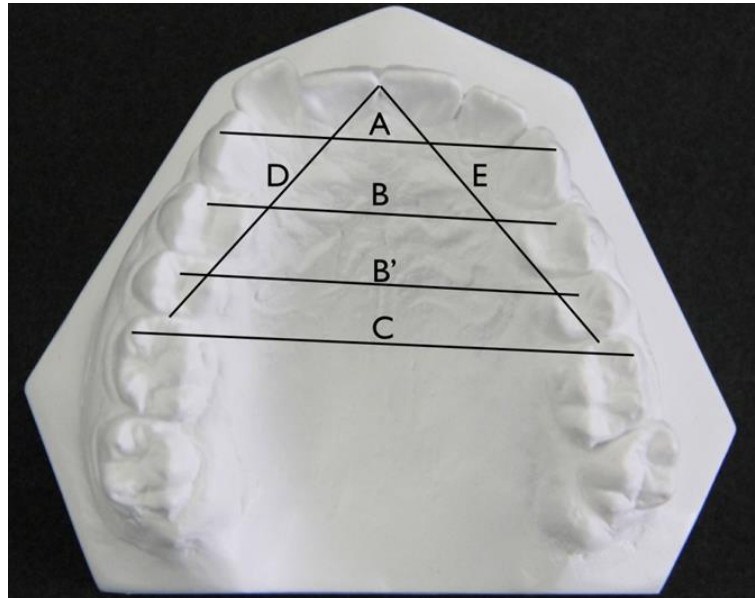

Fig. (1). Measurements of the arches dimensions.

Measurements were performed with the aid of a digital calliper Mitutoyo (Japan) (Fig. (**2**)),2with a capacity of 150 mm, capable of measuring up to 0.01 mm.

Fig. (2). Digital caliper Mitutoyo (Japan).

After measuring the variables in the maxillary and mandibular dental casts, the values in the initial and final stages intragroups and intergroups were compared statistically.

3. RESULTS

The systematic and casual errors evaluation was performed using the Dahlberg formula test, respectively, applied to the variables Little, IC, I1PM, I2PM, IM and maxillary and mandibular AL, measured in the dental casts with a time interval of one month. The casual errors ranged from 0.13 to 0.21, with a significant difference in the systematic error of 0.03, in the variable md I1PM.

The Shapiro-Wilk test showed the initial values (T1), final (T2) and alterations (T2-T1) for the Damon group and for the conventional group. The data that did not present normality were: in the Damon group, mandibular Little index (0.005), initial value of the maxillary intercanine distance (T1) (0.025) and alteration of the mandibular arch length (T2-T1) (0.007); in the Conventional group, maxillary Little index (0.007) and alteration in the maxillary intercanine distance (T2-T1) (0.001).

Table **1** presents the results of the intergroup compatibility of the initial and final ages and treatment time (mean and standard deviation) with the independent t test.

Table 1. Results of the intergroup compatibility of the initial and final ages and treatment time (independent t test).

Variables (Years)	Group 1 Damon (N=21)		Group 2 Conventional (N=24)		*P*
	Mean	S.D.	Mean	S.D.	
Initial age T1	18.37	6.99	19.50	7.16	0.596
Final age T2	20.48	7.26	21.49	7.01	0.636
Treatment time (T2-T1)	2.11	0.62	1.99	0.55	0.514

In Table **2**, was verified the compatibility results regarding the distribution of genders in groups 1 and 2 by means of the chi-square test.

Table 2. Compatibility results regarding the distribution of genders in groups 1 and 2 (*Chi*-square test).

GENDER GROUP	Female	Male	Total
Group 1- Damon	10	11	**21**
Group 2- Conventional	15	9	**24**
Total	25	20	**45**
X^2 =1.00 DF= 1 *P*=0.316			

Table **3** shows the results of intergroup compatibility of the amount of maxillary and mandibular crowding, assessed by the Little irregularity index through the Mann-Whitney non-parametric test.

Table 3. Results of intergroup compatibility of the amount of maxillary and mandibular crowding, assessed by the Little irregularity index (Mann-Whitney non-parametric test).

Variables (mm)	Group 1 Damon (N=21)		Group 2 Conventional (N=24)		*P*
	Mean (Median)	Interquartile range	Mean (Median)	Interquartile range	
Mx Little	3.29 (2.86)	1.83	3.60 (2.78)	2.74	0.945
Md Little	3.58 (3.41)	1.49	3.05 (2.87)	2.02	0.236

Mx=maxillary; Md=mandibular.

Table **4** presents the results of the intergroup comparison of the dimensions of the maxillary and mandibular dental arches in the initial treatment stage (T1) by means of the independent or non-parametric Mann-Whitney t test. There was no statistically significant difference in any variable.

Table 4. Results of the intergroup comparison of the maxillary and mandibular dental arches dimensions in the initial stage of treatment (T1) (independent t or Mann-Whitney tests).

Variables (mm)	Group 1 Damon (N=21)		Group 2 Conventional (N=24)		P
	Mean (Median)	S.D. (i.r.)	Mean (Median)	S.D. (i.r.)	
Mx IC	34.70 (35.24)	1.97 (1.87)	35.03 (35.25)	2.01 (3.46)	0.494 ¥
Mx I1PM	35.52	1.96	36.02	2.28	0.443 €
Mx I2PM	40.87	2.33	41.23	2.51	0.625 €
Mx IM	45.04	2.75	44.94	2.52	0.894 €
Mx AL	68.26	3.59	67.92	4.14	0.776 €
Md IC	26.15	1.52	26.63	1.23	0.246 €
Md I1PM	30.24	2.07	30.19	1.72	0.931 €
Md I2PM	35.19	2.42	35.15	2.32	0.956 €
Md IM	39.99	2.72	39.24	2.39	0.333 €
Md AL	57.85	2.65	57.20	3.50	0.496 €

Mx=Maxillary; Md=mandibular; IC=Intercanine distance; I1PM=inter first premolar distance; I2PM=inter second premolar distance; IM=intermolar distance; AL=arch length.

Mean and Standard Deviation (S.D.), when using independent parametric t test; Median and interquartile range (i.r.), when using the non-parametric Mann-Whitney test.

€ independent t test

¥ non-parametric Mann-Whitney test

Table **5** shows the results of the intergroup comparison of the dimensions of the maxillary and mandibular dental arches in the final treatment stage (T2) with that of the independent t test. The variables presented a statistically significant difference were: maxillary intermolar distance, mandibular intercanine and inter first premolars, and the Damon group had a mean final tooth dimension larger than the conventional group.

Table 5. Results of the intergroup comparison of the maxillary and mandibular dental arches dimensions in the final stages (T2) (independent t test).

Variables (mm)	Group 1 Damon (N=21)		Group 2 Conventional (N=24)		P
	Mean	S.D.	Mean	S.D.	
Mx IC	35.93	1.68	35.12	1.68	0.112
Mx I1PM	37.97	1.56	37.09	1.62	0.070
Mx I2PM	43.14	1.66	42.16	1.86	0.071
Mx IM	46.92	1.83	45.65	2.23	**0.045***
Mx AL	69.25	3.35	68.94	3.08	0.694
Md IC	27.31	1.51	26.44	1.32	**0.046***
Md I1PM	32.12	1.39	30.85	1.54	**0.006***
Md I2PM	36.84	1.74	35.81	1.96	0.071
Md IM	40.96	1.85	39.75	2.30	0.059
Md AL	58.54	2.84	59.04	2.74	0.548

Mx=maxillary; Md=mandibular; IC=intercanine distance; I1PM=inter first premolar distance; I2PM=inter second premolar distance; IM=intermolar distance; AL=arch length.

* Statistically significant for $p < 0.05$

Table **6** presents the results of the intergroup comparison of the dimensions of the maxillary and mandibular dental arches between the initial and final stages (T2-T1) using the independent or non-parametric Mann-Whitney t-test. The variables that did not present a statistically significant difference were the maxillary arch length, mandibular inter second premolars and intermolar distance.

Table 6. Results of the intergroup comparison of the maxillary and mandibular dental arches dimensions between the initial and final stages (T2-T1) (independent t or Mann-Whitney tests).

Variables (mm)	Group 1 Damon (N=21)		Group 2 Conventional (N=24)		*P*
	Mean (Median)	S.D. (i.r.)	Mean (Median)	S.D. (i.r.)	
Mx IC	1.22 (1.36)	0.95 (0.87)	0.08 (-0.27)	1.66 (1.69)	**0.000*¥**
Mx I1PM	2.44	1.12	1.06	1.56	**0.001*€**
Mx I2PM	2.27	1.16	0.93	1.63	**0.003*€**
Mx IM	1.87	1.38	0.71	1.50	**0.010*€**
Mx AL	0.99	1.80	1.02	2.33	0.958 €
Md IC	1.16	1.29	-0.19	1.08	**0.000*€**
Md I1PM	1.88	1.89	0.66	1.50	**0.020*€**
Md I2PM	1.65	1.51	0.65	2.30	0.100 €
Md IM	0.97	1.31	0.50	1.35	0.243 €
Md AL	0.69 (0.54)	2.33 (1.13)	1.83 (1.92)	1.95 (1.52)	**0.024*¥**

Mx=maxillary; Md=mandibular; IC=intercanine distance; I1PM=inter first premolar distance; I2PM=inter second premolar distance; IM=intermolar distance; AL=arch length.
Mean and Standard Deviation (S.D.) when using independent parametric t test; median and interquartile range (i.r.), when using the non-parametric Mann-Whitney test.
* statistically significant for *p* <0.05
€ independent test
¥ non-parametric Mann-Whitney test

4. DISCUSSION

For the maxillary intercanine distance, in the intergroup comparison, at the beginning and at the end of the treatment, there was no significant difference in the increase obtained (Table **4** and Table **5**). However, when the change of this variable in the initial and final stages was compared between the groups, a statistically significant difference occurred, and the Damon group showed a larger mean increase of 1.22 mm, and the conventional one, 0.08 mm (Table **6**). It is speculated that this larger increase in the Damon group is due to the difference of the wire used during the treatment and the diagramming of the arches. Other studies also showed a significant increase with the self-ligating appliances Damon 3 [8] and Smart Clip [10]. Some authors [11] also achieved the same result in patients treated with conventional brackets, while others [8] reported a significant increase.

Regarding the maxillary inter first premolars, comparing the initial and final stages, there was a significant increase in each group studied (Table **4** and Table **5**). Other authors also found the same results [8]. In the intergroup comparison, at the beginning and at the end of treatment, there was no significant difference. The Damon group presented a statistically significant higher increase in this distance, with an average of 2.44 mm more than the conventional group, which presented an average increase of 1.06 mm (Table **6**).

In the intergroup comparison of the maxillary inter second premolars distance, at the beginning and at the end of the treatment, there was no significant difference, the Damon group presented a larger increase, with a mean of 2.27 mm, and the Conventional group, a mean increase of 0.93mm (Table **6**). Some authors [11] did not find significant alteration of this distance in a group treated with only conventional appliances. However, they found a significant increase in group with the same appliances and rapid maxillary expansion. Other studies [8] showed a significant increase in this measure of 2.77 mm in patients treated with the self-ligating Damon appliances and 2.87 mm in the conventional one.

The maxillary intermolar distance presented a significant increase comparing the two groups at the beginning and at the end (Table **4** and Table **5**). In the intergroup comparison of the initial and final stages, the Damon group showed a statistically significant increase greater, mean of 1.87mm, and in the Conventional, of 0.71mm (Table **6**). Some authors have found similar results [8]. A study [12] showed a mean reduction of 0.14 mm of this distance in a group treated with conventional appliances, while in the Damon group, a decrease of 0.25 mm, however, in patients treated with premolars extraction. Other authors [11] reported a significant increase for this measure in a group treated with rapid maxillary expansion. This evidence, compared to the present study, that the self-ligating Damon appliances came closer to the results of the cases treated with rapid maxillary expansion, with a significant transverse expansion of the maxillary dental arch.

In the maxillary arch length, at the beginning and at the end of treatment, a statistically significant increase was found in both groups, with no significant difference in the initial and final stages between groups. The Damon group presented an average increase of 0.99mm and the conventional one, 1.02mm (Table **6**). One study showed an average increase of 2.42 mm in the group treated with Damon appliances and 1.37 mm in the conventional group, even with extractions of premolars [12]. Some authors found a statistically significant increase for this measure in a group treated with rapid maxillary expansion, and there was no significant alteration in the treated group without rapid expansion [11]. Other researchers [13] reported a significant reduction in Class II patients treated without extraction, as well as with premolar extractions and without rapid maxillary expansion [14]. However, increased arch length should be observed with caution, as it may indicate the occurrence of a protrusion of the incisors rather than a lateral expansion of the arch, as expected in cases treated with self-ligating brackets.

For the mandibular intercanine distance, in the intergroup comparison, at the beginning and at the end of the treatment, there was a significant difference at the end, and the Damon group presented this greater distance (Table **4** and Table **5**). In the comparison between groups, in the initial and final stages, the Damon group also showed a statistically significant mean increase of 1.16 mm, while the conventional group had a small decrease of 0.19 mm (Table **6**). Although not statistically significant, the Damon group presented a greater mandibular anterior crowding than the conventional group (Table **3**). Some studies [8] found a significant increase of this distance in both the Damon group, with a mean of 2.24 mm and in the conventional group, with a mean of 1.85 mm. Others also found an average increase of 2.55mm in the Damon group and in the Conventional group, 2.66 mm [15]. There are papers showing a statistically non-significant increase of this measure for the self-ligating and conventional groups [10, 16]. A decrease of 1.96mm in the Damon group and 2.86mm in the conventional one, both with premolar extractions, was also reported [12, 13].

In the assessment of the mandibular inter first premolars distance, in the intergroup comparison, at the beginning and at the end of the treatment, there was a significant difference between the groups at the end of the treatment, and the Damon group presented this greater measure than the conventional one (Table **4** and Table **5**). In the intergroup comparison of the initial and final stages, the Damon group also showed a larger increase of this distance, with a mean of 1.88mm, compared to the Conventional group, with a mean of 0.66mm (Table **6**). A similar result was found by other authors [8, 9]. However, there are studies showing a larger increase for the conventional appliances, although statistically not significant [10].

Regarding the mandibular inter second premolar distance, in the intergroup comparison, at the beginning and at the end of treatment, there was no significant difference (Table **4** and Table **5**). Comparing between the groups, the initial and final stages, there was no statistically significant increase of the Damon group in relation to the Conventional group (Table **6**). Some studies showed an increase in this distance in both the Conventional and SmartClip treated groups, while others found a statistically significant increase in both the Conventional group and the group with the Damon appliances [8, 10].

In the intergroup comparison of the mandibular intermolar distance, at the beginning and at the end of the treatment, there was no significant difference in the increase between the two groups, as well as in the initial and final stages, with the mean increase in the self-ligating appliances being 0.97 mm and, in the conventional one, of 0.50mm (Table **6**). Some studies demonstrated an increase in both groups, and, similarly, in a study of patients treated with premolars extraction [8, 12, 16]. Other authors found an average increase of this distance of 1.41 mm with self-ligating Smartclip brackets and 0.50 mm with the conventional appliances [10]. An average increase of 0.63 mm in group with conventional appliances and a small decrease of 0.09 mm in the Damon group treated with extractions was also found [15].

In the comparison of the initial and final stages, the increase of the mandibular arch length was statistically significant only in the conventional group (Table **4** and Table **5**). In a study, a mean reduction of 1.33 mm in the length of the mandibular arch in the conventional appliances group and of 2.27 mm in the Damon appliances group was obtained, whose treatment was carried out with extractions [15]. Other authors found an average increase of 1.69mm in the Damon group and 1.08mm in the group of patients treated with conventional appliances, both treated with dental extractions [12]. In the intergroup comparison, at the beginning and at the end of treatment, there was no significant difference. In the initial and final stages, the Conventional group had a statistically significant increase greater than 1.83 mm and Damon group, 0.69 mm (Table **6**). This increase may be caused by the expansion of the first molar region or the protrusion of the incisors. As the Damon group showed a greater expansion in the first molars region and a smaller increase of the bow length compared to the Conventional group, it is speculated that the Damon treatment less protrudes

the mandibular incisors than with the conventional appliances.

Regarding torque, since both appliances were pre-adjusted, patients presented similar malocclusions and were treated similarly, torque was not really a differential in these cases. Maybe cases with greater increase in transversal arch dimensions present more buccal inclination of posterior teeth and then need more palatal torque of these teeth. Since Damon showed greater transversal increase, more palatal torque must be needed. However, Damon had showed in a previous research to express more torque than the Roth preadjusted appliance used in this study [17]. This way, torque will be well controlled in these cases.

5. CLINICAL CONSIDERATIONS

The results found in the present study must be considered only for Class I cases with slight to moderate crowding. One has to remember that Class II and II malocclusions and complex cases were excluded from this sample.

The alterations found for the amount of increase of the dimensions of the maxillary dental arch, between treatments with the Damon and conventional appliances, were approximately 1mm more expansion for the self-ligating Damon System. This difference may be considered small and not as clinically significant. In the mandibular arch, the discrepancies were found only at the intercanine and interpremolar distances, and the increase was also greater in the group treated with the self-ligating Damon appliances, and also about 1 mm. In the arch length, the increase was slightly more than 1mm in the group treated with the conventional appliances, indicating perhaps a greater protrusion of the mandibular incisors in this group.

The largest increase in the maxillary arch in the Damon group develops the bone density of the maxilla, thus allowing a greater expansion of the dental arch, when they are known as expanded thermoactivated Cupper-Niti superelastic, as pre-conceived by this technique. In the mandibular arch, where the bone is denser, a larger expansion in the Damon group compared to conventional, not available in all regions of the arch, even with the use of wires above. The bone biology has proved imperative, and must be respected.

As for the differences in the treatments with the two types of appliances, the results and the interpretation of the same and the methodology used show us the importance of the diagram. Using diagrams based on the initial arch shape of each patient, as performed in the conventional group, we obtained a smaller expansion of the dental arches than with a diagram constructed after the initial Cupper-Niti wire leveling, as in the Damon group.

When planning an orthodontic treatment, the choice not only of the appliances, but of the wires and the diagram to be used should be according to the desired effects on the dental arches. When a greater expansion of the arch and perhaps a protrusion of the mandibular incisors are desired, it is recommended to use the self-ligating Damon System with Cupper-Niti expanded arches, and the diagram as advocated by this technique. When the expansion of the dental arches is contraindicated, or not desired, it is recommended to use the conventional appliances, using the diagram based on the initial arch shape of each patient.

CONCLUSIONS

Based on the results obtained for the studied sample, it was possible to conclude that, comparing the two groups, the self-ligating Damon appliances promoted a significantly larger increase of the dimensions of the maxillary arch than the conventional appliances, except for the arch length. In the mandibular arch, the Damon appliances promoted a greater increase in the intercanine and interpremolar distances than the conventional appliances. The mandibular arch length showed a significantly higher increase in the conventional group compared to the Damon group.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the research ethics committee of the UNINGA University Center, Maringá, Brazil.

HUMAN AND ANIMAL RIGHTS

No Animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2008 (http://www.wma.net/en/20activities/10ethics/10helsinki/).

CONSENT FOR PUBLICATION

Informed consent was obtained from the patient prior to being enrolled in the study.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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