

## RESEARCH ARTICLE

### ASSESSMENT OF THE RELATIONSHIP BETWEEN THE UPPER AND LOWER ARCH CHANGES WITH THE OPENING OF THE EXPANDING SCREW AFTER THE RAPID MAXILLARY EXPANSION

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#### Abstract

##### Objective

The purpose of this study is to assess the relationship of the upper and lower arch dimension changes after the rapid maxillary expansion (RME) with the screw opening of the modified Hyrax® type appliance.

##### Material and methods

Initial (T1) and final (T2) models of a study of 63 children between 7 years and 6 months and 16 years and 5 months were performed. From these, 21 showed maxillary atresia and/or posterior crossbite and were submitted to expansion, and 42 children formed the control group. The appliance used in this work was the modified Hyrax appliance using the 7mm expanding screws "Dentaurum". The measurements of the upper intercanine and the upper and lower intermolar distances were performed in plaster models with the help of a digital paquimeter. The opening of the appliance's screw was also assessed.

##### Results

The RME provoked a statistically significant increase in the upper interdental distances and no statistical significance in the lower interdental distances, i.e., the change in the 16 – 26, 13 – 23 and 36 – 46 distance was of 5,85 mm, 5,31 mm and 0,34 mm respectively. The average opening of the expander screw was 6,27 mm.

#### Conclusion

The appliance's opening is related to the interdental distance changes, i.e., for each appliance's opening mm, a 0,94 variation in the upper intermolar distance, a 0,87 in the upper intercanine distance and 0,054 in the lower intermolar distance are provoked.

#### Résumé

##### Objectif

Le but de ce travail est celui d'évaluer la relation des altérations des dimensions des deux arcades après l'expansion rapide du maxillaire (ERM) avec l'ouverture de la vis de l'appareil type Hyrax modifié.

##### Matériel et Méthodes

Nous avons sélectionné 63 enfants (7 ans et 6 mois et 16 ans et 5 mois) auxquels nous avons pris des modèles d'étude au début (T1) et à la fin (T2) du traitement. 21 de ces enfants, présentaient une atrésie du maxillaire et/ou articulé inversé postérieur raison pour laquelle ces enfants ont subi un traitement par expansion. Les 42 autres enfants, ont constitué le groupe contrôle. L'appareil utilisé a été l'Hyrax modifié avec vis d'expansion «Dentaurum» de 7 mm. Nous avons mesuré les distances inter canines et inter molaires, maxillaires et mandibulaires sur les modèles en plâtre à l'aide d'un pied à coulis numérique. Nous avons également mesuré l'ouverture de la vis de l'appareil d'expansion.

## Résultats

Les résultats obtenus nous ont montré des augmentations de la distance 16-26 de 5,85 mm, de la distance 13-23 de 5,31 mm et de la distance 36-46 de 0,34 mm. L'ouverture moyenne de la vis de l'appareil d'expansion a été de 6,27 mm.

## Conclusions

L'ouverture de l'appareil est associée aux altérations des distances inter dentaires, c'est-à-dire, à chaque millimètre d'ouverture correspond une variation de 0,94 mm de la distance 16-26, 0,87 mm de la distance 13-23 et 0,054 mm de la distance 36-46.

## Mots-clés

Expansion rapide du maxillaire; Articulé inversé postérieur; Disharmonie maxillaire transversale; Arc dentaire.

## Key Words

Rapid maxillary expansion, posterior crossbite, transverse maxillary deficiency, dental arch.

## Introduction

The RME purpose is to obtain the maxilla separation through the opening of the midpalatal suture. The permanent as well as the removable braces with orthopaedic purpose can be effective at the posterior crossbite and maxillary atresia correction (1, 2). However, the use of a permanent disjunctive appliance favours a major transfer of the activation forces to the bone bases and consequently allows greater orthopaedic results as well as more stability on the expansion, normalizing the transversal dimensions of the maxilla (3-7) and a remarkable clinical increase in the lower arch dimensions (8, 9, 10). As a consequence of these orthopaedic reactions, the opening of the palatine suture occurs and the central upper incisors separate themselves. But, since they are connected by the transeptal fibres, the crowns of these teeth converge to medial after the end of the activation, in order to search for the interproximal contact. When the crowns come into contact, the fibers' continuous traction causes the convergence of the roots (3, 11) increasing the space between the teeth for possible positioning of the lateral incisors in crossbite (9, 10).

The RME, through the opening of the midpalatal suture, has become a largely successful

procedure used by the orthodontist, when performed in children during the temporary and mixed dentition periods (2, 12). The RME cannot be considered a simple procedure, since it acts on the midface of the individual. Initially, the tensions produced by the first activations of the palatine disjunctive screw, that may oscillate between 1000 and 3000 grams in one single activation, are focused on the anterior region of the palate to the level of the alveolar processes. However, after successive activations more than 7,000 grams can be accumulated and considered to be orthopaedic forces that promote skeletal and dentoalveolar changes (13).

The expansion through the opening of the palatal suture progressively becomes more difficult as the patients grow old. The main resistance to the opening of the palatal suture is not only due to its own (to the increase of the midpalatal suture interdentalization), but also to the surrounding sutures as the sphenoid and zygomatic bones, thus reducing the success of the opening of the palatal suture after the end of adolescence. In this situation, the RME performed in young adults frequently shows failures and complications on the bone correction, being offset by dental-alveolar inclination (12, 14, 15).

The literature reveals works reporting nasal obstruction relief after the opening of the midpalatal suture, noticing a significant air passage improvement in the nasopharynx (16-18), as a consequence of the significant increase of the area and volume of the nasal cavity after the RME (19, 20).

## Activation protocol

According to Haas, in 2001, the RME is characterized by a protocol with 2/4 turns per day, up to 14 years of age, as well as 1 / 4 turn per day from the age of 15. The slightly lower activations would promote semi-rapid expansions (8).

Chagas et al, 2001 and Claro et al., 2003 carried out treatments with an expander attached in children between seven and ten years of age with an activation of 1/4 turn and 4/4 turn per day, to verify if this would significantly change the axial inclination of the upper permanent molars and the quantity of expansion. They concluded that both 1/4 turn per day and 4/4 turn activation promote an effective treatment, since the effects of axial inclination in the anchor teeth were similar in both types of activation, but also in the transversal

increase (21, 22).

According to these results, the activation protocol of the Hyrax type appliance used in this study was activated 2/4 turns daily, at night, which corresponds to an opening of 0.5 mm of the expander screw, also agreeing with the activations used in studies by other authors such as Sarver (6), Viazis (23), Sandikcioglu and Hazar (24), Akkaya et al (25), Faltin et al (26) and Lamparski et al (27),

## Material and methods

### Sample

The research involved 63 children between 7 years and 6 months and 16 years and 5 months. From this group, 21 were submitted to expansion, forming the expander group (EG), 9 males and 12 females and 42 children formed the control group (CG), 18 males and 24 females. In the CG, the children did not show maxillary atresia and/or crossbite and therefore no orthodontic treatment was conducted. All children participated in this study with informed parental consent.

For the study group there were selected children of both sexes, provided that they showed their first upper molars completely erupted; Caucasian; presenting maxillary atresia and/or unilateral or bilateral posterior crossbite; with RME indication for malocclusion correction.

We excluded all children with known genetic syndromes or diseases such as cleft palate; who had undergone orthodontic treatment or surgical procedures in the maxillofacial area, and who did not present the first molars completely erupted.

The data records were made in the same time intervals, T1 – beginning of the treatment, pre-expansion, before placing the appliance and T2 - after rapid maxillary expansion at the end of contention, after removing the Hyrax type appliance for both the CG and EG.

### Type and activation of the appliance

The appliance used in this study was the modified Hyrax<sup>®</sup> appliance. This appliance contains connection bars which consist of stainless steel round wire of 0.9 mm diameter that surround the palatal dental face near the arm of the expanding screw to the band, continuing by vestibular. The appliances were always prepared by the same professional and always respecting the same manufacturing procedure, using the 7 mm expanding

screws Dentarum<sup>®</sup> (Figure 1).

The activation of the appliance was of 2/4 turn daily, at night (0.25 mm per activation). The activation started after the appliance's cementation, being 1/4 turn performed by the

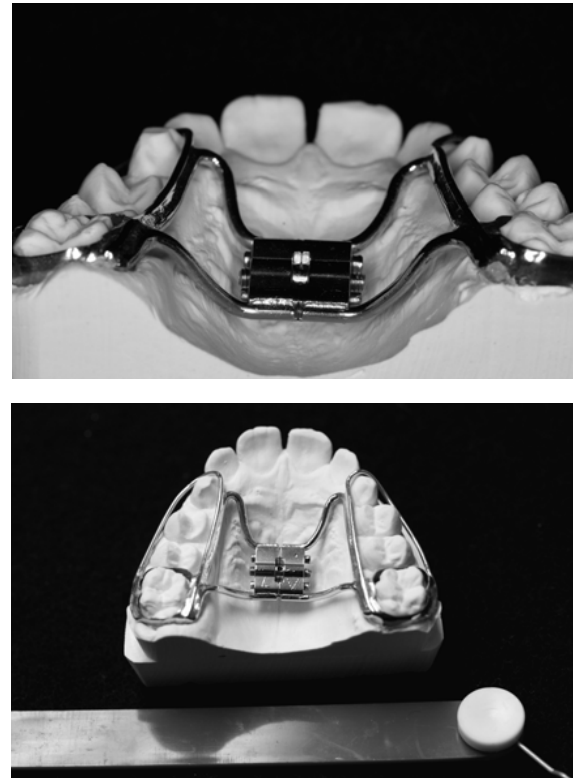


Figure 1a and 1b – The modified Hyrax type appliance.

practitioner and 1/4 of turn by the patient's companion (parents or tutors), under professional supervision.

During the active phase of the maxilla disjunction, the patients were assessed weekly, to control the activation of the expanding screw and assess the oral hygiene status.

The activations only finalized after an over-correction of the upper and lower teeth, i.e., when it was observed there was contact of the palatal cusp of the upper molar with the vestibular cusp of the lower molar (Figure 2) (24-27).

After the activation, the stabilization of the screw was made with metal ligation and light-cured resin. This appliance is used not only as part of the initial treatment but also throughout the contention period that lasted approximately five months. Patients were evaluated monthly to control the appliance and the hygiene care.

After removing the Hyrax appliance, an acrylic upper removable plaque was applied adapted

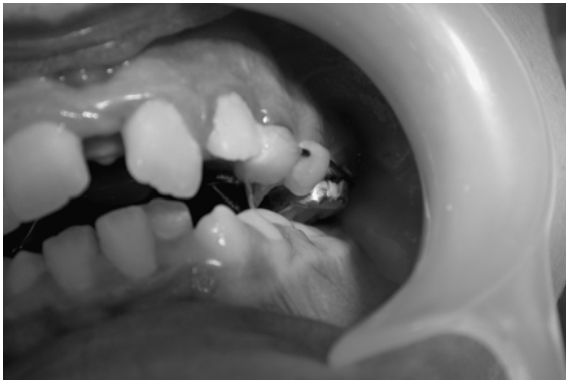


Figure 2 - The palatal cusp of the upper molar contacts with the vestibular cusp of the lower molar.

to the hard palate, in order to contain it until the beginning of the corrective orthodontic treatment (9, 28).

**Preparation and evaluation methods of the plaster models**

For the evaluation of the changes in the upper and lower arch, models were necessary for study at stages T1 and T2. The mouldings of the upper and lower jaw were performed with standard moulders and irreversible hydrocolloid alginate - Orthoprint of Zhermack®. For scattering this material, the manufacturer's instructions were followed, using the dosage supplied. After attaching the material, the mould is carefully removed from the patient's mouth, and then rinsed with running water.

After about five minutes, the mould was emptied into stone plaster for the construction of the study models, in order to avoid the syneresis and the alginate imbibition phenomena. In this study, the maximum waiting time for a mould, until it was emptied, was approximately twenty to thirty minutes. The plaster's manipulation followed the manufacturer's instructions.

The intermolar distance was obtained from the interception of the lingual sulcus with the

gingival margin of the first upper and lower molars; the intercanine distance was measured from the cusp tip (Figure 3).

The distances in both the intercanine and intermolar segments in the plaster models were evaluated with the digital paquimeter with a resolution of 0,01 mm and accuracy of 0,03 mm (Figure 4).

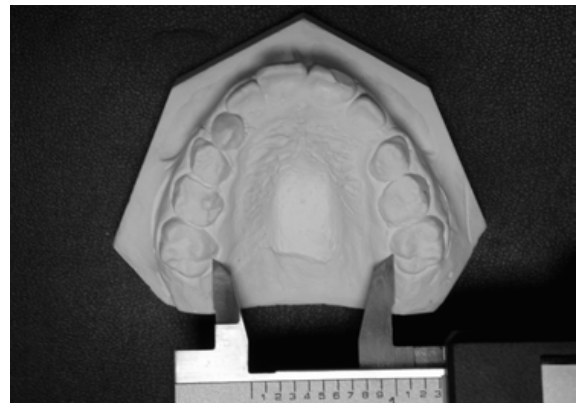


Figure 4 - The paquimeter tips placed in the interception of the lingual sulcus with the gingival margin of the first upper molars.lower molar.

After treatment, the modified Hyrax type appliance was withdrawn (Figure 5), and the measurement of the screw opening was performed. The paquimeter tips were placed at the end of the screw opening as shown in Figure 6.

**Statistical analysis**

The collected data were analyzed in SPSS 15.02, using the most suitable techniques for the involved variables. Techniques of descriptive statistics were used (graphics and tables) to organise the data. Given the nature of the involved variables the analysis consisted of:

- Data descriptive study - qualitative and quantitative variables (bar graphs, circulars,

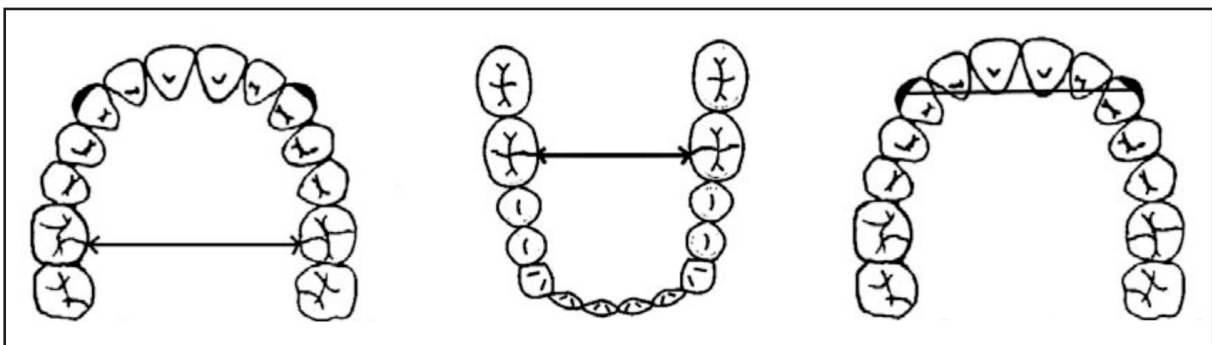


Figure 3 – Upper and lower intermolar and upper intercanine distance.lower molar.

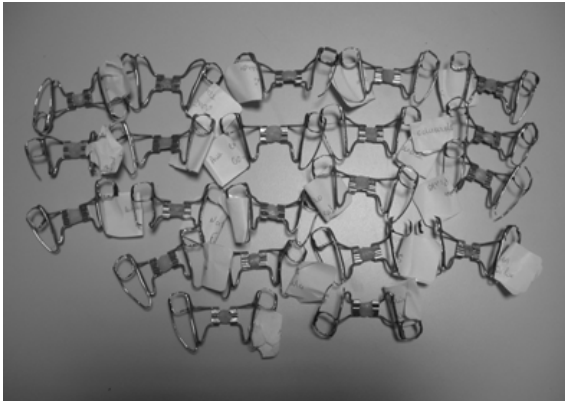


Figure 5 - the modified Hyrax type appliance.

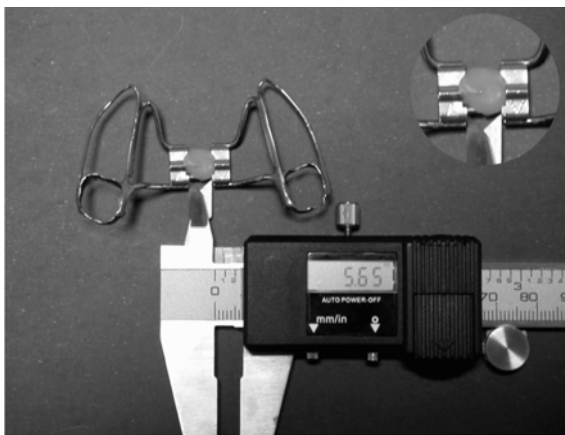


Figure 6- The paquimeter tips were placed at the end of the screw opening

tables of frequencies)

- Data analytical study - relationship between variables, using the Pearson correlation or equivalent non-parametric Spearman correlation
- Comparative study - comparisons between groups were performed by the t-Student test (for independent samples), or, if the underlying assumptions were not checked to this one, using the non-parametric equivalent, Wilcoxon Mann-Whitney test. For the matched samples, either the t-Student test or the non-parametric equivalent Wilcoxon test was used.

The used rule of decision consists of detecting significant statistical evidence for probability values (proof value of the test) inferior to 0.05.

### Results

The sample consists of 63 children, of which 21 belong to the EG and 42 to the CG. Of the 63 children in the study, 36 are females and 27 are males. According to the planning set,

the distribution of the children regarding gender remains similar on the CG and EG.

In the CG, of the 42 children, 29 (69%) have mixed dentition while 13 (31%) have definitive dentition. In the EG, of the 21 children, 15 (71.4%) have mixed dentition while 6 (28.6%) have definitive dentition.

The evaluation of the plaster models was made by a paquimeter as previously described. For the evaluation of the observer's error measurements were made on the distances between the teeth 16-26 and the teeth 13-23, at stages T1 and T2. Each step was repeated five times.

The graphics of Figures 7 to 10 illustrate the variation of these measures, on the five repetitions, for consultation at stages T1 and T2 of the EG.

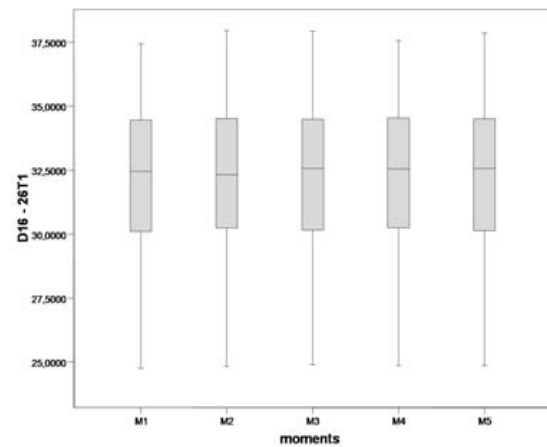


Figure 7 - Distribution of the measurement of the distance between the teeth 16-26 in the plaster model on five repetitions in T1.screw opening

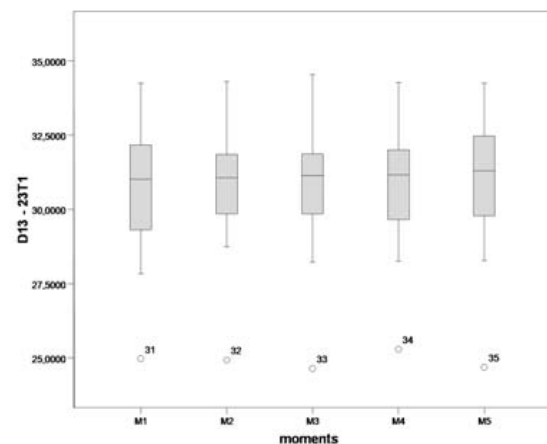


Figure 8 – Distribution of the measurement of the distance between the teeth 13-23 in the plaster model on five repetitions in T1.

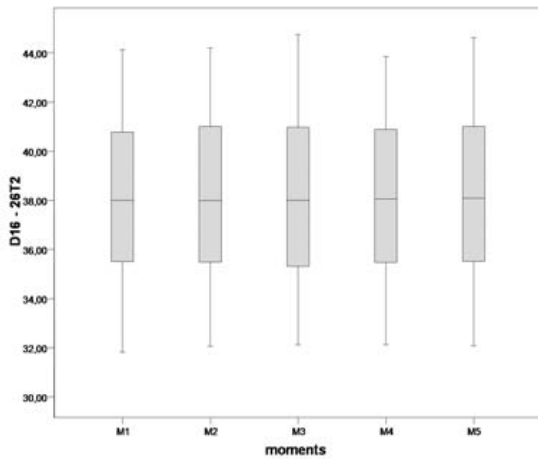


Figure 9 – Distribution of the measurement of the distance between the teeth 16-26 in the plaster model on five repetitions in T2.

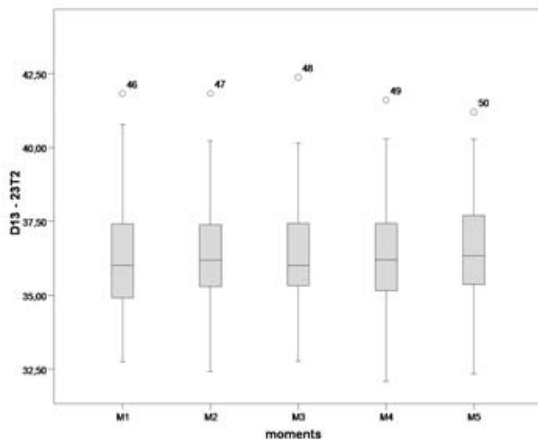


Figure 10 - Distribution of the measurement of the distance between the teeth 13-23 in the plaster model on five repetitions in T2.

Due to the data normality (Kolmogorov test,  $p > 0,05$ ) of the distance between the teeth 16-26 and between the teeth 13-23, an ANOVA test was performed to assess if there were measurements with significant statistical differences, for each of the measures.

It also verified the assumption of homocedasticity (Levene test,  $p > 0,05$ ) associated with this analysis. Thus, the null hypothesis associated with this ANOVA test is of the type:

**H0: there are no significant differences in the measure average value in every moment of the measurement.**

According to the proof figures ( $p > 0,05$ ), there are no significant statistical differences in the average measures in the five groups of

the performed measurements. Thus, it was decided to work with their average values for studies with the measures carried out in the models, assigning to each one the values of descriptive statistics.

Then, an evaluation of the average changes in the plaster models for the CG and EG before and at the end of the treatment, and the amendment at the screw's opening, was attempted.

Tables 1 and 2 present the descriptive statistics illustrating the averages for the distances between the molars and upper canines and lower molars at stages T1 and T2 and their respective average changes for the CG and EG.

As shown in Table 1, there is significant statistical change for the interdental distances measured in plaster models for the CG. However, this change is not clinically significant (0,18 mm, 0,38 mm and 0,11 mm).

By analysis of table 2 it can be seen that there is a statistically significant change to the upper interdental distances for the EG. However, unlike the previous one, it can be seen that this change is clinically significant (5,85 mm, 5,51 mm, 0,34 mm).

Table 3 presents a descriptive statistic illustrating the average opening of the expander screw, which was 6,27 mm with a standard deviation of 0,73.

Then the variables were set up, the difference between T1 and T2 stages of each EG measured, to verify the produced change and compare it with the opening of the screw on the appliance.

The t-Student test for paired samples did not detect any statistically significant differences in the distances measured of teeth 36-46 between T2 and T1 ( $p > 0,05$ ), so this measure was not used for comparison. The graph in Figure 11 illustrates the differences of the changes between T1 and T2 stages for the distances measured between teeth 16-26, of the distances between teeth 13-23, and the opening produced on the appliance.

To assess the relationship between the opening of the appliance and the variation produced in the differences of the measured distances between teeth 16-26 and teeth 13-23 on T2 and T1 (diff D16-26 and diff D13-23), simple linear regression models were drawn, passing on the origin, because this way it can be detected if the opening of 1 mm on the appliance is significant and what the relationship with these measurements is.

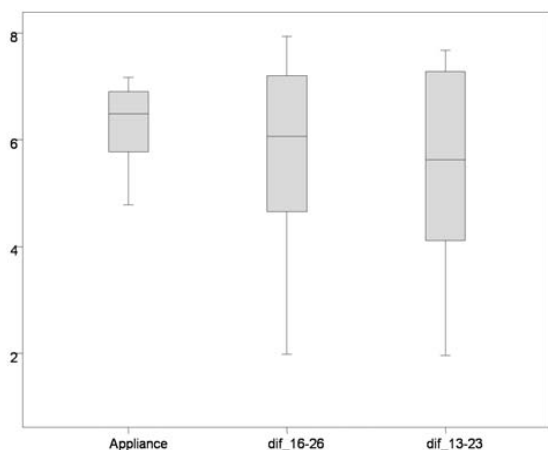


Figure 11 – Changes distributions on the measures and the appliance.

Upon analysis of the simple linear regression, whose dependent variable is the difference of the distance between the teeth 16-26 (yi), and the independent appliance's opening (xi), a value was obtained for the determination coefficient of 0,966, which means that the de-

pendent variable is explained in 96.6% by the variation of the independent variable. This figure is an indicator of the adjustment quality. **The obtained estimated model has the following equation:**

$$\hat{y}_i = 0,939x_i^*$$

This relationship means that for every opening mm on the appliance, a difference is observed of 0,94 mm in the measurement of the distance between teeth 16-26. For the measure that corresponds to the distance between the teeth 13-23, an analysis of simple linear regression was conducted, whose dependent variable is the difference of the distance between the teeth 13-23 (yi) and independent of the opening of the appliance (xi), A value was obtained for the determination coefficient of 0,914, which means that the dependent variable is explained in 91.4% by the variation of the independent variable. This figure is an indicator of the good quality of the adjustment.

	T1		T2			
	Average	St. deviation	Average	St. deviation	Mean differences	t test
16 – 26	34,73	2,45	34,91	2,32	<b>0,18</b>	Sig
13 – 23	32,63	1,93	33,01	1,87	<b>0,38</b>	Sig
36 – 46	32,89	2,15	33,01	2,1	<b>0,11</b>	Sig

Table 1 - Summary statistics for plaster models of CG.

	T1		T2			
	Average	St. deviation	Average	St.d deviation	Mean differences	t test
16 – 26	32,16	3,79	38,01	3,55	<b>5,85</b>	Sig
13 – 23	30,89	2,05	36,4	2,29	<b>5,51</b>	Sig
36 – 46	33,79	3,36	34,13	3,43	<b>0,34</b>	Não Sig

Table 2 – Summary statistics for plaster models of EG.

	N	Min.	Max.	Average	St. deviation
Appliance	21	4,78	7,17	<b>6,27</b>	0,73

Table 3 - Summary statistics for the opening of the expander screw

The estimated obtained model has the following equation:

$$\hat{y}_{ij} = 0,873^*$$

This means that, for each opening mm on the appliance, a difference of 0,87 mm is observed in the measure of the distance between the teeth 13-23.

A similar analysis was made on the measure of the distance between the teeth 36-46 whose dependent variable is the difference of the distance between the teeth 36-46 ( $y_i$ ) and independent of the appliance's opening ( $x_i$ ). It was verified that this model was not statistically significant because the value of the determination coefficient is very low (0,184), which implies that the linear model is not the most appropriate.

The estimated obtained model has the following equation:

$$\hat{y}_{ij} = 0,054^*$$

Although this implies that, for every opening mm on the appliance, a difference of 0,054 mm in the distance's measurement between the teeth 36-46 is observed. This value, however, is not statistically significant.

For all estimated models, the normality and homogeneity assumptions of the variance in errors were verified and confirmed.

## DISCUSSION

This study used the modified Hyrax type appliance with dental supported anchorage, which contains extra connection bars with the aim of providing greater anchorage and expander forces being distributed over all the teeth. Thus, this appliance was chosen believing that it will offer greater comfort to the patient and better stability in the occlusion mainly during mastication, as the occlusal interferences are minimal or practically null.

### Displacement of the anchorage molars

Despite the great force exerted, which exceeds the ideal limit for the induced dental movement, there are some characteristic dental alveolar changes, such as the alveolar process inclination and vestibularization of the anchorage teeth. These changes in the long axis of the posterior teeth present themselves as highly recurrent and need an over-expansion of the posterosuperior segment, in

order to achieve a satisfactory final result (3, 8, 21).

The immediate changes after the RME, of the interdental transversal distances observed in models of study, such as Adkins et al, whom in 1990 studied a sample composed of patients treated with the Hyrax appliance. An increase of 6.5 mm was noted for the upper inter-first molars distance (29). Handelman, in 1997, reported an increase in the upper inter-first molars distance of 3.9 to 7.5 mm with the Haas type expander appliance (30). Lagravère et al in 2006 examined the intermolar maxillary distances through models and frontal telera-diographies reporting an increase of 6.04 mm and 6.74 mm, respectively. The intermolar maxillary distance measured in the apices of the medial root raised 4.44 mm (31).

In our study, the average change of the interdental distance of the teeth 16-26 between T1 and T2 can be analyzed in Table 3, appearing to be statistically significant with 5.85 mm.

### Displacement of the upper canines

When examining the effect of the treatment carried out in the variables studied, we can verify, according to Table 3, that the inter-canine distance exhibited a statistically significant increase of 5.51 mm. Adkins et al reported that the upper intercanine distance increased 2.9 mm (29). Lagravère et al examined the maxillary intercanine distance and registered an increase of 5.35 mm, when measured from the most apical area of the crown (31). The increase in the intercanine distance was proportionately smaller than the intermolar distance. This result is contrary to the appliance's form of action, which produces a midpalatal suture opening, with greater intensity in the anterior region than in the posterior, an opening in the triangle shaped base for the anterior (3), possibly explained as being due to the greater vestibular inclination of the molars.

Our study's sample was composed mostly of children at the mixed dentition stage and some cases of the sample did not present the temporary canine. So, when they did not show the canine, the intercanine distance was obtained through the point of the alveolar ridge, calculated at half the distance between the lateral incisor and the first premolar. Perhaps due to this measuring option the results of the intercanine distance showed discrepancies.

### Displacement of the inferior molars

The average increase of the mandibular in-



termolar distance, in plaster models, was of 0.33 mm and considered to have no statistic significance.

The descriptive statistical analysis reported by Adkins et al for the lower measures, indicated that there are no major spontaneous changes of the lower arch during the RME, being completely insignificant (less than 0.8 mm) (29). The mandibular transversal dental average changes, also evaluated by Lagravère et al. in 2006 through models and teleradiographies was of 0.49 mm and was not considered statistically significant (31).

### Conclusions

The RME caused a statistically significant increase in the interdental distances with this group of patients. That is to say that the change in distance 16-26, 13-23 and 36-46 in the models was of 5.85 mm, 5.31 mm, and 0,34 mm respectively.

The opening of the appliance is associated with the increase in the interdental distances, i.e., for each opening mm on the appliance, an increase of 0.94 mm is caused in the upper intermolar distance, an increase of 0.87 mm in the upper intercanine distance, and an increase of 0,054 mm in the lower intermolar distance.

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