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KLAMMT'S ELASTIC OPEN ACTIVATOR: RICKETTS' CEPHALOMETRICS RESULTS

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MOTS CLES: appareil fonctionnel, Klammt, céphalométrie, Ricketts.

RESUME

L'intention de cet article c'est la recherche sur les effets orthodontiques et orthopédiques réels de l'Activateur Ouvert Elastique de Klammt (AOE) en 25 patients avec Classe II Division 1 en période de la croissance. Nous voulons établir statistiquement les changes produits sur la céphalométrie de Ricketts dans les téléradiographies latérales du crâne en occlusion, utilisé pour le diagnostique et à la fin du traitement en chaque patient.

La conclusion de cette étude c'est que l'Appareil du Klammt il a une bonne réponse, surtout en les effets dentaires on s'observe une correction de la Relation Molaire et du Overjet. Corrige la protrusion et l'inclination des incisives, même si la finalisation des cases avec les appareils fixes parait inévitable. Squelettiquement se met en évidence la réduction de la Convexité Facial, augmente peu la Profondeur Facial, mais diminue plus la Profondeur Maxillaire. La Longueur du corps mandibulaire augmente, quoique ce change ce soit pour la croissance. No détachent les changes en le profil esthétique.

ABSTRACT

The purpose of this study is to investigate the orthodontic and orthopaedic real effects of the Klammt's Elastic Open Activator (EOA) in 25 Class II Division 1 patients in growing period. We wanted to determine statistically the cephalometrics changes produced in the patients, comparing the lateral cranium teleradiographies we took for the diagnosis with the ones we took at the end of treatment.

At the end of this study we confirm that by using the EOA we obtained the desired effects, especially reducing the molar relation 2.53 mm and the overjet 2.56 mm. The EOA corrected the inclination and protrusion of incisors, although we cannot avoid the use of fixed appliances to round off. The reduction of 2.48 mm of facial convexity stands out as the most important skeletal effect; the facial depth angle increases 0.8º, and the maxillary depth decreases 1.16º. The length of the mandibular corpus also increases 6.7 mm, although this change is mainly due to the growth of the patient. The changes in the aesthetic profile do not stand out.

INTRODUCTION

At the beginning of the 20th century there was a great development in Europe of orthodontic appliances of bimaxillary functional treatment. These changes began with Robin (1902) and Andresen-Häupl (1923). Since then, we talk about rigid activators, elastic devices in double appliances, bimaxillary elastic activators, and rigid double appliances (Bossy A. 1987).

The effects of the functional appliances have been studied in detail in the skeletal level as well as in the dental level. There are many studies in humans and in animals. McNamara (McNamara JA. et al.1987) showed an increased potential of the mandibular growth, which is produced in the condyle in primates. The point of view of Petrovic (Petrovic AG. et al. 1985) is that the activation of the muscles is important to improve the condyle growth. Other authors (Ghafari J. et al. 1986; Tonge EA. et al. 1982) say that by taking out the exterior pterygoid muscle the condilar growth decreases and confirm this hypothesis in experimental mice studies, and Woodside (Woodside DG. et al. 1983) confirms it in experiments with primates. On the other hand, Awn (Awn M. et al. 1987) cut off the lateral pterygoid muscle, which is considered an important factor of regulation of the mandibular growth, and he did not observe any inhibition in the growth of the condyle gristle.

Some studies about the skeletal effects of functional appliances show that the most important differences are in the mandibular growth. Some authors say that this treatment leads to an important growth of the mandible. Birkebaek (Birkebaek L. et al. 1984) says that the most important effect of the activator is that it increases the condyle growth and it produces the modelling of the articular fosse. That combination produces an anterior mandibular displacement. He concludes that this appliance doesn't inhibit the maxillary growth, but it produces a posterior and inferior rotation of the maxillary and the mandible.

Maxillary effects. Vargervik (Vargervik K. et al. 1985) states that the activator inhibits the horizontal maxillary growth about 2 mm, so it produces a better result in the convexity and also in the skeletal relation of the bone basis. Pancherz (Pancherz H. 1984) observed an inhibition of 1.7 mm in the horizontal growth of the maxilla. Fischer-Brandies (Fischer H. 1989) in a study with the Bimler appliance did not find any meaningful difference in the mandible development and maxillary length. Thus, he concluded that the correction of the class II division 1 is not only due to skeletal changes but also to the dentoalveolar changes.

About mandibular effects there are different opinions too. Some authors defend that the mandible length increases with functional therapy (Reey RW. et al. 1978; Luder HU. 1981; Chang H. et al. 1989; Jakobsson SO. 1967). Other concludes that the functional therapy can inhibit the sagital maxillary growth and it can also stimulate the mandible growth (Joffe L. et al. 1979; Fotis V. et al. 1984). DeVicenzo (DeVincenzo JP. 1991) found meaningful increments in the mandible length during the two first years of treatment, less meaningful increments in the third year and no differences in the fourth year. These results mean that the effects we see and we think that are produced by the activator are only an advance of what will happen in the future without treatment. Moreover he finds a very important individual variability in the growing response.

Petrovic (Petrovic AG. et al. 1985) says that while the activator is in the mouth, the protruded position of the mandible (due to the constructive bite) produces a reduction in the growth of the lateral pterygoid muscle. This fact produces a new sensitive gear that makes the mandible get used to that new position. When the appliance is not in the mouth, the mandible is placed in an advanced position and it makes that the condilar gristle have a quicker growth. He concluded that the effect of the lateral pterygoid muscle is essential for the increment of the condyle growth. Whetten (Whetten LL. et al. 1985) believes that a protrusive position of the mandible, which should be obtained in periods when the activator is not in the mouth, should benefit the condyle growth.

McNamara (McNamara JA. et al. 1985) observed an increment, both in the mandibular body length, and in the vertical dimension. His opinion is that the mandibular advancement takes place in the facial axis direction. Other authors found meaningful differences in the increment of the mandible length, like Menéndez (Menéndez M. et al. 1992) in a study with 50 patients who used the Bionator appliance or Solano (Solano E. 1992) with a study that compared the Bimler appliance and the EOA. Vargervik (Vargervik K. et al. 1985) and Gianelly (Gianelly AA. et al. 1983) said that the mandible length couldn't change with any functional therapy. Nelson (Nelson C. et al. 1993) did not find any evidence to prove that either the Harvold activator or the Fränkel regulator, are able to change the mandible length. The same authors confirm that they found meaningful changes in the mandible length before and after the functional treatment when it is compared with a control group. However when the variable has a relation with the height of the patient, this signification is reduced to zero. Thus, the mandible length doesn't grow more in these patients compared to the ones who don't use these appliances. Robertson (Robertson NRE. 1983) and Hamilton (Hamilton SD. et al. 1987) find the same negative results in the mandible length growth. Jakobsson (Jakobsson SO. et al. 1990) says that the changes he found in his treatments were due to changes in the condyle position.

Mamandras (Mamandras AH. et al. 1990) suggested that the patients who have a reduced mandible length - determined with the standard growing patrons- would benefit more the use of the Bionator appliance than those who have a "correct" mandible length.

McNamara (McNamara JA. 1984) in a study of young adults showed that in none of these cases was found a meaningful increment of the mandible length. He also said that the dental and skeletal changes he caused were the smallest possible and they weren't enough to resolve their malocclusion. These results confirm that the treatment with functional appliances is only useful in periods of active growth.

Dental effects. Jakobsson (Jakobsson SO. 1967) observed a vestibular displacement of the alveolar bone and the lower incisors. Surber (Surber H. 1970) observed that there's an inverse exponential decrease in the overjet as well as in the overbite using the EOA. He got changes from 1.8 to 0.3 mm in the three first months of treatment, and become stable at the 5th month as 0.2 mm. Drage (Drage KJ. et al. 1990) concluded that the changes in the overjet were due to dentoalveolar changes, and the improvement he found was of 0.8 mm with an important individual variation (from +5.2 to -3.7 mm). Wieslander (Wieslander L. et al. 1979) and Rutter (Rutter RR. et al. 1990) described the same lower incisors protrusion effect and upper incisors retrusion in treatments of class II division 1 with functional appliances, giving more importance to the dentoalveolar changes. Calvert (Calvert FJ. 1982) Pancherz (Pancherz H. 1984) and Wieslander (Wieslander L. et al. 1979) observed dentoalveolar meaningful changes with the use of an activator. Harvold (Harvold EP. et al. 1971) observed that his activator produced a retrusion of 1.4 mm in the upper incisor and a protrusion of 0.5 mm in the lower incisor, which is considered very useful in class II division 1 treatments. Solano (Solano E. 1992) in a study about Klammt and Bimler appliances found that there were meaningful reductions in the overjet (6.4 mm) and overbite (-3.6 mm) and he did not find any difference between both appliances.

McNamara (McNamara LL. et al. 1985) found a decrease in the natural forward movement of the first upper molar and an increment of the vertical growth of the first lower molar. There was a meaningful retrusion of the upper incisor (2 mm). He treated young adults of class II division 1 with functional appliances, and he observed an improvement in the relationship of the anterior teeth after two years of treatment.

Haynes (Haynes S. 1986) made a study about the profile with functional appliances. He saw that the profile modifications are only due to changes that take place in the incisors, but there are no changes in the profile caused by variations in the mandible position or mandible growth.

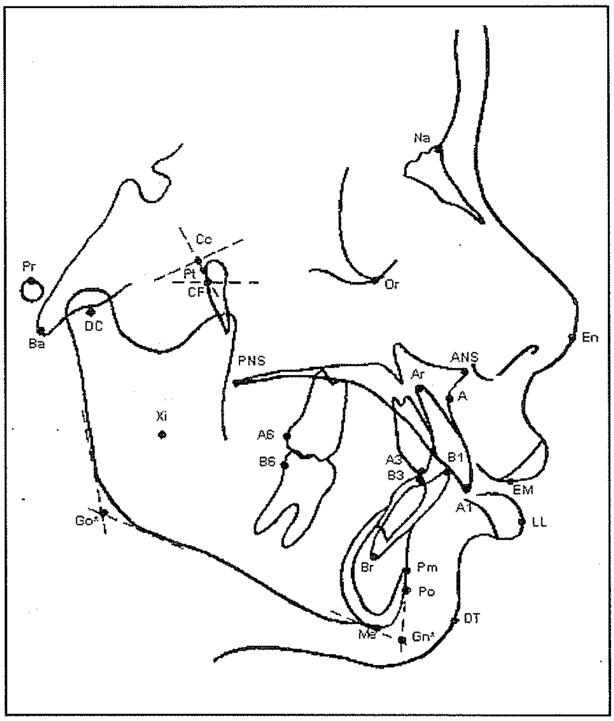

Fig. 1: *Points of Ricketts' cephalometrics. Cranial: Na (Nasion), Ba (Basion), Pr (Porion), Cc (intersection Ba-Na/Na-Po), Pt (posterior Pterigoid fissure), Cf (intersection FH/PTV), OR (Orbicular). Maxilla: A (deepest anterior edge), ANS (anterior nasal spine), PNS (posterior nasal spine), A1 (incisor tip), Ar (incisor apex), A3 (canine tip), A6 (first molar posterior edge). Mandible: DC (center condyle), Xi (center ramus), Go (Gonion), Me (Menton), Gn* (spatial gnation), Po (Pogonion), Pm (infexion symphysis), B1 (incisor lip), Br (incisor apex), B3 (canine lip), B6 (first molar posterior edge). Profile: En (nase lip), EM (inferior upper lip), LL (anterior lower lip), DT (anterior edge soft chin).*

MATERIAL AND METHODS

In this study we used the data obtained from 50 lateral teleradiographics and their Ricketts' cephalometric analysis (Figg. 1-2). This teleradiographics were made to 25 patients, 12 boys and 13 girls (Fig. 3), who had molar class II or incisors biprotrusion. The teleradiographics were made before and after the treatment with the EOA.

The average age at the beginning of the treatment was 8 years and 8 months and the average duration of the treatment was 30.2 months. For this reason we take the norm values of 8.5 years at the beginning of treatment and we add 2.5 years at the end of treatment in the parameters needed. The signboard presents a facial patron predominant mesocephalic (Fig. 4).

Patient's selection

Patients should be in an active phase of growth, they should present an skeletal class II, and molar and incisors class II (or at least an upper incisors protrusion); they should have quality teleradiographics of the beginning and end of the treatment; the patients should

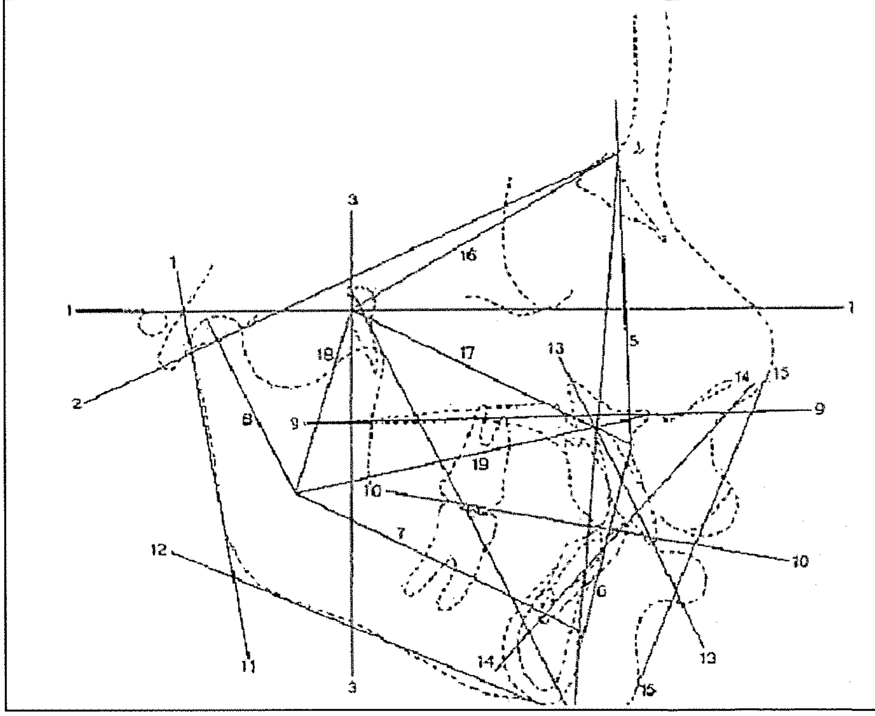

Fig. 2: *Ricketts planes and lines of reference:*
1. Frankfort plane (FH),
2. Basion-Nasion plane (Ba-Na),
3. Pterygoid vertical plane (PTV),
4. Facial plane (Na-Po),
5. Nasal plane (Na-A),
6. Dental plane (A-Po),
7. Corpus axis (Xi-Pm),
8. Condyle axis (Xi-Dc),
9. Palatal plane (ANS-PNS),
10. Occlusal plane,
11. Postmandibular plane,
12. Mandibular plane (Go-Gn),
13. Upper incisor,
14. Lower incisor,
15. Esthetic line (E line),
16. Anterior cranial base Cf-Na,
17. Cf-A plane,
18. Cf-Xi plane,
19. Xi-ANS plane.

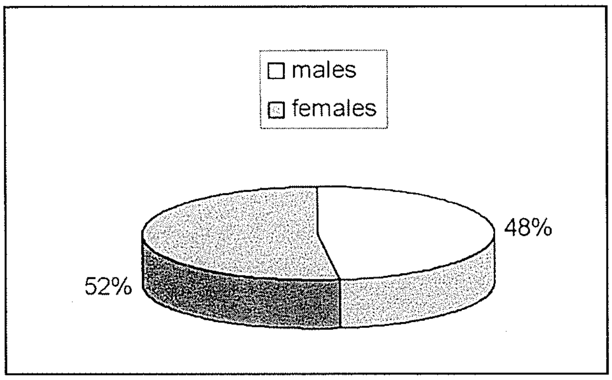

Fig. 3: *Patient's distribution according to sex.*

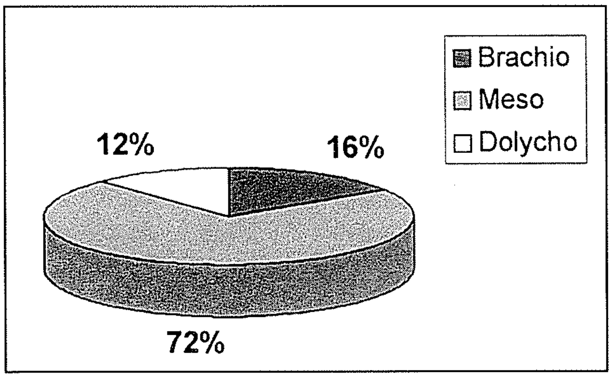

Fig. 4: *Patient's distribution according to facial pattern.*

have used a EOA (Fig. 5) during a minimum of 12 months at least without any other treatment at the same time; they should be good collaborators during the treatment.

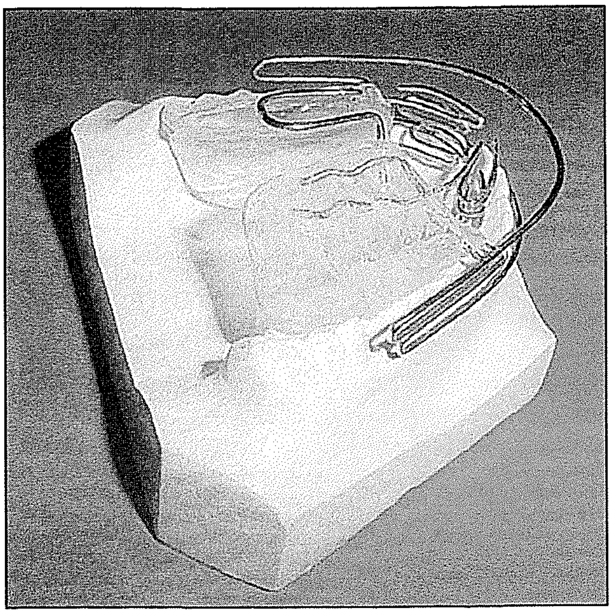

Fig. 5: *Klammt's Elastic Open Activator.*

Working method

The cephalometry is one of the most exact methods we use to measure the bone and soft tissues profile, but it is highly subject to the operator error, and there are some points in which during it's determination the error danger is frequent.

We trace and measure all the teleradiographics twice to confirm the result and to avoid a tracing error, a measure error or a transcription error.

We used all of the parameters of the 6 fields of Ricketts' cephalometrics except for two: the canine relation (because the patients are in mixed dentition) and the cranial length (because we can not modify it). The cranial deflection (not affected by growth) and Porion (Po) location (affected by growth) are used as control parameters.

Statistic method

The two average measures were obtained from the same sample, using a design of couplet data. Every patient was compared with himself.

Once we obtained the cephalometrics measures of the 25 patients and made the average of every patient, we calculated the average of all the patients and also the typical deviation of the beginning and ending values.

From this values we calculated the Student's "t" which shows us if one difference is statistically significant or not, after comparing it with the values which appear in Tab. 1 for 24 degrees of liberty (n-1) and with an error a of 0.001 (0.1%).

There is a problem with the parameters that change with the patient's age, because the norm we are confronting them with is changing from the beginning to the end of the treatment.

We calculated the test value without considering the age or the value variation that takes place with the growing. Using this method we see if there is any change between the values in the beginning and in the end of the treatment.

Once we made this calculation we add (or subtract) from the differences mean (ÍdÙ), the standard variation linked to the growth factor during the 2.5 years of average duration of the treatment. Ricketts defines the parameters, which change with the age as an annual deviation from the 8.5 years onwards, which is the age by which the norm is defined.

The values of the Student's "t" table for 24 (n-1) liberty degrees with an error a < 0.001 is 3.745; for p < 0.01 is 2.797 and for p < 0.05 is 2.064 (Tab. 2).

RESULTS

Now we are going to describe in detail the most important results we have found. All the results are in Tab. 1.

Dental results

The molar relation improves significantly (2.53 mm average), thus shifting from molar class II into molar class I. The upper molar position has increased, resulting in a meaningful difference, although it is mainly due to growth. The overjet that was 7.71 before the treatment is 5.15 after the treatment, so we are near the norm. The overbite has not changed after the treatment, which is an expected result as the values were according to the norm before the treatment. The interincisal angle improves in mean, changing from 125.7 to 128.84, but the high deviation of this value makes the difference unimportant. The lower incisors extrusion, which was correct at the beginning of the treatment, did not change. The EOA lets the normal increase of the upper molar position but it does not vary this value more than it would have varied with just the physiological growth. The Oclusal plane values have had no alterations during the treatment.

Aesthetic results

Only the upper lip length suffered a meaningful change, as it increased significantly for $p<0.02$.

Skeletal results

The EOA has been very useful in the correction of the convexity: the skeletal class II has become a class I. The test results are highly significant to $p<0.001$ (from 5.11 to 2.63). An explanation for this fact is that the facial depth has increased, although not as much as to observe signification in this variation, which has been of only 0.8º. This variation was mainly due to growth: when we take away the standard growing parameters from the values before mentioned, we will hardly find a significant result ($t = 0.066$). The maxillary depth decreased more than 1º, so there was a meaningful difference ($p < 0.01$). We conclude that the convexity decrease was due to a maxillary decrease (or only its growth inhibition), and not to mandible advancement.

The only change that the maxillary height had was due to growth. The palatine plane did not have any significant difference during the treatment.

The mandible parameters show us that there weren't any significant changes in the facial patron of the patient.

Tab. 1. *Result of the means of pre and post-treatment and value of Student's test before and after growing modification. In black the meaningfully values for $p < 0.01$.*

Parameter		Initial Mean	Final Mean	Value of Test t	Value of t after growing modification
1A	Molar relation	1.54	-0.99	**9.1333**	
1C	Incisor overjet	7.71	5.15	**5.9644**	
1D	Incisor overbite	2.98	3.26	0.6244	
1E	Lower incisor extrusion	2.35	2.34	0.5386	
1F	Interincisal angle	125.7	128.84	1.7321	
2A	Convexity of point A	5.11	2.63	7.4799	
2B	Lower facial height	45.12	44.76	0.8475	
3A	Upper molar position	11.97	15.13	6.6104	1.3807
3B	Mand. Incisor protrusion	0,02	1.29	**3.8115**	
3C	Maxil. Incisor protrusion	7.73	6.46	**2.9233**	
3D	Mand. Incisor inclination	21.48	23.04	2.0234	
3E	Maxil. Incisor inclination	33.02	28.16	**3.3323**	
3F	Occlusal plane to ramus	-1.37	-1.3	0.1299	2.1900
3G	Occlusal plane inclination	21.36	21.48	0.2671	2.5148
4A	Lower lip to E-plane	0.85	0	2.1634	0.8908
4B	Upper lip length	24.16	25.71	4.8914	2.5246
4C	Lip embrasure/Occlusal	-3,03	-3.45	1.2525	1.9981
5A	Facial depth angle	84.92	85.72	2.1318	0.0666
5B	Facial axis	87.88	88.24	0.6966	
5C	Facial taper	70.02	69	**2.9396**	
5D	Mandibular plane angle	25.04	25.24	0.3626	1.1332
5E	Maxillary depth	90.42	89.26	**3.5418**	
5F	Maxillary height	56	57.62	5.0749	1.9422
5G	Palatal plane/Frankfort	2,34	2	1.0504	
6A	Cranial deflection	26.82	26.78	0.0990	
6C	Posterior facial height	59.26	65.18	8.3605	**5.5360**
6D	Ramus position	72.44	72.16	0.5147	
6E	Porion location	-40.66	-41.86	2.3496	0.5874
6F	Mandibular arch	24,24	27.02	4.7098	2.5921
6G	Corpus length	63.36	69.06	11.2877	**3.3665**

Tab. 2. Values of t for 24 degrees of liberty.

□Error	Values of Student's t
0.2	1.318
0.1	1,711
0.05	2.064
0,02	2.492
0.01	2,797
0.001	3,745

Neither the mandibular plane angle nor the lower facial height presented a significant change (0.36º). The facial axis and facial arch did not change. Anyhow we have still found some significant changes in the facial taper for $p<0.01$. This parameter decreases in 1.02º and it may be because the Pg point is in a more advanced position, and this closes a little the compass, which makes us find a significant difference in the signboard. Anyway, the conclusion we got was that the EOA did not change the patient's facial patron.

Looking at the mandible, we realize there has been a determining change in the posterior facial height, thus obtaining a significant variation this parameter for $p < 0.001$ once the growth factor has been corrected. The Angle of the mandibular ramus did not present any change during this period.

The mandibular length has changed, but the expected growth was also high. We cannot say there is another reason for the mandibular length increase apart from growth. In this treatment we got significant differences for $p < 0.01$ but not for $p < 0.001$.

The control parameters (Cranial deflection and Porion location) have had the expected changes. The cranial deflection has hardly changed (0.04º) and Student's "t" is 0.09, thus assuring a statistic no-signification of the difference. The Porion location, which is affected by growth, when it's modified with the values of the expected growth, it has a "t" value of 0.58. With this parameter we see that the measurements changed by age, can also be done with the method we use. This confirms us that our method is correct, or at least rigorous, because the variations we observed in controls were minimum.

DISCUSSION

The results we obtained were the ones we expected from a functional appliance: A class II therapy that corrects the convexity, the molar class, the overjet and the inclination and position of the incisors. The convexity reduction was made with an "A" point reduction as Vargevik (Vargervik K. et al. 1985) said who observed a reduction of 2 mm. Also Pancherz (Pancherz H. 1984) obtained similar results getting a reduction of 1.7 mm. The reduction we got in our study was of 1.5 mm. This result confirms the right sense of our therapy. The convexity reduction was made by two facts. On the one hand, there was a reduction of the maxillary growth, and on the other hand there was the activation of the mandibular growth. Thus, we should say that the convexity reduction was due to both bone basis (maxillary and mandible). There are no meaningful changes in the mandible length during the treatment, but there is a significant difference for $p < 0.01$. The length and width of the maxillary arch were not considered. As McNamara (McNamara JA. Et al. 1985) said, the molar relation improved. There is a meaningful decrease of the overjet of -2.56 mm. These results are similar to the ones Harvold (Harvold EP. Et al. 1971) or McNamara (McNamara JA. Et al. 1985) got in their corresponding studies. Drage (Drage KJ et al. 1990) got a result of 0.8 mm and result of Klammt (Klammt G. 1995) was 4.5 mm. Surber (Surber H. 1970) got a reduction from 1.8 to 0.2 mm in three months period. Solano (Solano E. 1992) got reductions of 6.4 mm in the overjet using Klammt and Bimler appliances. In our study there is also a lower incisor advancement (McNamara JA. Et al. 1985; Wieslander L. et al. 1979) of 1.27 mm, which is very favourable for the class II correction. As we did not have values of overbite out of the norm at the beginning of the treatment, the variation was the smallest and at the end of the treatment our values were also into the norm. Some authors began in worst conditions and were able to improve the open bite (Fischer H. 1989; Surber H. 1970). The inclination and location of the upper and lower incisors has also improved. The most significant change was made by the upper incisor location, and the less significant change was made by the lower incisor inclination. There are no important aesthetic changes, although the upper lip length increased significantly. The control parameters we used give us the expected results.

CONCLUSIONS

The evaluation of therapeutics with functional appliances depends largely on the professional expectancy. There is an effective correction of the bone basis; similar to the one we would get using fixed appliances. Functional appliance is only one more method we can use to correct malocclusion. The malocclusions in which we get better results are class II division 1 with upper incisors protrusion and lower incisors retrusion, important overbite and skeletal mandibular retrusion.

The treatment's success depends on the patient's cooperation as well as of the period in which the treatment is used (it should be used in growing period). The appliance should be used from 1.5 to 2.5 years to get a correct condyle adaptation (we must remember that we displace it from the glenoid fosse). Moreover, we should consider that there is a great individual variation in response. After the functional treatment, we'll generally have to use fixed appliances to obtain a perfect function and aesthetics by a correct alignment and occlusion.

REFERENCES

AWN M., GORET-NICAISE M., DHEM A. - Unilateral section of the lateral pterygoid muscle in the growing rat does not alter condylar growth.
Eur. J. Orthod. 9, 123-127, 1987.

BIRKEBAEK L., MELSEN B., TERP S. - A laminographic study alterations of temporo-mandibular joint following activator treatment.
Eur. J. Orthod. 14, 131-137, 1984.

BOSSY A. - Aproximación a una clasificación clínica de los aparatos funcionales bimaxilares.
Ortod. Esp. 28, 47-55, 1987.

CALVERT F.J. - An assessment of Andreasen therapy on Class II Division 1 malocclusion.
Br. J. Orthod. 9, 149-153, 1982.

CHANG H., WU K., CHEN K., CHENG M. - Effects of activator treatment on Class II Division 1 malocclusion.
J. Clin. Orthod. 23, 560-563, 1989.

DEVINCENZO J.P. - Changes in mandibular length before, during and after successful orthopedic correction of Class II malocclusion using a functional appliance.
Am. J. Orthod. 99, 241-257, 1991.

DRAGE K.J, HUNT N.P. - Overjet relapse following functional appliance therapy.
Br. J. Orthod. 17, 205-213, 1990.

FISCHER-BRANDIES H. - Cephalometrics changes in Angle Class II treatment.
Int. J. Orthod. 27, 9-13, 1989.

FOTIS V., MELSEN B., WILLIAMS B., DROSCHL H. - Vertical control as an important ingredient in the treatment of severe sagittal discrepancies.
Am. J. Orthod. 86, 224-232, 1984.

GHAFARI J., DEGROOTE C. - Condylar cartilage response to continuous mandibular displacement in the rat.
Angle Orthod. 56, 49-56, 1986.

GIANELLY A.A., BROSNAN P., MARTIGNONI M., BERNSTEIN L. - Mandibular growth, condyle position and Fränkel appliance therapy.
Angle Orthod. 53, 131-142, 1983.

HAMILTON S.D., SINCLAIR P.M., HAMILTON R.H. - A cephalometrics, tomographic, and dental cast evaluation of Fränkel therapy.
Am. J. Orthod. 92, 427-434, 1987.

HARVOLD E.P., VARGERVIK K.S. - Morphogenetic response to activator treatment.
Am. J. Orthod. 60, 478-490, 1971.

HAYNES S. - Profile changes in modified functional regulator therapy.
Angle Orthod. 56, 309-314, 1986.

JAKOBSSON S.O. - Cephalometrics evaluation of treatment effect on Class II Division 1 malocclusions.
Am. J. Orthod. 53, 446-457, 1967.

JAKOBSSON S.O., PAULIN G. - The influence of activator treatment on skeletal growth in Angle Class II: 1 cases. A roentgenocephalometric study.
Eur. J. Orthod. 12, 174-184, 1990.

JOFFE L., JAKOBSON A. - The maxillary orthopedic splint.
Am. J. Orthod. 75, 54-69, 1979.

KLAMMT G. - El activador elástico abierto.
Quintess. Tecn. (ed. Española) 6, 32-47, 1995.

LUDER H.U. - Effects of activator treatment evidence for the occurrence of two different types of reaction.
Eur. J. Orthod. 3, 205-222, 1981.

MAMANDRAS A.H., ALLEN L.P. - Mandibular response to orthodontic treatment with the Bionator appliance.
Am. J. Orthod. 97, 113-120, 1990.

MCNAMARA J.A. - Dentofacial adaptations in adult patients following functional regulator therapy.
Am. J. Orthod. 85, 57-71, 1984.

MCNAMARA J.A., BOOKSTEIN F.L., SHAUGHNESSY T.G. - Skeletal and dental changes following functional regulator therapy on class II patients.
Am. J. Orthod. 88, 91-110, 1985.

MCNAMARA J.A., BRYAN F.A. - Long-term mandible adaptation to protrusive function: An experimental study in macaca mulatta.
Am. J. Orthod. 92, 98-108, 1987.

MENÉNDEZ M., CARREÑO J. - Efectos ortopédicos y ortodóncicos del Bionator: un estudio sobre una muestra de 50 pacientes con maloclusiones de clase II división 1ª. *Ortod. Esp.* 33, 138-150, 1992.

NELSON C., HARKNESS M., HERBISON P. - Mandibular changes during functional appliance treatment. *Am. J. Orthod.* 104, 153-161, 1993.

PANCHERZ H. - A cephalometrics analysis of skeletal and dental changes contributing to Class II correction in activator treatment. *Am. J. Orthod.* 86, 125-134, 1984.

PETROVIC A.G., STUTZMANN J.J., LAVERGNE J. - Effect of functional appliances on the mandibular condylar cartilage. In: Graber TM. Physiologic principles of functional appliances. St. Louis: Mosby; 1985.

REEY R.W., EASTWOOD A. - The passive activator: case selection, treatment response and corrective mechanics. *Am. J. Orthod.* 73, 378-409, 1978.

ROBERTSON N.R.E. - An examination of treatment changes in children treated with the functional regulator of Fränkel. *Am. J. Orthod.* 83, 299-310, 1983.

RUTTER R.R, WITT E. - Correction of Class II Division 2 malocclusions through the use of the Bionator appliance. *Am. J. Orthod.* 97, 106-112, 1990.

SOLANO E. - Activateurs élastiques: modeleur élastique de Bimler et activateur élastique de Klammt. *Orthod. Fran.* 63, 373-380, 1992.

SURBER H. - Vorlaufige Behandlungsergebnisse mit dem "elastischen offenen Aktivator" nach Klammt. *Fortsch. Kieferorthop* 31, 239-248, 1970.

TONGE E.A., HEATH J.K., MEIKLE M.C. - Anterior mandibular displacement and condylar growth: an experimental study in the rat. *Am. J. Orthod.* 82, 277-287,1982.

VARGERVIK K., HARVOLD E.P. - Response to activator treatment in Class II malocclusion. *Am. J. Orthod.* 88, 242-251, 1985.

WHETTEN L.L., JOHNSTON L.E. - The control of condylar growth: an experimental evaluation of the role of the lateral pterygoid muscle. *Am. J. Orthod.* 88, 181-190, 1985.

WIESLANDER L., LAGERSTRÖM L. - The effect of activator treatment in Class II malocclusions. *Am. J. Orthod.* 75, 20-26, 1979.

WOODSIDE D.G., ALTUNA G., HARVOLD E., HERBERT M., METAXIS A. - Primate experiments in malocclusions and bone induction. *Am. J. Orthod.* 83, 460-468, 1983.

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