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Effects of the mandibular protraction appliance FLF on the face: morphometric analysis

Efeitos do aparelho de protração mandibular FLF na face: análise morfométrica

Efectos del aparato de protracción mandibular FLF en la cara: análisis morfométrico

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Abstract
Objective: To determines the effects of the Mandibular Protraction Appliance FLF associated with fixed orthodontic braces on the face, by means of morphometric analysis. Method: the sample consisted of 60 photographs taken in profile view (30 initial and 30 final photographs) of 30 young Brazilians (17 males and 13 females), with a mean initial age of 12 years and 7 months. Patients who participated in this sample, used the FLF device, and had to have white skin color, with Class II malocclusion, 1st division (minimum ½ class II), mandibular deficiency and convex profile, complete permanent dentition, and balanced growth pattern. The mean time of use of the FLF was 8 months and the mean total time of treatment with fixed devices and MPA FLF was 2 years and 1 month. For comparison between the FLF sample and the skeletal pattern according to Farkas, and comparison between the Pre- and Post-phases, the paired "t" test was used. The significance level of 5% ($p<0.05$) was adopted. Results: there was a statistically significant difference between the values of the sample studied (MPA FLF) and the Farkas sample in T1 analyzed alone, in T2 also analyzed alone, however, when the difference between T2 - T1 was verified, that is, the effect on the proportion of the face, which occurred, there was no statistically significant difference. Conclusion: it could be affirmed that the MPA FLF showed no impact on the face, despite being an effective method for the correction of Class II malocclusion.
Keywords: Malocclusion, Angle Class II; Orthodontics; Face.

Resumo
Objetivo: Determinar os efeitos do Aparelho de Protração Mandibular FLF associado ao aparelho ortodôntico fixo na face, por meio de análise morfométrica. Método: a amostra foi composta por 60 fotografias em perfil (30 iniciais e 30 finais) de 30 jovens brasileiros (17 homens e 13 mulheres), com média de idade inicial de 12 anos e 7 meses. Os pacientes que participaram desta amostra, utilizaram o aparelho FLF, e deveriam ser leucodermas, com má oclusão de Classe II, 1ª divisão (mínimo ½ classe II), deficiência mandibular e perfil convexo, dentição permanente completa e padrão de crescimento equilibrado. O tempo médio de uso do FLF foi de 8 meses e o tempo médio total de tratamento com aparelhos fixos e MPA FLF foi de 2 anos e 1 mês. Para comparação entre a amostra FLF e o padrão esquelético segundo Farkas, e comparação entre as fases Pré e Pós, foi utilizado o teste "t" pareado. Adotou-se o nível de significância de 5% ($p<0,05$). Resultados: houve diferença estatisticamente significante entre os valores da amostra estudada (MPA FLF) e a amostra de Farkas em T1 analisado isoladamente, em T2 também analisado isoladamente,

porém, quando se verificou a diferença entre T2 - T1, ou seja, o efeito na proporção da face, o que ocorreu, não houve diferença estatisticamente significante. Conclusão: pode-se afirmar que o MPA FLF não apresentou impacto na face, apesar de ser um método eficaz para a correção da má oclusão de Classe II.
Palavras-chave: Má Oclusão Classe II de Angle; Ortodontia; Face.

Resumen
Objetivo: Determinar los efectos del Aparato de Protracción Mandibular FLF asociado a ortodoncia fija en la cara, mediante análisis morfométrico. Método: la muestra consistió en 60 fotografias tomadas de perfil (30 fotografias iniciales y 30 finales) de 30 jóvenes brasileños (17 varones y 13 mujeres), con una edad inicial media de 12 años y 7 meses. Los pacientes que participaron de esta muestra, utilizaban el dispositivo FLF, y debían tener color de piel blanca, con maloclusión Clase II, 1ra división (mínimo ½ clase II), deficiencia mandibular y perfil convexo, dentición permanente completa y patrón de crecimiento balanceado. El tiempo medio de uso del FLF fue de 8 meses y el tiempo medio total de tratamiento con dispositivos fijos y MPA FLF fue de 2 años y 1 mes. Para la comparación entre la muestra de FLF y el patrón esquelético según Farkas, y la comparación entre las fases Pre y Post, se utilizó la prueba de "t" pareada. Se adoptó el nivel de significancia del 5% ($p<0,05$). Resultados: hubo diferencia estadísticamente significativa entre los valores de la muestra estudiada (MPA FLF) y la muestra de Farkas en T1 analizada sola, en T2 también analizada sola, sin embargo, cuando se verificó la diferencia entre T2 - T1, o sea, la efecto sobre la proporción de la cara, que se produjo, no hubo diferencia estadísticamente significativa. Conclusión: se puede afirmar que el MPA FLF no mostró impacto en la cara, apesar de ser un método eficaz para la corrección de la maloclusión de Clase II.
Palabras clave: Maloclusión Clase II de Angle; Ortodoncia; Cara.

1. Introduction

Individuals with dentoskeletal disharmony grow differently from those with normal dentoskeletal relationships, both in quantity and in the direction of growth of craniofacial structures. Regarding Class II, 1st division, there is significant deficiency in the amount of mandibular growth in untreated individuals, when compared with untreated Class I individuals (Baccetti et al., 1997; Silva Filho et al., 2009).

Based on the dentoskeletal components that may be involved in this malocclusion, several mechanisms and devices for their correction have been studied. The main objective of any strategy is to correct the sagittal discrepancy, normalize the dentoalveolar and skeletal positions and make the facial profile more harmonious (Ruf & Pancherz, 1999; Silva Filho et al., 2009).

Many devices are used for Class II correction in a non-extraction approach, and the choice of the best device depends on many factors, including patient compliance and knowledge or preference of the professional. Coelho Filho described the Mandibular Protraction Appliance considering an alternative for Class II correction by mandibular protraction, with several modifications (Coelho Filho, 2001). The version described in 2003, modifying only the manner of insertion (now from the mesial aspect) and named MPA FLF (Fontão et al., 2003).

Facial analysis has been a valuable diagnostic resource in Orthodontics. The study of the face and the ability to change its shape has fascinated humanity over the course of time. The clinical ability to change dentofacial shapes by means of orthodontics, modification of facial growth or surgery requires an understanding of the beauty of the face, including the evolution of facial esthetics, proportion, and symmetry (Arnett & Bergman, 1993; Reis et al., 2006; Siqueira et al., 2007).

Farkas et al., (1992) reported on an anthropometric study of the facial growth pattern and the relationships between its parts. This anthropometric study of the head and face was based on a cross-sectional study of data collected from a sample of 1,594 North Americans aged between 01 and 18 years, to provide a mathematical expression for each age group and the gain in growth reflected in each group. Age-related changes in the face were calculated using three vertical, two horizontal, and two projected surface (sagittal) measurements. Among these, there were two sagittal measures of facial depth. The depth in the middle third of the face was determined by measuring the distance between the tragus and subnasal points (T-Sn). In the lower third of the face, it was determined by the distance between the tragus and the gnathion' (T-Gn'). Measurements were taken directly on the individuals' faces, using a caliper (Farkas et al., 1992).

This knowledge is of fundamental importance, since the soft tissue establishes the limit to which the orthodontist can change the dimensions of the dental arches and the position of the mandible (Ackerman, Proffit, & Sarver, 1999). Ultimately, the soft tissue determines the limits of dental compensation for a skeletal discrepancy, since the enthusiasm to achieve a correct dental relationship can compromise facial balance (Pancherz & Anehus-Pancherz, 1994).

Continuous advancement of the mandible is one of the most effective orthopedic treatments used in orthodontics, for correcting Class II malocclusion. Previous studies have demonstrated the impact that this mandibular advancement has on the face, whether performed with removable orthopedic (Jena & Duggal, 2010; O'Neill et al., 2000) or fixed devices (Almeida et al., 2010; Barroso et al., 2012; N. Bock & Pancherz, 2006; Cozza et al., 2006; Flores-Mir et al., 2006; Giuntini et al., 2015; Jena & Duggal, 2010; Marsico et al., 2011; Ruf & Pancherz, 2004). The correction of malocclusion is successfully achieved (Giuntini et al., 2015), with statistically significant effects on the integument, with facial impact that is clinically noticeable by orthodontists but not identifiable by lay persons (Barroso et al., 2012; O'Neill et al., 2000) and with good stability of results in the long term (Bock et al., 2018; N. C. Bock, von Bremen, & Ruf, 2016).

After these considerations, a question remains: does the use of MPA FLF associated with fixed orthodontic braces promote only dentoalveolar changes or would its application be capable of causing integumentary changes in the lower third of the face, resulting from the repositioning of the maxilla and mandible?

2. Method

This was a retrospective study, duly approved by the Research Ethics Committee of the Sagrado Coração University.

The sample consisted of 60 photographs taken in lateral view (30 initial photographs and 30 final photographs) of 30 consecutive patients treated at the Center for Surgery and Orthodontics (CCO), at the Sagrado Coração University (USC) and at the Society for the Social Promotion of Cleft Lip Palatal (Profis), in the cities of Bauru, Jaú and São Paulo-SP.

The sample was consisted of all patients who met the necessary inclusion criteria and who used the MPA FLF device. The MPA FLF acts through the advancement of the mandible, promoting a muscle stretch, which generates a force on the maxilla 24 hours a day, remaining for an average period of 8 months.

Further criteria were observed for sample selection, that is, young people had to have the following characteristics:

- Leukoderma.
- Class II, mandibular deficiency (defined by subjective facial analysis).
- Convex profile (positive sagittal level).
- Angle Class II, Division 1 malocclusion, with a minimum severity of ½ Class II, observed directly on models. Class II had to be 100% corrected at the end of the treatment, seen in the final photographs.
- Complete permanent dentition, without third molars.
- Balanced growth pattern (mesofacial or brachyfacial) determined by subjective facial analysis (presence of passive lip seal and good proportion between the thirds of the face, that is, without increased Lower Anterior Facial Height (LAFH).

Thus, the group consisted of 17 young men and 13 young women, with an average initial age of 12y 7m (10 to 14y 7m) and mean final age on conclusion of treatment of 14y7m (11y 1m to 16y 6m). The mean time of use of the MPA FLF was 8 months (5m to 12m) and the mean total time of treatment with fixed braces and MPA FLF was 2a 1m (1y 2m to 3y 1m).

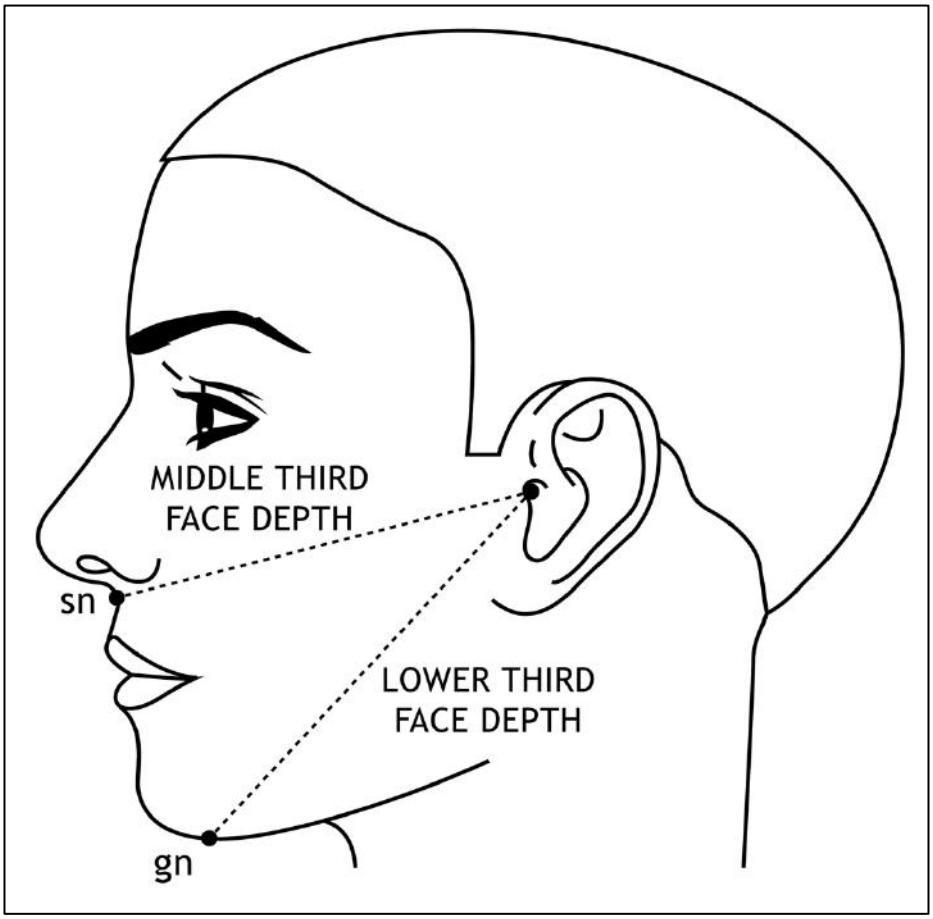
Photographic Method

To conduct this study, two photographs were used, in lateral view, for each patient, considered T1 (initial) and T2 (final – post-corrective). In order to correctly obtain the photographs, the patients were instructed to hold a natural head position and

had a mirror in front of them to help them visualize the position. The lips were in a resting position, slightly sealed, avoiding any forced projection of the jaw.

The photographs were transferred to the Adobe® Photoshop® CS3 program (Adobe Systems Incorporated, San Jose – California) to mark the points and later obtain the linear quantities (Figure 1).

Figure 1: Measurement originally made by Farkas, Posnick and Hreczko.

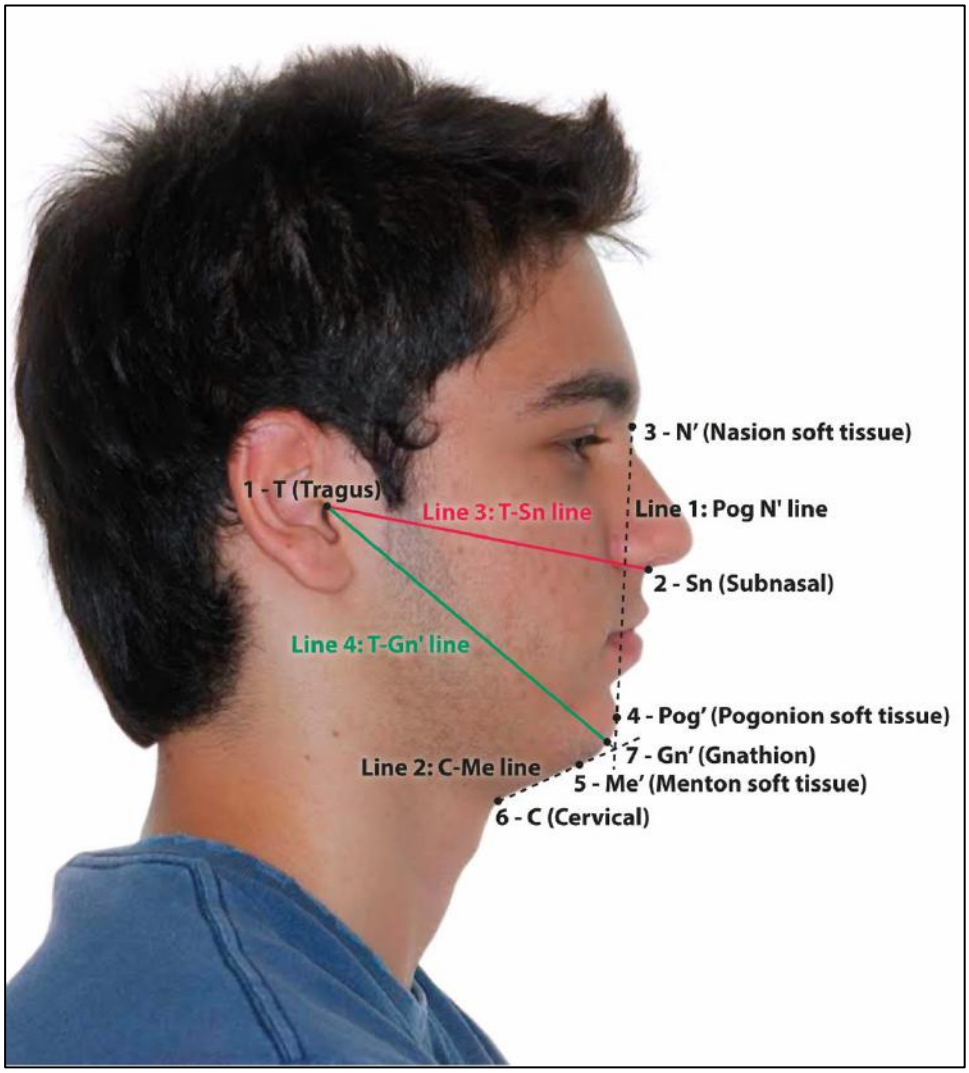


Source: Authors.

In the integumentary profile, the following points and lines were identified (Figure 2):

1. T (tragus): the most anterior point of the supratragic notch of the ear.
2. Sn (subnasal): point located at the confluence between the inferior margin of the nasal columella and the upper lip.
3. N' (nasio soft tissue): point located in the largest depression between the union of the forehead and the nose.
4. Pog' (soft tissue pogonion): most prominent point on the contour of the soft chin.
5. Me' (soft mention): lowermost point of the chin contour.
6. C (cervical): point of union between the lower base of the mandible and the neck.
7. Gn' (gnathion'): constructed point situated between the soft tissue pogonion and the soft mention, located in the bisector projection of the angle formed by the line joining the soft tissue nasion and soft tissue pogonion, with the line joining the cervical points and soft tissue (projection of the angle formed between the lines N'-Pog' and C-Me').
8. N'-Pog' Line: line that passes through points N' and Pog' (line 1).
9. C-Me' Line: line that passes through points C and Me' (line 2).

Figure 2: Points and lines used for measuring.



Source: Authors.

Method of Farkas, Posnick and Hreczko

Farkas, Posnick and Hreczko(Farkas et al., 1992), in their anthropometric study, used three vertical, two horizontal and two projected surface measurements (sagittal) to determine the pattern of facial growth and the relationships between its parts.

Among these, there were two sagittal measures of facial depth. The depth in the middle third of the face was determined by measuring the distance between the tragus and subnasal points (T-Sn). In the lower third of the face, measured by the distance between the tragus and the gnathion' (T-Gn'):

1. Depth of the middle third of the face (T-Sn): formed by points T and Sn (line 3)
2. Depth of the lower third of the face (T-Gn'): formed by the points T and Gn' (line 4).

The photographs were taken in various places, with different cameras and by different operators, that is, there was no standardization among them. In order to make a correlation between the initial and final photographs, a mathematical proportion between them was established.

From the data obtained, the T-Gn' measure was divided by the initial and final T-Sn measure. Thus, there would be a relationship of proportion between the two lines, making it possible to compare them. This comparison reflects the impact on the face due to the use of the MPA FLF with fixed orthodontic braces. The measurement was performed by the same examiner (ALC) and certified by his/her advisor (DFS).

Measurement error evaluation

To determine the intra-examiner error, 30% of the initial photographs and 30% of the final photographs, chosen at random, were traced and measured again after a period of two weeks. To verify the intra-examiner systematic error, the paired "t" test was used. In determining the random error, the error calculation proposed by Dahlberg was used.

Table 1 demonstrates the mean and standard deviation, and the statistical test ("paired t") and Dahlberg error that were used to assess the systematic error and random error of the sample.

Table 1 – Means, standard deviations of the two measurements, paired "t" test and Dahlberg's formula were applied to evaluate systematic error and random error.

Measure	1st Measurement		2nd Measurement		t	p	Error
	mean	SD	mean	SD			
Mand/Max	1.10	0.03	1.10	0.03	11.000	0.331 ns	0.01

ns – No statistically significant difference. Source: Authors.

Statistical analysis

Data were described in tables using mean and standard deviation.

To verify whether the data followed a normal distribution, the Kolmogorov-Smirnov test was used, and, in all groups, there were no statistically significant deviations from normality.

For comparison between the FLF sample and the skeletal pattern according to Farkas, and comparison between the Pre- and Post-phases, the paired "t" test was used. The significance level of 5% ($p<0.05$) was adopted.

All statistical procedures were performed using the Statistica v.5.1 program (StatSoft Inc., Tulsa, USA).

A comparison was made between males and females in the Pre, Post and Post-Pre variation phases and the results were not statistically significant (Table 2).

Table 2. Comparison between male and female genders in the Pre, Post and Post-Pre variation phases.

Phase	Male		Female		Diff.	p
	Mean(mm)	SD	Mean(mm)	SD		
Pre	1,11	0,03	1,10	0,03	-0,01	0,415 ns
Post	1,13	0,05	1,12	0,04	-0,01	0,671 ns
Post-pre	0,02	0,04	0,02	0,05	0,00	0,882 ns

ns – ns – No statistically significant difference. * - Statistically significant difference ($p<0.05$). Source: Authors.

3. Results

The results of the systematic error assessments, evaluated by the paired "t" test, and the random error measured by the Dahlberg formula are shown in Table 1. Nine (9) pre-treatment photographs and nine (9) post-treatment photographs were used, and the results demonstrated the reliability of the methodology used in the measurements.

Table 3. Mean, standard deviation, minimum and maximum values of the variables studied.

Measure	Mean	SD	Minimum	Maximum
Initial age	12.58	1.41	10.00	15.00
Treatment time.	2.06	0.53	1.17	3.75
MPA time	0.67	0.17	0.42	1.00
Final age	14.64	1.42	11.17	16.83
Mand / Max pre	1.10	0.03	1.04	1.17
Mand / Max post	1.12	0.04	1.04	1.21
Farkas pre	1.08	0.01	1.06	1.11
Farkas post	1.09	0.01	1.07	1.11

Source: Authors.

Table 3 shows the mean and standard deviation, and the minimum and maximum values of the variables in the sample studied. Table 4 illustrates the comparison between the sample treated with MPA FLF and the fixed orthodontic braces and the standard sample by Farkas, Posnick and Hreczko in the pre- and post-treatment phases, the Post-Pre variation, using the paired "t" test ".

Table 4. Comparison between the MPA sample and the Farkas pattern[10] in the Pre, Post and Post-Pre variation phases.

Phase	MPA sample		Farkas		Diff.	p
	Mean (mm)	SD	Mean (mm)	SD		
Pre	1.10	0.03	1.08	0.01	-0.03	<< <0.001 *
Post	1.12	0.04	1.09	0.01	-0.03	0.002 *
Post-pre	0.02	0.04	0.01	0.02	-0.00	0.766 ns

ns – No statistically significant difference. * - Statistically significant difference ($p<0.05$). Source: Authors.

A statistically significant difference ($p<0.05$) was observed in the comparison between the two groups in the initial and final comparison (pre- and post-treatment), however, there was no statistically significant difference ($p<0.05$) in the comparison between the groups when the real change resulting from the treatment was analyzed (Post-Pre). Table 5 shows the intra-group comparison, demonstrating the significance of the variation between pre-treatment and post-treatment.

Table 5. Comparison between the MPA sample and the Farkas pattern[10] in the Pre, Post and Post-Pre variation phases.

Group	Pre		Post		Diff.	p
	Mean (mm)	SD	Mean (mm)	SD		
MPA sample	1.10	0.03	1.12	0.04	0.02	0.044 *
Farkas[11]	1.08	0.01	1.09	0.01	0.01	0.001 *

* - Statistically significant difference ($p<0.05$). Source: Authors.

4. Discussion

Orthodontists have traditionally viewed structural discrepancies as the major limitations of orthodontic treatment. In reality, the soft tissue is the feature that enables the therapeutic possibilities to be determined most exactly. Planning changes in facial esthetic is a challenging task, especially when they are integrated with occlusal corrections. Unfortunately, occlusal correction does not always promote correction or even maintenance of facial esthetics.(Arnett & Bergman, 1993) Considering that the main aspiration of orthodontic patients is to recognize themselves as being beautiful, or at least normal, and be recognized as such by society as well, it is important to eliminate unpleasant features of their smile and face (Reis et al., 2006).

Clinical evaluation of the face has been described and complemented by several authors (Ackerman et al., 1999; Arnett & Bergman, 1993; Farkas et al., 1992; Reis et al., 2006). As it constitutes a morphogenetic heritage, the face is defined at an early stage, which makes it possible to qualify skeletal discrepancies clearly, at least the sagittal types, by means of facial analysis from the time of deciduous dentition. The morphology that is identified will be preserved throughout the spontaneous growth of the face (Baccetti et al., 1997; Silva Filho et al., 2009). Based on Farkas' methodology, the present study determined the impact of MPA FLF, associated with fixed orthodontic braces, on the face, by evaluating Class II patients by their soft tissue, without the use of cephalometric measurements. Only the face was evaluated (Farkas et al., 1992; Jena & Duggal, 2010).

The results showed that when the observation in the final comparison, the groups were not equal (Table 4). The control sample showed a proportion of 1.08mm at the beginning and this increased to 1.09mm. In the FLF group this proportion changed from 1.10mm to 1.12mm, and in both groups these changes were statistically significant. The real changes: that is, when values at the end of treatment (T2) were compared with those at the beginning of the treatment (T1), statistically significant changes could be seen in both groups, as shown in Table 5, but without differences between them (Table 4).

Class II individuals grow, their facial proportions change, but they will still have facial pattern II. Therapeutically they also continue to be different; that is, even after being treated they continue to be Pattern II. Therefore, they are different at the beginning and will be different at the end. The growth manifested in Class I and Class II individuals does not change the morphological relationship of the apical bases in the face, substantiating the affirmation that the face grows while the initial model is preserved (Baccetti et al., 1997; Cozza et al., 2006; Silva Filho et al., 2009).

The continuous advancement of the mandible is one of the most significant orthopedic phenomena in orthodontics. However, the most predictable effect of devices with sagittal orthopedic forces is the correction of Class II malocclusion. No

matter how well the device works, it is not possible to achieve the pure orthopedic effect in practice, as there is no device capable of inducing exclusively skeletal effects. In some cases, the devices may have an impact on the face, depending on the patient's growth pattern, the presence of remnant growth at the time of treatment and the effectiveness of the device itself (Silva Filho et al., 2009; Siqueira et al., 2007).

Treatment with orthopedic intent to correct mandibular deficiency triggers a mixture of orthopedic and, particularly, orthodontic effects. The continuous advancement of the mandible promotes an adaptation of muscle function within a relatively short period. Compensatory dentoalveolar changes occur, represented by mesial displacement of the mandibular arch, distal displacement of the maxillary arch (Coelho Filho, 2001; Siqueira et al., 2007), some restriction of maxillary growth (Diógenes et al., 2011; Guimarães et al., 2013; Pancherz & Anehus-Pancherz, 1994) and increased mandibular growth (Ardeshna et al., 2019; Cozza et al., 2006; Giuntini et al., 2015; Marsico et al., 2011). Orthodontic changes involve distalization and intrusion of the maxillary molars (Ruf & Pancherz, 1999; Siqueira et al., 2007), uprighting of the maxillary incisors (Diógenes et al., 2011; Jena & Duggal, 2010; Ruf & Pancherz, 1999, 2004; Siqueira et al., 2007), buccalization of the mandibular incisors (Coelho Filho, 2001; Diógenes et al., 2011; Furquim et al.,2013; Giuntini et al., 2015; Guimarães et al., 2013; Jena & Duggal, 2010; Pontes et al., 2017; Ruf & Pancherz, 1999, 2004; Siqueira et al., 2007) and mesialization of the mandibular molars (Furquim et al., 2013; Jena & Duggal, 2010; Pontes et al., 2017; Ruf & Pancherz, 1999, 2004; Siqueira et al., 2007).

Fixed orthopedic devices reduce facial convexity (Diógenes et al., 2011; Pancherz & Anehus-Pancherz, 1994; Pontes et al., 2017; Ruf & Pancherz, 1999, 2004; Siqueira et al., 2007) mainly by acting on the nasolabial angle (Furquim et al., 2013; Siqueira et al., 2007) (due to the inclination of the maxillary incisors towards the palatine region) and by the protrusion of the lower lip (Siqueira et al., 2007) (caused by the mesialization of the mandibular teeth), thus providing an improvement in the facial profile (Diógenes et al., 2011). This is a positive factor since the literature describes a preference for straight facial profiles (Almeida et al., 2010). During treatment there is a temporary mesial displacement of the mandible. The drive to return to the original position leads to an *en bloc* distalization of the maxillary dentoalveolar process. This provides a significant improvement in the maxilla/mandible relationship and produces positive aspects in the face. However, as Silva Filho (Silva Filho et al., 2009) said, we have to admit the impossibility of fully restoring the congenital deficit through orthopedic/orthodontic treatment.

Siqueira et al (Siqueira et al., 2007) observed some changes in the profile of patients treated with MPA associated with the fixed braces. These alterations were related to the reduction in the value of the nasolabial angle, resulting from the palatal inclination of the maxillary incisors, and to the protrusion of the lower lip, resulting from the mesialization of the mandibular teeth. In agreement with these results, Diógenes et al, 2011) also confirmed that the use of MPA significantly influenced the integumentary profile of patients.

The responses obtained in this study were consistent with the findings in the literature. Moreover, they demonstrated that the effects on the face were of small magnitude and could not be verified when compared with the control group. Previous studies (Almeida et al., 2010; Barroso et al., 2012; Flores-Mir et al., 2006; Marsico et al., 2011) have also evaluated the face of patients undergoing continuous mandibular advancement and demonstrated a statistically significant mandibular growth, which could not be clinically perceived. Moreover, they showed the inability of lay persons to identify the advancement of the mandible and change in the attractiveness of the facial profile (Barroso et al., 2012; O'Neill et al., 2000).

Perhaps the absence of a significant effect on the face is an advantage, at least from the point of view of patients who, according to recent research (Espinosa et al.,2021), assessed their face and were satisfied with it without the impact of treatment. They did not identify sagittal changes of up to 2mm and most of them were dissatisfied with the profiles after the 4mm advancement of the mandible. After all, the person who should be most satisfied with the result of the treatment must be our patient.

5. Conclusion

Analysis by the morphometric method about the impact on the face in Class II individuals with mandibular deficiency allowed us to conclude that although the MPA FLF was an effective method for the correction of Class II malocclusion, it did not demonstrate any impact on the face. The changes found were attributable to the individual's inherent growth and the reflection of dental compensation resulting from occlusal correction.

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