UNIVERSIDADE DE SÃO PAULO
FACULDADE DE ODONTOLOGIA DE BAURU

CRISTINA BASTIANI

Effects of Twin Block and Herbst devices on pharyngeal airway, hyoid bone and soft palate in Class II malocclusion during the peak period

Efeitos dos aparelhos Twin Block e Herbst nas vias aéreas faríngeas, osso hioide e palato mole no tratamento da má oclusão de Classe II durante o período de pico de crescimento

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Orientador: Prof. Dr. José Fernando Castanha Henriques

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DEDICATÓRIA

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ABSTRACT

Effects of Twin Block and Herbst devices on pharyngeal airway, hyoid bone and soft palate in Class II malocclusion during the peak period

Introduction: This retrospective study aimed to compare cephalometrically the effects promoted by the Twin Block (TB) and Herbst devices on the pharyngeal airway, hyoid bone and soft palate in patients with Class II mal occlusion during the peak growth period. **Material e Methods:** The sample consisted of 44 patients divided into 2 groups. The TB group comprised of 21 subjects (13 male and 8 female) with mean initial and final ages of 11.59 and 12.69 years, respectively, and the Herbst group comprised of 23 subjects (13 male and 10 female) with initial mean age of 12.69 and final mean age of 14.47. Head films were obtained in 2 stages: (T1) pre-treatment and (T2) pos orthopedic phase to compare skeletal, dental, pharyngeal airway, hyoid bone and soft palate (SP) measurements. Paired samples and independent-samples *t* tests were used for the intragroup and intergroup comparisons, respectively. **Results**: The Herbst group demonstrated significantly greater amount of labial tipping and protrusion of the mandibular incisors than the TB group. In pharyngeal area and soft palate thickness, the Herbst group presented a significantly greater increase than the TB group. **Conclusion:** The effects of Herbst device on the mandibular incisors, pharyngeal area, and soft palate were greater in relation than the effects of TB device. TB produced an improvement in oropharyngeal area and lower pharyngeal dimension.

Key words: Functional appliances; Twin Block; Herbst; Orthodontics; Pharyngeal airway.

RESUMO

Título: Alterações das vias aéreas faríngeas, osso hioide e palato mole após o tratamento da má oclusão de Classe II com os aparelhos Twin Block e Herbst durante o período de pico de crescimento.

Introdução: Este estudo retrospectivo teve como objetivo verificar os efeitos produzidos pelos aparelhos Twin Block e Herbst nas vias aéreas faríngeas, osso hioide, palato mole, alterações dentoesqueléticas e tegumentares em pacientes com má oclusão de Classe II durante o período de pico de crescimento. **Materiais e métodos:** A amostra foi composta por 44 pacientes divididos em 2 grupos: O grupo Twin Block (TB) foi composto por 21 pacientes (13 do sexo masculino e 8 do sexo feminino) com idade média inicial de 11,59 anos e idade média final de 13,69 anos. O grupo Herbst será constituído por 23 pacientes (13 do sexo masculino e 10 do sexo feminino) com idade média inicial de 12,69 anos e idade média final de 14,47 anos. Telerradiografias obtidas ao em 2 estágios (T1) pré-tratamento e (T2) após a conclusão da fase ortopédica foram utilizadas para a verificação das medidas esqueléticas, dentárias, vias aéreas faríngeas, osso hioide e palato mole. Para as comparações intragrupos, o teste *t* pareado foi utilizado e para as comparações intergrupos, o teste *t* independente foi o eleito. **Resultados:** O grupo Herbst demonstrou um aumento significativamente maior inclinação labial e protrusão dos incisivos inferiores do que no grupo TB. Na área faríngea e espessura do palato mole, o grupo Herbst apresentou aumento significativamente maior em relação ao grupo TB. **Conclusão:** Os efeitos do dispositivo Herbst nos incisivos inferiores, região faríngea e palato mole foram maiores em relação aos efeitos do dispositivo TB. O TB produziu uma melhora na área orofaríngea e na dimensão faríngea inferior.

Palavras-chave: Aparelhos funcionais; Twin Block; Herbst; Ortodontia; Vias aéreas;

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LIST OF ABBREVIATIONS AND ACRONYMS

S	Midpoint of sella turcica (the center of sella turcica)
N	Nasion, the most anterior point of the frontonasal suture in the midsagittal plane
A	The deepest midline point on the anterior outer contour of the maxillary alveolar process
B	The deepest point on the anterior outer contour of the mandible
Mx1	Incisal tip of most anterior maxillary central incisor
Md1	Incisal tip of most anterior mandibular central incisor
Po	Pogonion, the most anterior point of the bony chin in the midsagittal plane
Go	Gonion, a point at the intersection of lines tangent to the posterior border of the ramus and the lower border of the mandible
Gn	Gnathion, the most anterior inferior point of the bony chin
ANS	Anterior nasal spine, anterior point of maxillary bone
PSN	Posterior nasal spine, posterior limit of bony palate
Ba	The most posterior limit of the lowest point in the midline on the anterior margin of the foramen magnum
AD1	Posterior pharyngeal wall along the line from PNS to Ba
AD2	Adenoid tissue along, the line from PNS to H
Ptm	Pterygomaxillare
Cv3ai	The most anterior point on the inferior margin of the outline of the body of the third cervical vertebra
Cv3pi	The most posterior point on the inferior margin of the outline of the body of the third cervical vertebra
aa	Anterior arch of the atlas the most anterior point on the anterior arch of the atlas (C1) assumed to be in the median sagittal plane
Hyoid	The most superior point on the anterior surface of the outline of the body of the third cervical vertebra

T point	Tuberculum sella, the intersection point of the lower contours of the anterior clinoid processes and the contour of the anterior wall of the sella
W point	Wing points, the intersection of the contour of the ala majõr with the jugum sphenoidale
P point	Lower tip of the uvula
SP1	Front of uvula at its thickest point
SP2	Back of uvula at its thickest point
SNA(°)	The angle between the lines Sella-Nasion and Nasion-A point
SNB(°)	The angle between the lines Sella-Nasion and Nasion-B point
ANB(°)	The angle between the lines Nasion-A point and Nasion-B point
Mx1-NA (mm)	Perpendicular distance of the incisal point of the maxillary incisor to the NA line
Mx1-NA (°)	Angle between maxillary incisor long axis and NA plane
Md1-NB (mm)	Perpendicular distance of the incisal point of the mandibular incisor to the NB line
Md1-NB (°)	Angle between mandibular incisor long axis and NB plane
SN-GoGn (°)	Angle between the SN plane and GoGn plane
FMA (°)	Angle between the Frankfort horizontal plane and the mandibular plane
IMPA (°)	Inclination of the mandibular incisors to the mandibular plane
VRL	Vertical reference line, perpendicular line passing through the T point
HRL	Horizontal reference line, the line passing through the T and W points
PNS-AD1	The distance from PNS to AD1
PNS-AD2	The distance from PNS to AD2
McNamara upper pharyngeal dimension	Minimum distance from the SP to the nearest point of the posterior pharyngeal wall

McNamara lower pharyngeal dimension	Minimum distance from the point in which the posterior pharyngeal wall through the line between Cv3ai and Cv3pi points
PL	The palatal line, the line passing through ANS and PNS points
SpL	Sphenoid line, tangent to lower border of sphenoid registered on basion
AAL	Anterior atlas line, perpendicular line to PL registered on Ptm
PML	Pterygomaxillary line, perpendicular line to PL registered on Ptm
Np	Area Describe the 4 sides of a trapezoid which defines the nasopharyngeal area
Aerial area	Part of NP area that is consisting of air
Adenoidal area	Part of NP area that is consisting of soft tissue
Oropharyngeal area	PL and the Cv3ai-Cv3pi line were accepted as the upper and lower border of the oropharyngeal area
Hyoid-SWpoint	The distance from hyoid to the horizontal reference line
Hyoid-VRL	The distance from hyoid point to VRL
Hyoid-CV3ai	The distance from hyoid to Cv3ai
SP length	The distance between PNS and P points
SP thickness	The distance between PNS and P points
SP angle	Angle between the ANS-PNS line and PNS-P line
T1	Pre-treatment stage
T2	Posttreatment stage
(°)	Degree
mm	Milimeter

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1 INTRODUCTION AND JUSTIFICATION

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Skeletal Class II malocclusion is a problem that affects around one third of the population. (MCLAIN; PROFFITT, 1985; PROFFIT; FIELDS JR; MORAY, 1998) When associated with mandibular retrognathism, it impairs facial harmony and dental relationships.

Functional appliances are indicated for the treatment of skeletal Class II malocclusion, especially in patients who are in the growth spurt. (BACCETTI; FRANCHI; MCNAMARA JR, 2005) This type of device promotes a therapy able of potentiating mandibular growth. (MCNAMARA JR, 1981) There are numerous types of functional appliances aimed at stimulating mandibular growth by positioning it forward and downward. (MCNAMARA JR; CARLSON, 1979) A study realized in young primates stated that the Herbst fixed functional appliance would be able to promote changes in the glenoid fossa, condyle and temporomandibular joint. (WOODSIDE; METAXAS; ALTUNA, 1987) However, results in humans are often controversial and ambiguous. (COZZA et al., 2006)

While some researchers report favorable results based on mandibular growth, equally in terms of length increase and in terms of effective condyle growth, (MCNAMARA JR; HOWE; DISCHINGER, 1990; FRANCHI; BACCETTI; MCNAMARA JR, 1999) other authors question the magnitude of these effects. (BACCETTI; FRANCHI; MCNAMARA JR, 2005; FLORES-MIR et al., 2007). In addition, existing evidence indicates that the dentoalveolar changes produced by treatment outweigh the skeletal changes achieved.

Studies have reported that early orthodontics in treatment of patients with Class II malocclusion associated with mandibular retrognathism with Functional appliances could be beneficial in preventing airway problems. (HÄNGGI et al., 2008; KANNAN; SATHYANARAYANA; PADMANABHAN, 2017)

There is a close relationship between the anatomy and function of the pharyngeal airways and craniofacial development. Due to the posterior position of the mandible, mandibular retrusion has been associated with respiratory problems. The

fact that the jaw and tongue are positioned more posteriorly in patients with mandibular retrusion causes the airways to be restricted. (CEYLAN; OKTAY, 1995; COZZA et al., 2008; ALI; SHAIKH; FIDA, 2015) Ansar et al, stated that normal airways are responsible for adequate craniofacial development. (ANSAR et al., 2015)

Because the correction of Class II malocclusion is associated with anterior positioning of the mandible, there is an improvement in the airway. (GÖYMEN; MOURAD; GÜLEÇ, 2019) Thus, studies have related the use of functional appliances in patients at pre-peak and peak growth to a positive influence on the airways. (MURAT ÖZBEK et al., 1998) In contrast, other researchers have not been able to find a correlation between functional appliances and the airway. (LIN; LIN; TSAI, 2011)

Conceived by Dr. Clark in his orthodontic practice in Scotland, the Twin Block removable functional appliance has been widely used in the correction of Class II malocclusion. (CLARK, 1988) Its efficiency is widely described in the literature, stating that the use of this removable appliance in the treatment of Class II allows a correction in the maxillomandibular relationship and promotes an increase in mandibular increments in patients during growth. Because it is comfortable and well accepted by patients, it is the most widely used removable functional appliance in the UK. (BANKS; WRIGHT; O'BRIEN, 2004; GIUNTINI et al., 2015; KORETSI et al., 2015; TSIOULI et al., 2017; CAMPBELL et al., 2020)

Due to the popularity of its results, its effect on the airways has been speculated. A recent study published in 2019 states that the improvement in the airways is mainly due to the soft tissue and muscle changes that accompany the sagittal position of the mandible. Thus, it can prevent the habit of mouth breathing that can negatively affect the developing occlusion and skeletal morphology. It can also eradicate the causative factors of obstructive sleep apnea in adulthood. (ELABBASY, 2019)

In the same way that the relationship between removable functional appliances and the airways is questioned, the effects of fixed functional appliances on these are also speculated. There are reports of great individual variability in changes in the posterior airway space (PAS) in defined planes, apparently not directly correlated with the extent of therapeutic sagittal effects and improvement in overjet and molar positions. (KINZINGER et al., 2011b) One study stated that the effects immediately

after insertion of the fixed functional appliance promote expansion of pharyngeal depth in all planes. However, after completion of treatment, investigators reported no long-term effect on pharyngeal dimensions compared to baseline. (KINZINGER et al., 2011a; KINZINGER et al., 2011b)

The Herbst appliance connects the maxillary first molar with the mandibular dentition on both sides through a telescopic (rod and tube), thus keeping the mandible in continuous anterior position. Treatment time is usually lasting from 6 to 9 months. The condyles are positioned inferiorly and anteriorly in relation to the original position of the condyle-fossa. As a result, the mandibular position and muscle function could result in growth enhancement to correct skeletal malocclusion. (COZZA et al., 2006; KINZINGER et al., 2018)

A study claims that there was an increase in air space in patients treated with Herbst and maxillary expansion, despite the stable position of the hyoid bone. In contrast, this same study showed a descending position of the hyoid bone after treatment and follow-up, in relation to the start of treatment. (SCHÜTZ et al., 2011)

Therefore, the aim of the present study was to compare alterations in the pharyngeal airways, position of the hyoid, soft palate (SP), dentoskeletal and tegumentary morphology between patients treated with the removable Twin Block and the fixed Herbst.

2 ARTICLES

2 ARTICLES

2.1 ARTICLE 1 - Effects of Twin Block and Herbst devices on pharyngeal airway, hyoid bone and soft palate in Class II malocclusion during the peak period.

ABSTRACT

Introduction: This retrospective study aimed to compare cephalometrically the effects promoted by the Twin Block (TB) and Herbst devices on the pharyngeal airway, hyoid bone and soft palate in patients with Class II mal occlusion during the peak growth period. **Material e Methods:** The sample consisted of 44 patients divided into 2 groups. The TB group comprised of 21 subjects (13 male and 8 female) with mean initial and final ages of 11.59 and 12.69 years, respectively, and the Herbst group comprised of 23 subjects (13 male and 10 female) with initial mean age of 12.69 and final mean age of 14.47. Head films were obtained in 2 stages: (T1) pre-treatment and (T2) pos orthopedic phase to compare skeletal, dental, pharyngeal airway, hyoid bone and soft palate (SP) measurements. Paired samples and independent-samples *t* tests were used for the intragroup and intergroup comparisons, respectively. **Results**: The Herbst group demonstrated significantly greater amount of labial tipping and protrusion of the mandibular incisors than the TB group. In pharyngeal area and soft palate thickness, the Herbst group presented a significantly greater increase than the TB group. **Conclusion:** The effects of Herbst device on the mandibular incisors, pharyngeal area, and soft palate were greater in relation than the effects of TB device. TB produced an improvement in oropharyngeal area and lower pharyngeal dimension.

Key words: Functional appliances; Twin Block; Herbst; Orthodontics; Pharyngeal airway.

INTRODUCTION

There is a relationship between Class II malocclusion and respiratory disorders due to upper airway obstruction in the early stages of growth.[1]. Functional appliances when used during the growth period, stimulate mandible growth and promote dentoalveolar alterations in patients with mandibular retrognathism, also increasing oropharyngeal dimensions through the force exerted forward on the mandible, tongue and SP.[1,2]

In the literature, the functional appliances normally assess the dentoskeletal and tegumentary changes.[3-5] However, there is a lacuna regarding the effect of these appliances on the pharyngeal airways, hyoid bone, and soft palate in patients treated during the growth period. Severe mandibular deficiency has been associated with reduced oropharyngeal airway size increasing the chances of reduced respiratory function and probably producing problems such as snoring, upper airway resistance syndrome, and obstructive sleep apnea-hypoapnea syndrome.[6]

The Twin Block is a functional removable appliance, composed of two acrylic bite blocks (maxillary and mandibular) that modify the inclination of the occlusal plane to favorably direct occlusal forces through mandibular advancement.[7] The maxillary and mandibular blocks are connected at an angle of 70º to be used at a full time, inclusive during the functional forces of mastication.[7] Its efficiency is established in the literature, however, few studies have evaluated the effect of this device on the pharyngeal airways, hyoid bone and soft palate during the growth spurt.[8-11] (Fig.1)

In 1979, Hans Pancherz reintroduced the Herbst appliance, aiming to minimize patient collaboration, producing continuous mandibular advancement and promoting force for 24 hours/day.[12-14] The efficiency of this device in the treatment of Class II malocclusion is widely described in the literature.[14-16] (Fig.2)

The Twin Block and Herbst appliances are recognized in the literature for their efficiency in the treatment of Class II malocclusion.[9,14,17,18] However, it is speculated concerning the effects of these devices on the pharyngeal airways, hyoid bone and the soft palate.[19,20] Therefore, the purpose of this retrospective study was to compare cephalometrically the dimensions of the pharyngeal airways, hyoid bone and soft palate in patients treated with the Twin Block and Herbst appliances during the growth spurt.

MATERIAL AND METHODS

This retrospective study was approved by the Ethics in Research Committee of Bauru Dental School, University of Sao Paulo, Brazil (Protocol number: 53482821.2.0000.5417; decision number: 5.142.321) and all legal guardians signed informed consent.

The sample size was calculated based on a test power of 90% and an alpha of 5% in this study, to detect an average difference of 0.66 for the ANB angle, obtained in the study realized by Göymen Mourad and Gülec. The result showed that a minimum of 13 patients were necessary for each group.[20]

The sample consisted of 44 patients with Class II, division 1 malocclusion, divided into 2 groups: TB group (n=21) and Herbst group (n=23). The period of assessment of the patients was during the use of the functional appliances and all sample were treated at the Department of Orthodontics, Bauru Dental School, University of Sao Paulo, Brazil.

The inclusion criteria were as follows: Class II division 1 malocclusion associated with mandibular retrognathism (ANB > 4˚, SNB < 78˚), treated during the growth period, absence of systemic diseases or syndromes, no history of nasal respiratory complex surgery at baseline and during treatment, absence of pharyngeal pathology, patients with the presence of all teeth up to the first molar in both arches, presence of head films in the treatment stages (T1 = at the initiation of the treatment and T2 = at the conclusion of the orthopedic phase) with sufficient sharpness and contrast for adequate visualization and identification of structures.

The construction of the Twin Block appliance was realized through models of the maxillary and mandibular arches, the necessary mandibular advancement was recorded through the constructive wax bite at the moment when the edge of the maxillary incisors encountered the edge of the mandibular incisors.[21] Subsequently installing the appliances, the patient commenced to occlude in Class I, in the position achieved during the constructive bite. The orientation received by the patients was for the device to be removed only during meals, hygiene and sports practices (Fig.1).[22]

In 1905, a German professor idealized the Herbst, with the main advantage of being a fixed functional device, producing force 24 hours a day. Therefore, minimizing patient collaboration regarding the use of the device (as in the removable functional

device). Treatment time with Herbst is lower than removable functional appliances (approximately 6 to 8 months).[23]

There are many variations regarding the Herbst appliance design. The variation used in this study was developed by Mayes in 1994, it is the Herbst Catilever Bite Jumper (CBJ – Ormco Corporation, Orange, Calif).[24] This variation offerings benefits in relation to other Herbst designs, especially when used during the young permanent denture.[25] Patients in the Herbst group were treated without extractions and after correction of the anteroposterior discrepancy, the fixed appliance was used to refine the occlusion. (Fig. 2)

This study used head films obtained in two stages: (T1) in the pre-treatment; (T2) following the orthopedic phase. Several Dental Radiology Centers in the city of Bauru-SP were used to obtain radiographs. Accordingly, they were digitized in JPEG format using the ScanMaker i800 scanner (Microtek, Hsinchu, Taiwan), with a resolution of 300 dpi so that the images could be used in the Dolphin Imaging 11.5 software (Dolphin Imaging and Management Solutions, Chatsworth, Calif, USA). During scanning, the Dolphin millimeter ruler (100 mm Dolphin Radiographic Film Calibration Ruler, model PN 130-0168) was attached to the side of head films, in order to calibrate the size of the captured image with the real size of the radiograph.

The reference points and lines used in the analysis, including skeletal, dental, linear pharyngeal airway measurements, pharyngeal airway area, hyoid bone position and SP measurements were determined according to various authors, are presented below in Table I.[26-30] Subsequently demarcating the cephalometric points, the Dolphin Imaging 11.5 software automatically produced the cephalometric tracing.

Statistical analysis

The software used to perform the statistical analysis was the STATISTICA software for Windows, version 6.0; Statsoft, Tulsa, Okla. Concerning the assessment of the intergroup distribution of the sexes, the chi-square test was used. To verify the homogeneity of variance between the groups, the Shapiro-Wilk and Levene tests were used. For intragroup comparisons, a paired-samples *t* test was performed, and for intergroup comparisons, an independent-samples *t* test was used. The values were considered statistically significant for $P < 0.05$.

A total of 30 radiographs were randomly selected, retraced and remeasured after a 2-week interval to assess the tracing errors and examiner reliability. The

analysis of random and systematic errors were realized using the Dahlberg formula and paired-sample *t* test, respectively.[31,32] There were no statistically significant differences concerning the first and second measurements (P <0.05).

RESULTS

The treatment time of the TB group was 2.10 (standard deviation [SD], 0.37) years and of the Herbst group was 1.78 (standard deviation [SD], 0.45) years (Table II).

In pretreatment, the TB group demonstrated a significantly smaller mandibular length compared to the Herbst group (P < 0.05). In contrast, the Herbst group showed a significantly greater protrusion in the maxillary incisors compared the TB group (P < 0.05). The oropharyngeal, the lower pharyngeal dimension and the SP thickness in the Herbst group evidenced significantly greater compared to the TB group (P < 0.05) (Table III)

During treatment, the Herbst group demonstrated significantly greater increase in mandibular incisor protrusion and labial tipping when compared to the TB group (P < 0.05). The Herbst group showed a significantly greater increase in the pharyngeal area, lower pharyngeal airway dimension, and SP thickness in relation the TB group (P < 0.05). (Table IV)

DISCUSSION

Functional appliances, when used in growing patients, promote change in mandibular position.[6,33] As the mandible advances, it is speculated that there is an indirect increase in the airways.[6] As craniofacial development is directly related to the anatomy and function of the pharyngeal airways, this study aimed to investigate whether there are differences between the changes in the pharyngeal airways dimensions, hyoid bone positions and soft palate measurements promoted by TB and Herbst appliances in patients in growth peak.[27,34,35]

Regarding the treatment time between the groups being different, the literature has already shown that fixed functional appliances have a shorter treatment time compared to removable functional appliances.[36] However, it is alleged that this

difference between treatment times with removable and fixed functional appliances is not the determining factor in selecting the type of appliance.[36]

Concerning the Herbst group presented a greater dentoalveolar effect in relation to the protrusion and labial tipping on the mandibular incisors is something expected. In 2016, a systematic review evaluating fixed functional appliances stated that mandibular advancement when occurs in stepwise is associated with a greater retroinclination of the maxillary incisors and greater proclination of the mandibular incisors compared to single step advancement. The same study stated that the Forsus device also promotes this effect on the mandibular incisors, corroborating our finding.[3] The effect of fixed functional appliances on the mandibular incisors, especially Herbst, is widely described in our literature.[37-40]

In this study, the Herbst group demonstrated a significant increase in the pharyngeal area compared to the TB group at the conclusion of the orthopedic phase. (Table III). This finding is in opposition to that reported in another study that stated a significant increase in the pharyngeal area in the TB group.[11] However, according to Table IV, the difference between the groups was not significant.

Individuals with skeletal Class II malocclusion associated with mandibular deficiency are predicted to have a reduced pharyngeal width than healthy individuals with Class I malocclusion.[35,41,42] Kannan, *et al.* reported that severe mandibular deficiencies could be associated with decreased oropharynx airways, impairing respiratory function and consequently causing problems such as snoring, upper airway resistance syndrome, and obstructive sleep apnea-hypoapnea syndrome.[6] Therefore, the finding that the TB group presented a significant increase in the oropharyngeal area is beneficial to the patient and has already been reported in the literature.[6] Another study also stated that the TB device is able to promote an increase in the oropharyngeal dimensions.[11] The Herbst group did not present alterations in the oropharynx corroborates with previous studies that evaluated the effect of this device on the airways.[19] However, other studies contention that this fixed functional device is able of promoting improvement in oropharyngeal area. [43]

Regarding to greater increase promoted by the TB device in the lower pharyngeal dimension in relation to the Herbst device, this finding has already been described in the literature. Dina Osman ElAbbasy stated that forward positioning of the mandible by the functional appliance improves the position of the hyoid bone that

advances the tongue due to increased genioglossus muscle tone, thus improving the dimensions of the airways. [43,44]

According to Baka and Fidanboy, the relationship between the SP and the pharyngeal airways influences important functions in mastication, respiration, and phonation.[11]This study showed a statistical difference in relation to the thickness of the SP at the initiation and on the conclusion of the orthopedic phase, with the TB group present a smaller SP thickness at the two times (T1 and T2) when compared to the Herbst group (Table III). However, this difference between the groups was not significant, corroborating other findings.[45]

CONCLUSIONS

In conclusion:

- The Herbst appliance promoted a greater increase in the pharyngeal area, however the difference was not significant.
- The TB group promoted an improvement in the oropharynx and lower pharyngeal dimension.
- The Herbst appliance caused an increase in the thickness of the SP, nonetheless the difference between the groups was not significant.

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FIGURE CAPTIONS

Fig. 1– Twin Block appliance installed.

Fig. 2– Herbst appliance installed.

Fig. 1

Fig. 2

Table I. Summary of cephalometric landmarks and definitions

Abbreviation	*Definition*
S	Midpoint of sella turcica (the center of sella turcica)
N	Nasion, the most anterior point of the frontonasal suture in the midsagittal plane
A	The deepest midline point on the anterior outer contour of the maxillary alveolar process
B	The deepest point on the anterior outer contour of the mandible
Mx1	Incisal tip of most anterior maxillary central incisor
Md1	Incisal tip of most anterior mandibular central incisor
Po	Pogonion, the most anterior point of the bony chin in the midsagittal plane
Go	Gonion, a point at the intersection of lines tangent to the posterior border of the ramus and the lower border of the mandible
Gn	Gnathion, the most anterior inferior point of the bony chin
ANS	Anterior nasal spine, anterior point of maxillary bone
PSN	Posterior nasal spine, posterior limit of bony palate
Ba	The most posterior limit of the lowest point in the midline on the anterior margin of the foramen magnum
AD1	Posterior pharyngeal wall along the line from PNS to Ba
AD2	Adenoid tissue along, the line from PNS to H
Ptm	Pterygomaxillare
Cv3ai	The most anterior point on the inferior margin of the outline of the body of the third cervical vertebra
Cv3pi	The most posterior point on the inferior margin of the outline of the body of the third cervical vertebra
aa	Anterior arch of the atlas the most anterior point on the anterior arch of the atlas (C1) assumed to be in the median sagittal plane
Hyoid	The most superior point on the anterior surface of the outline of the body of the third cervical vertebra
T point	Tuberculum sella, the intersection point of the lower contours of the anterior clinoid processes and the contour of the anterior wall of the sella
W point	Wing points, the intersection of the contour of the ala majõr with the jugum sphenoidale
P point	Lower tip of the uvula
SP1	Front of uvula at its thickest point
SP2	Back of uvula at its thickest point
SNA(°)	The angle between the lines Sella-Nasion and Nasion-A point
SNB(°)	The angle between the lines Sella-Nasion and Nasion-B point
ANB(°)	The angle between the lines Nasion-A point and Nasion-B point
Mx1-NA (mm)	Perpendicular distance of the incisal point of the maxillary incisor to the NA line
Mx1-NA (°)	Angle between maxillary incisor long axis and NA plane
Md1-NB (mm)	Perpendicular distance of the incisal point of the mandibular incisor to the NB line
Md1-NB (°)	Angle between mandibular incisor long axis and NB plane
SN-GoGn (°)	Angle between the SN plane and GoGn plane
FMA (°)	Angle between the Frankfort horizontal plane and the mandibular plane
IMPA (°)	Inclination of the mandibular incisors to the mandibular plane
VRL	Vertical reference line, perpendicular line passing through the T point
HRL	Horizontal reference line, the line passing through the T and W points
PNS-AD1	The distance from PNS to AD1
PNS-AD2	The distance from PNS to AD2
McNamara upper pharyngeal dimension	Minimum distance from the SP to the nearest point of the posterior pharyngeal wall

McNamara lower pharyngeal dimension	Minimum distance from the point in which the posterior pharyngeal wall through the line between Cv3ai and Cv3pi points
PL	The palatal line, the line passing through ANS and PNS points
SpL	Sphenoid line, tangent to lower border of sphenoid registered on basion
AAL	Anterior atlas line, perpendicular line to PL registered on Ptm
PML	Pterygomaxillary line, perpendicular line to PL registered on Ptm
Np	Area Describe the 4 sides of a trapezoid which defines the nasopharyngeal area
Aerial area	Part of NP area that is consisting of air
Adenoidal area	Part of NP area that is consisting of soft tissue
Oropharyngeal area	PL and the Cv3ai-Cv3pi line were accepted as the upper and lower border of the oropharyngeal area
Hyoid-SWpoint	The distance from hyoid to the horizontal reference line
Hyoid-VRL	The distance from hyoid point to VRL
Hyoid-CV3ai	The distance from hyoid to Cv3ai
SP length	The distance between PNS and P points
SP thickness	The distance between PNS and P points
SP angle	Angle between the ANS-PNS line and PNS-P line

Table II. Intergroup comparisons of gender, initial and final ages and treatment times

Variable	Twin Block group *(n= 21)*		Herbst group *(n= 23)*		*P*
Gender					
Male	13		13		0.51†
Female	8		10		
	Mean	S.D.	Mean	S.D.	
Initial age	11.59	0.94	12.69	0.61	0.13‡
Final age	13.69	1.08	14.47	0.98	0.06‡
Treatment time	2.10	0.37	1.78	0.45	0.04*‡

* Statistically significant at $P<0.05$; † Chi-square test; ‡ independent *t* test.

Table II. Descriptive values and comparison of variables at pretreatment (T1) and posttreatment (T2).

	Grupo TB (n=21)					*Grupo Herbst (n=23)*				
	T1		*T2*			T1		T2		
Variables	Mean	S.D.	Mean	S.D.	P *value*	Mean	S.D.	Mean	S.D.	P *value*
Skeletal dental measurements										
SNA(º)	82.83	4.19	82.19	4.05	0.718	82.34	4.79	79.17	15.64	0.39
SNB(º)	76.70	3.05	77.51	2.71	0.35	77.59	3.17	78.90	2.87	0.10
Go-Gn (mm)	68.25	6.85	73.30	3.81	**0.03***	73.33	8.2	75.75	5.72	0.01
GoGn-SN (º)	67.6	2.45	68.15	2.18	0.82	67.49	3.40	67.06	2.84	0.16
ANB(º)	6.13	2.04	4.68	2.76	0.05	4.76	2.54	3.80	2.05	0.23
Mx1.NA (º)	24.19	6.38	21.51	5.82	0.07	28.23	7.97	22.83	7.73	0.53
Mx1-NA (mm)	4.17	2.17	3.70	2.34	**0.01***	6.37	3.36	5.05	2.68	0.08
Md1.NB (º)	28.70	5.07	28.69	6.35	0.18	26.1	6.8	33.17	5.15	**0.01***
Md1-NB (mm)	5.83	2.03	6.31	2.45	0.08	4.72	2.19	69.4	2.00	0.35
FMA (º)	26.32	4.65	26.84	4.55	0.27	24.98	3.23	26.75	3.35	0.94
IMPA(º)	95.95	5.02	5.16	4.69	0.45	94.13	5.53	98.79	10.61	0.15
Pharyngeal airway linear measurements										
PNS-AD1(mm)	23.28	4.54	24.58	3.72	0.31	24.95	6.26	22.90	3.19	0.11
PNS-AD2 (mm)	16.68	3.94	18.43	3.26	0.41	17.82	5.17	17.87	4.32	0.63
PNS-BA	44.52	3.53	46.16	2.76	0.90	44.70	5.42	45.65	3.59	0.52
McNamara upper (mm)	11.57	4.2	12.48	3.86	0.31	12.59	2.80	13.91	3.31	0.19
McNamara lower (mm)	13.11	3.19	13.27	2.14	0.22	14.45	3.91	14.27	3.48	0.26
Pharyngeal airway area measurements										
Pharyngeal area (adenoidal + aerial) (mm^2)	16.26	3.67	16.60	4.37	0.06	18.11	2.86	19.40	2.65	**0.01***
Oropharyngeal area (mm^2)	10.29	2.00	11.60	2.28	**0.01***	12.62	3.68	12.12	2.47	0.47
Lower pharyngeal dimension (mm)	11.15	2.49	12.91	2.34	**0.00***	14.4	3.32	15.38	2.61	**0.00***
Hyoid bone position										
Hyoid-C3 (mm)	31.55	4.84	32.95	3.71	0.644	30.94	3.82	31.59	3.04	0.18
MP-H: Hyoid position (mm)	12.27	3.12	13.22	3.6	0.73	12.64	4.11	13.23	3.44	0.99
SP measurements										
SP length (mm)	31.25	2.91	31.16	3.34	0.68	31.71	4.41	32.71	5.50	0.27
SP thickness (mm)	8.43	1.53	8.60	1.56	0.02*	9.36	1.19	9.92	1.53	0.00*
SP angle (º)	138.68	6.64	134.20	6.86	0.15	135.98	5.78	132.13	3.63	0.21

* Statistically significant at $P < 0.05$.

Table IV. Comparison of the alterations between TB group and Herbst group.

	TB group (n=21)		*Herbst group (n=23)*	P *value*	
Variables	*Mean*	*S.D.*	*Mean*	*S.D.*	
Skeletal dental measurements					
SNA (º)	-0.64	2.91	-3.16	17.72	0.52
SNB (º)	0.80	2.08	1.31	2.52	0.47
Go-Gn (mm)	5.05	6.05	2.04	7.36	0.20
GoGn-Sn (º)	0.46	2.03	-0.42	2.06	0.16
ANB (º)	-1.45		-0.95	1.88	0.37
Mx.NA(º)	-2.67	5.74	-5.40	7.60	0.189
Mx-NA (mm)	-0.47	2.56	-1.31	2.82	0.308
Md1.NB (º)	0	3.55	6.98	5.12	**0.00***
Md-NB (mm)	0.48	0.95	2.22	1.00	**0.00***
FMA (º)	0.51	1.76	2.67	2.36	0.10
IMPA (º)	-0.79	4.12	4.05	9.82	**0.0**4*
Pharyngeal airway linear measurements					
PNS-AD1 (mm)	1.30	5.21	-2.04	6.06	0.05
PNS-AD2 (mm)	1.75	3.69	0.05	4.98	0.21
PNS-BA (mm)	1.63	4.05	-1.05	4.95	0.05
McNamara upper (mm)	0.90	1.84	1.32	2.30	0.51
McNamara lower(mm)	0.16	2.84	-0.17	2.65	0.63
Pharyngeal airway area measurements					
Pharyngeal area (adenoidal + aerial) (mm^2)	0.34	2.54	1.29	2.02	0.17
Oropharyngeal area (mm2)	1.31	2.42	-0.49	3.34	**0.047***
Lower pharyngeal dimension (mm)	1.75	2.17	0.94	2.78	0.28
Hyoid bone position					
Hyoid-C3 (mm)	1.40	5.17	0.64	2.20	0.52
MP-H: Hyoid position (mm)	0.95	3.81	0.58	4.10	0.75
SP measurements					
SP length (mm)	-0.09	3.73	0.99	4.03	0.35
SP thickness (mm)	0.16	1.35	0.56	1.79	0.41
SP angle (º)	-4.48	6.72	-3.85	5.21	0.72

* Statistically significant at P <0.05.

2.2 ARTICLE 2 - Evaluation of dentoskeletal and tegumentary alterations promoted by Twin Block and Herbst appliances during the growth spurt

ABSTRACT

Introduction: This retrospective study aimed to compare the cephalometric changes in Class II malocclusion patients treated with Twin Block (TB) and Herbst appliances. **Methods:** The sample comprised 44 subjects with Class II division 1 malocclusion divided into 2 groups: TB group comprised 21 patients (13 male and 8 female) with an initial mean age of 11.59 (S.D. 0.94) years. Herbst group comprised 23 patients (13 male and 10 female), with an initial mean age of 12.69 (S.D. 0.61) years. Intragroup and intergroup comparisons was realized with dependent-paired *t* tests and independent-paired *t* tests, respectively. **Results:** Herbst showed a significantly protrusion and labial tipping in mandibular incisors than TB. Mandibular molars in TB group demonstrated a statistically greater increase in vertical development than Herbst group. Both groups presented significant reduction in overjet, overbite and molar relationship. **Conclusions:** The appliances promoted correction in the maxillomandibular relationship mainly due to dentoalveolar effects. Herbst produced the effect of protrusion and labial tipping on mandibular incisors.

INTRODUCTION

The use of functional appliances for the treatment of Class II malocclusion has been extensively discussed in the literature.[1-4]It is speculated about the real effect of these appliances when indicated for growing patients, especially the amount of dentoalveolar skeletal effects.[5-8] Recent studies have stated that the skeletal effects promoted by functional appliances (removable or fixed) are minimal and not clinically relevant.[2,4]

The Twin Block is a removable functional appliance, which is mainly used in the UK for the treatment of Class II malocclusion.[9] Its efficiency is established in the literature and the amount of effects found in different growth stages is still controversial.[10-13] Baccetti *et al*., stated that the use of the TB appliance during or at

the initiation pubertal growth could promoted skeletal improvements in patients with Class II malocclusion.[14] Irezli and Baysal The Herbst appliance is capable of promoting improvement in mandibular skeletal dimensions when compared to a distalizer.[15]

The Herbst appliance was conceived in 1905 by Emil Herbst, nonetheless it was not until the late 1970s that Hans Pancherz reintroduced and popularized the fixed functional appliance.[16] The Herbst appliance is considered one of the most powerful fixed functional appliances. Woodside, Metaxas, and Altuna conducted a study in young primates, and Herbst was able to promote significant changes in the glenoid fossa, articular disc and condyle.[17] Urban Hägg and Hans Pancherz stated that there is a close relationship between maximal pubertal growth in standing height (PEAK) and maximal mandibular growth.[18]

Accordingly, a factor of great interference in the results obtained with the use of functional appliances is the growth period presented by the patient. Therefore, the objective of this retrospective study was to compare the changes promoted by two functional appliances, the TB (removable) and the Herbst (fixed) in the treatment of Class II malocclusion in patients during the pubertal growth spurt.

MATERIALS AND METHODS

This retrospective study was approved by the Ethics in Research Committee of Bauru Dental School, University of Sao Paulo, Brazil (Protocol number: 53482821.2.0000.5417; decision number: 5.142.321), and all parents or legal guardians provided informed consent.

Sample calculation was performed based on an alpha significance level of 5% and a power of 0.8, to detect an intergroup difference of 1.0 for the Wits appraisal, previously reported.[19] Thus, a minimum sample of 18 patients were required in each group,

Selection criteria consisted in patients with at least bilateral ¼ Class II molar relationship[20] (evaluated from the cast models), mandibular retrusion, presence of all permanent teeth up to the first molar, mandibular arches with slight or no crowding at pretreatment and no previous orthodontic treatment.

The TB group was composed of 23 subjects (13 male; 08 female) with initial and final mean ages of 11.59 years (SD, 0.94) and 13.69 years (SD, 1.08), respectively. The mean treatment time of the orthopedic phase was 2.10 years (S.D, 0.37). This

group was treated by one orthodontist (L.V.P.) The orthopedic phase was finalized when the patients had at least 2 mm of Class I molar overcorrection. The appliance adjustment was performed once a month and the acrylic was progressively removed from the occlusal of the maxillary bite- blocks to allow eruption of the mandibular molars, to reduction of the curve of Spee.[14,21] Patients continual to use the appliance as active retention for a mean period of 9 months.

Herbst group was composed of 23 subjects (13 male; 10 female) with initial and final mean ages of 12.69 years (SD, 0.61) and 14.47 years (SD, 0.98), respectively. The mean treatment time with the Herbst appliance was 1.78 (S.D, 0.45). Treatment was considered completed at 2 mm, on average, elsewhere Class I molar relationship was achieved. Likewise, the appliance was maintained for 3 months as active retention.

Error study

Thirty lateral cephalograms were randomly selected and retraced by the same examiner (C.B.) after a 2-week interval. Random and systematic errors were calculated according to Dahlberg´s formula and with dependent t tests, respectively; at $P<0.05$.[22,23]

Statistical analyses

Normal distribution was tested and confirmed with Shapiro-Wilk and Levene tests for all variables. Comparability of the groups regarding gender and occlusal malocclusion severity distributions were performed with Chi-square tests.

Group comparisons regarding initial and final ages, treatment times and cephalometric status at pretreatment stage and the after the conclusion of the orthopedic phase were compared with independent-samples *t.* Statistical analyses were performed with Statistica software (Statistica for Windows, version 7.0, Statsoft, Inc, Tulsa, Oklahoma, United States). Results were considered statistically significant at $p < 0.05$.

RESULTS

A total of 30 radiographs were randomly selected, retraced and remeasured after a 2-week interval to assess the tracing errors and examiner reliability. The

analysis of random and systematic errors were realized using the Dahlberg formula and paired-sample *t* test, respectively.[22,23] There were no statistically significant differences concerning the first and second measurements ($P < 0.05$).

The groups were comparable regarding initial and final ages, treatment time and gender distribution.

In pretreatment, the TB group presented a significantly smaller mandibular length compared to the Herbst group. On the other hand, the Herbst group showed significantly greater protrusion on maxillary incisors compared to the TB group. The maxillary molars demonstrated a significantly greater vertical development in TB group than the Herbst group. The Herbst group presented a significantly greater overjet in relation the TB group.

During the treatment, the TB group continued to demonstrate a significantly smaller mandibular length and significantly greater vertical development of the maxillary molars compared to the Herbst group. However, the difference in this variable between the groups was not significant. The Herbst group demonstrated a significantly greater increase in mandibular incisor protrusion and labial tipping compared to the TB group. The Herbst group also demonstrated a significantly greater decrease in overjet, overbite and molar relation compared to the TB group.

DISCUSSION

In order to achieve a greater amount of skeletal effects, functional appliances (removable or fixed) are used during the growth spurt.[14,24] However, there is always a discussion regarding how the effects for the correction of Class II malocclusion occur and whether the effects achieved will remain lasting until the end of growth.[25] Therefore, the aim of this study was to observe the differences promoted between two types of functional appliances (removable and fixed) in patients with skeletal Class II malocclusion during the growth spurt.

The fact that the TB group present a significantly smaller mandibular length at the beginning of treatment compared to the Herbst group could be a bias in this study. Nevertheless, the research evaluated amount difference in mandibular growth between the period in which patients were treated with the appliances.

In relation of the Herbst group to demonstrated significantly greater protrusion of the mandibular incisors and a significantly greater reduction in overjet compared to

the TB group was an expected result. The effect of fixed functional appliances on the mandibular incisors, consequently, on the reduction of overjet, is something that many studies have already reported.[10,26]

Other fixed functional appliances have also described these effects in the literature. Kinzinger *et al*., found that most of the overjet and molar relationship correction was mainly due to significant dentoalveolar changes when evaluating the treatment of 21 patients with Class II malocclusion treated with the Functional Mandibular Advancer appliance.[27] The AdvanSync2 appliance, which is a molar-to-molar attachment produces sagittal, intrusive, and expansive force vectors with a combination of mandibular molar mesialization and mild mandibular incisor proclination.[24] Especially, mandibular incisor protrusion was more evident in Herbst group compared with the TB and control groups.[28] Pancherz reported backward movement of maxillary teeth and forward movement of mandibular teeth after Herbst appliance therapy. In addition, control of mandibular incisors was reported to be difficult regardless of the anchorage system used.[18]

The finding that the TB group has a minimal effect on the mandibular incisors could associated to the acrylic capping of the mandibular incisors in the TB appliance. It appears that the effects of removable functional appliances are most pronounced in the dentition, with a considerable amount of retroclination of the maxillary incisors and slight proclination of the mandibular incisors..[2]

This proclination effect in the Herbst group may have contributed to the lower amount of mandibular growth and advancement compared to the TB group. In addition, increasing mandibular incisor angulation reduced overbite and overjet.[29] The mandibular incisor inclination, it is observed that most of the authors who study the effects of orthopedic appliances always found a degree of buccal inclination of the mandibular incisor and mandibular skeletal changes produced by this appliance.[19,29]

The finding where the Herbst group promoted a greater correction in the Class II molar relationship corroborates other studies. Pancherz stated in 1982 that molar correction occurs by a combination of dentoskeletal effects, such as the increase in mandibular length associated with the distal movement of the maxillary molars and mesial movement of the dental changes observed during treatment with the Herbst appliance were basically the result of loss of anchorage in both dental arches. The telescope mechanism produced a directed posterior force on the maxillary teeth and

an anterior directed force on the mandibular teeth, resulting in distal tooth movements in the maxillary buccal segments and mesial tooth movements in the mandible.[30,31]

CONCLUSION

Both appliances corrected the Class II malocclusion, however the Herbst appliance showed a greater amount of dentoalveolar effects in relation to the TB. However, the Herbst appliance demonstrated a greater dentoalveolar effect of protrusion and labial tipping of the mandibular incisors and a greater decrease in Class II molar relationship.

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FIGURE CAPTIONS

Fig. 1– Twin Block appliance installed.

Fig. 2– Herbst appliance installed.

Fig. 1

Fig. 2

Table I. Skeletal, dental and soft-tissue cephalometric variables

Maxillary skeletal component	
SNA (°)	SN to NA angle
Co-A (mm)	Condylion to A-point distance
Mandibular skeletal component	
SNB (°)	SN to NB angle
Go-Gn (mm)	Gonion to gnation distance
Co-Go (mm)	Condylion to gonion distance
Maxillomandibular relationship	
ANB (°)	NA to NB angle
Wits (mm)	Distance between the perpendicular projections of A and B points on the functional occlusal plane (FOP).
Vertical component	
SN.GoGn (°)	SN to GoGn angle
OP.SN (°)	SN to occlusal plane angle
LAFH (mm)	Distance between ANS point and Me point.
Maxillary dentoalveolar component	
Mx1.NA (°)	Maxillary incisor long axis to NA angle
Mx1-NA (mm)	Distance between most anterior point of crown of maxillary incisor and NA line
Mx6-PP (mm)	Mean perpendicular distance between mesial and distal cusp of maxillary first molar and palatal plane
Mandibular dentoalveolar component	
Md1.NB (°)	Mandibular incisor long axis to NB angle
Md1-NB (mm)	Distance between most anterior point of crown of mandibular incisor and NB line
IMPA (°)	Incisor mandibular plane angle
Md6-GoMe (mm)	Mean perpendicular distance between the mesial and distal cusp of mandibular first molar and mandibular plane
Dental relationship	
Overjet (mm)	Distance between incisal edges of maxillary and mandibular central incisors, parallel to occlusal plane
Overbite (mm)	Distance between incisal edges of maxillary and mandibular central incisors, perpendicular to occlusal plane
Molar relationship (mm)	Linear distance from the mean of the most distal points of maxillary first molar crowns to the mean of the most distal points of mandibular first molar crowns. Negative values mean more favorably Class I molar relationship. Positive values or zero means class II tendency.
Soft-tissue profile	
Nasolabial angle (°)	Angle formed by lines columella to Subnasal and from Subnasal to upper lip
UL-E plane (mm)	Distance from the upper lip to the esthetic plane of Ricketts (line from soft tissue pogonion to pronasale)
LL-E plane (mm)	Distance from the lower lip to the esthetic plane of Ricketts (line from soft tissue pogonion to pronasale)

Table II. Intergroup comparisons of gender, initial and final ages and treatment times

Variable	Twin Block group *(n= 21)*		Herbst group *(n= 23)*		*P*
Gender					
Male	13		13		0.51†
Female	8		10		
	Mean	S.D.	Mean	S.D.	
Initial age	11.59	0.94	12.69	0.61	0.13‡
Final age	13.69	1.08	14.47	0.98	0.06‡
Treatment time	2.10	0.37	1.78	0.45	0.04*‡

* Statistically significant at $P<0.05$; † Chi-square test; ‡ independent *t* test.

Table III. Descriptive values and comparison of variables at pretreatment (T1) and posttreatment (T2)

	TB group (n=21)					*Herbst group (n=23)*				
	T1		T2		*P value*	T1		T2		*P value*
Variables	Mean	S.D.	Mean	S.D.		Mean	S.D.	Mean	S.D.	
Maxillary skeletal components										
SNA (°)	82.83	4.19	82.19	4.05	0.71	82.34	4.79	79.17	5.64	0.39
Co-A (mm)	77.03	3.33	78.91	3.83	0.14	79.12	5.51	81.21	5.48	0.11
Mandibular skeletal components										
SNB (°)	76.70	3.05	77.51	2.71	0.35	77.59	3.17	78.90	2.87	0.10
Go-Gn (mm)	68.25	6.85	73.33	6.85	**0.**03*	73.39	6.82	75.75	5.72	0.01*
Co-Go (mm)	47.65	5.47	51.64	4.28	0.23	49.40	4.02	51.64	4.20	0.84
Maxilomandibular relationship										
ANB (°)	6.13	2.04	4.68	2.76	0.05	4.76	2.54	3.80	2.05	0.23
Wits (mm)	2.94	2.38	0.99	2.59	0.92	2.86	2.38	-0.23	2.93	0.14
Vertical Component										
SN.GoGn (°)	67.69	2.45	68.15	2.18	0.82	67.49	3.40	67.06	2.84	0.16
OP.SN (°)	16.90	3.03	17.30	3.14	0.05	14.70	4.23	16.86	3.71	0.67
LAFH (mm)	58.97	7.39	63.47	5.38	0.052	60.15	4.52	63.63	4.57	0.95
Maxillary dentoalveolar components										
Mx1.NA (°)	24.19	6.38	21.51	5.82	0.07	28.23	7.97	22.83	7.73	0.53
Mx1-NA (mm)	4.17	2.17	3.70	2.34	0.01*	6.37	3.36	5.05	2.68	0.08
Mx6-PP (mm)	17.89	2.52	19.45	2.12	0.00*	15.16	1.87	15.54	1.90	0.00*
Mandibular dentoalveolar components										
Md1.NB (°)	28.70	5.07	28.69	6.98	0.18	26.19	6.98	33.17	5.15	0.01*
Md1-NB (mm)	5.83	2.03	6.31	2.45	0.08	4.72	2.19	6.94	2.00	0.35
IMPA (°)	95.95	5.02	95.16	4.69	0.45	94.73	5.53	98.79	10.61	0.15
Md6-GoMe (mm)	20.05	5.37	20.09	7.96	0.75	19.53	5.67	21.06	8.43	0.69
Dental Relationships										
Overjet (mm)	6.00	2.32	3.72	2.45	0.03*	7.57	1.32	3.20	1.34	0.20
Overbite (mm)	2.95	1.75	2.99	1.82	0.95	2.38	2.74	0.85	1.82	0.00*
Molar Relation (mm)	1.33	1.90	-0.01	2.08	0.87	1.42	1.73	-2.43	1.41	0.00*
Soft-tissue profile										
Nasolabial angle(°)	119.23	3.48	11.67	1.85	0.38	115.30	5.6	115.06	2.95	0.22
UL-E plane (mm)	0.19	2.24	-1.50	2.62	0.12	-0.80	2.04	-2.83	2.66	0.10
LL-E plane (mm)	1.08	2.29	2.17	7.57	0.40	0.41	2.86	1.16	2.83	0.55

* Statistically significant at $P<0.05$.

Table IV. Intergroup treatment changes comparison (T2-T1)

Variables	*TB group (n=21)*		*Herbst group (n=23)*		*P*
	Mean	S.D.	Mean	S.D.	
Maxillary skeletal components					
SNA (º)	-0.64	2.91	-3.16	7.72	0.52
Co-A (mm)	1.87	2.84	2.08	2.39	0.79
Mandibular skeletal components					
SNB (º)	0.80	2.08	1.31	2.52	0.47
Go-Gn (mm)	5.05	6.05	2.41	7.36	0.20
Co-Go (mm)	3.98	5.21	2.48	2.65	0.22
Maxilomandibular relationship					
ANB (º)	-1.45	1.82	-0.95	1.88	0.37
Wits (mm)	-1.95	2.23	-3.10	2.27	0.09
Vertical Component					
SN.GoGn (º)	0.46	2.03	-0.42	2.06	0.16
OP.SN (º)	0.40	3.00	2.16	2.93	0.05
LAFH (mm)	4.50	4.66	3.47	2.11	0.03
Maxillary dentoalveolar components					
Mx1.NA (º)	-2.67	5.74	-5.40	7.60	0.18
Mx1-NA (mm)	-0.47	2.56	-1.31	2.82	0.30
Mx6-PP (mm)	1.56	2.23	1.52	1.67	0.05
Mandibular dentoalveolar components					
Md1.NB (º)	0.00	6.98	3.55	5.12	0.00*
Md1-NB (mm)	0.48	0.92	2.22	1.00	0.00*
IMPA (º)	-0.79	4.12	4.05	9.82	0.04*
Md6-GoMe (mm)	2.66	2.19	1.37	1.35	0.02*
Dental Relationships					
Overjet (mm)	-2.28	2.04	-4.37	2.39	0.03*
Overbite (mm)	-0.46	1.62	-2.13	2.07	0.07*
Molar Relation (mm)	-1.49	1.88	-3.85	2.44	0.00*
Soft-tissue profile					
Nasolabial angle(º)	0.43	5.72	0.13	6.84	0.89
UL-E plane (mm)	-1.70	1.21	0.75	1.65	0.45
LL-E plane (mm)	1.09	7.15	0.22	1.69	0.82

* Statistically significant at $P<0.05$.

3 DISCUSSION

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The increase in pharyngeal dimensions through mandibular advancement using orthopedic devices incites questioning. Therefore, this study aimed to evaluate changes in pharyngeal airway dimensions, hyoid bone position, soft palate, dentoskeletal and tegumentary changes after functional orthopedic treatment with Twin Block and Herbst appliances in patients during de growth spurt. Although the efficiency of functional appliances used to increase airway dimensions have been extensively investigated in the literature, the comparison between these differences promoted by these two popular devices is questionable.

To evaluate the changes in these structures promoted by these devices, head films of patients were used. Nonetheless, could be question the accuracy this method, since the radiograph demonstrates a two-dimensional image of a three-dimensional structure. One study compared the dimensions of the pharyngeal airways' measurements in lateral cephalograms with the measurements obtained using three-dimensional CT images. This same study demonstrated that there is a high-precision correlation between the methods. The advantages of using head films include the ease of use, low cost and minimal exposure to radiation, and offers the opportunity to obtain sufficient information on craniofacial structures. (RILEY; POWELL; GUILLEMINAULT, 1986) The cephalometric analysis and reference points used in this study were chosen for the reason that of their ease of identification and its compatibility with other studies.

Dental changes demonstrated significant increases in Md1-NB (º), Md1-NB (mm) and IMPA values in the Herbst group compared to the TB group. The results also showed that the correction of Class II malocclusion in the Herbst group was mainly by mandibular dentoalveolar protrusion. While in the Twin Block group, correction seems to have occurred due to a restriction in maxillary development (even though it was not statistically significant) associated with an improvement in mandibular length. It appears that the Twin Block appliance has been shown to have greater skeletal effects than the Herbst. This observation was similar to those found in previous studies. (BAYSAL; UYSAL, 2014; CANÇADO et al., 2021; MEHYAR; SANDLER; THIRUVENKATACHARI, 2021)

The TB group presented a minimal effect on the mandibular incisors, this finding could be associated to the acrylic capping of the mandibular incisors in the TB appliance. It appears that the effects of removable functional appliances are most pronounced in the dentition, with a considerable amount of retroclination of the maxillary incisors and slight proclination of the mandibular incisors. (KORETSI et al., 2015)

The Herbst group to showed a significantly a significantly greater reduction in overjet, overbite and molar relation when compared to the TB group was an expected result. The large amount of dentoalveolar effects produced by fixed functional appliances is something already established in the literature. (BAYSAL; UYSAL, 2014; CANÇADO et al., 2021)

The Herbst group showed a significant increase in the pharyngeal area compared to the TB group at the conclusion of the orthopedic phase. This finding is in opposition to that reported in another study that stated a significant increase in the pharyngeal area in the TB group. (BAKA; FIDANBOY, 2021) However, the difference between the groups was not significant. Individuals with skeletal Class II malocclusion associated with mandibular deficiency are predicted to have a reduced pharyngeal width than healthy individuals with Class I malocclusion. (CEYLAN; OKTAY, 1995; KIRJAVAINEN; KIRJAVAINEN, 2007; ENTRENAS et al., 2019)

Kannan, *et al.* reported that severe mandibular deficiencies could be associated with decreased oropharynx airways, impairing respiratory function and consequently causing problems such as snoring, upper airway resistance syndrome, and obstructive sleep apnea-hypoapnea syndrome. (KANNAN; SATHYANARAYANA; PADMANABHAN, 2017) Therefore, the finding that the TB group presented a significant increase in the oropharyngeal area is beneficial to the patient and has already been reported in the literature. (KANNAN; SATHYANARAYANA; PADMANABHAN, 2017) Another study also stated that the TB device is able to promote an increase in the oropharyngeal dimensions. (BAKA; FIDANBOY, 2021) The Herbst group did not present alterations in the oropharynx corroborates with previous studies that evaluated the effect of this device on the airways. (GU et al., 2021) However, other studies contention that this fixed functional device is able of promoting improvement in oropharyngeal area. (CELIKOGLU et al., 2016)

Concerning to greater increase produced by the TB device in the lower pharyngeal dimension in relation to the Herbst device, this finding has already been described in the literature. Dina Osman ElAbbasy specified that forward positioning of the mandible by the functional appliance improves the position of the hyoid bone that advances the tongue due to increased genioglossus muscle tone, thus improving the dimensions of the airways. (CELIKOGLU et al., 2016; ELABBASY, 2019)

In relation to SP, this study showed a statistical difference in relation to the thickness of the SP at the initiation and on the conclusion of the orthopedic phase, with the TB group present a smaller SP thickness at the two times (T1 and T2) when compared to the Herbst group. However, this difference between the groups was not significant, corroborating other findings. (GHODKE et al., 2014)

Future studies are suggested to compare the effects of functional appliances in the pharyngeal airway dimensions, hyoid bone and soft palate during the growth spurt. Long-term stability studies of the changes promoted by functional appliances in the airways are necessary.

4 CONCLUSIONS

4 CONCLUSIONS

Both appliances corrected the Class II malocclusion, however the Herbst appliance demonstrated a greater amount of dentoalveolar effects in relation to the TB. Nevertheless, the Herbst appliance demonstrated a greater dentoalveolar effect of protrusion and labial tipping of the mandibular incisors and a greater decrease in Class II molar relationship. The Herbst appliance promoted a greater increase in the pharyngeal area and thickness of the SP, though the difference was not significant. The TB group promoted an improvement in the oropharynx and lower pharyngeal dimension.

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APPENDIX

Appendix A - DECLARATION OF EXCLUSIVE USE OF THE ARTICLE IN DISSERTATION/THESIS

We hereby declare that we are aware of the article **"Effects of Twin Block and Herbst devices on pharyngeal airway, hyoid bone and soft palate in Class II malocclusion during the peak period."** will be included in Dissertation of the student Cristina Bastiani and may not be used in other works of Graduate Programs at the Bauru School of Dentistry, University of São Paulo.

Bauru, March 03rd, 2022.

Cristina Bastiani _____ _____
Author Signature

José Fernando Castanha Henriques _____
Author Signature

_____ _____
Author Signature

_____ _____
Author Signature

ANNEXES

ANNEX A. Ethics Committee approval, protocol number 53482821.2.0000.5417 (front).

USP - FACULDADE DE ODONTOLOGIA DE BAURU DA USP

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: ALTERAÇÕES DAS VIAS AÉREAS FARÍNGEAS, OSSO HIOIDE E PALATO MOLE APÓS O TRATAMENTO DA MÁ OCLUSÃO DE CLASSE II COM OS APARELHOS TWIN BLOCK E HERBST DURANTE O PERÍODO DE PICO CRESCIMENTO.

Pesquisador: CRISTINA BASTIANI

Área Temática:

Versão: 1

CAAE: 53482821.2.0000.5417

Instituição Proponente: Faculdade de Odontologia de Bauru

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 5.142.321

Apresentação do Projeto:

As informações relativas a este projeto de pesquisa foram tiradas dos documentos Informações Básicas do Projeto na Plataforma Brasil e Dispensa de TCLE. Trata-se de estudo retrospectivo envolvendo amostra de telerradiografias de pacientes com má-oclusão de classe II tratados a partir da década de 70 por meio de dois tipos diferentes de aparelhos, os quais podem ter produzido alterações no osso hioide, vias aéreas faríngeas e palato mole durante o pico de crescimento.

Objetivo da Pesquisa:

O objetivo do estudo é verificar os efeitos produzidos pelos aparelhos Twin Block e Herbst na via aérea faríngea, o osso hioide e palato mole em pacientes com má oclusão de Classe II durante o período de pico de crescimento.

Avaliação dos Riscos e Benefícios:

Os riscos foram descritos como possibilidade de ocorrer injúria com a documentação, sendo tomado extremo cuidado por parte da pesquisadora para que isso não ocorra.

Os benefícios são indiretos, já que a pesquisa poderá elucidar a seguinte questão: O tratamento com aparelhos funcionais em pacientes com má oclusão de Classe II durante o surto de crescimento poderá ser benéfico também para as vias aéreas faringes, osso hioide e palato mole?

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Continuação do Parecer: 5.142.321

Comentários e Considerações sobre a Pesquisa:

O estudo envolverá análise cefalométrica de imagens de telerradiografia digitalizadas obtidas antes e depois do tratamento ortodôntico. A pesquisadora solicita dispensa de TCLE, justificando que os responsáveis pelos pacientes à época do tratamento assinaram um termo autorizando o uso das imagens e dos dados obtidos durante o tratamento para fins didáticos e acadêmicos, incluindo publicação dos casos em periódicos especializados. Informa ainda que os pacientes foram tratados quando eram menores de idade, iniciando-se a partir de 1973, e que hoje esses pacientes já são adultos, não sendo possível o contato com os mesmos, já que os endereços e telefones de contato que constam dos prontuários são dos pais dos pacientes.

Considerações sobre os Termos de apresentação obrigatória:

Vide "Conclusões ou Pendências e Lista de Inadequações".

Recomendações:

Vide "Conclusões ou Pendências e Lista de Inadequações".

Conclusões ou Pendências e Lista de Inadequações:

Pode-se considerar o projeto de pesquisa como aprovado desde que a pesquisadora se comprometa a corrigir as seguintes inadequações, submetendo-as na forma de Emenda ao CEP:

1. Acrescentar na Plataforma Brasil o nome do orientador, Prof. Dr. José Fernando Castanha Henriques, como membro da equipe de pesquisa.
2. Corrigir o cronograma, já que a data para início da coleta dos dados está marcada como novembro de 2021.
3. Não foi apresentado check list.

Considerações Finais a critério do CEP:

Esse projeto foi considerado APROVADO na reunião ordinária do CEP de 01/12/2021, via Google Meet, devido à pandemia da COVID-19 e por orientações da CONEP, com base nas normas éticas da Resolução CNS 466/12. No entanto, solicita-se ao pesquisador responsável adequações no protocolo de pesquisa, conforme descrito no item: Conclusões ou Pendências e Lista de Inadequações. Ao término da pesquisa o CEP-FOB/USP exige a apresentação de relatório final. Os relatórios parciais deverão estar de acordo com o cronograma e/ou parecer emitido pelo CEP. Alterações na metodologia, título, inclusão ou exclusão de autores, cronograma e quaisquer outras mudanças que sejam significativas deverão ser previamente comunicadas a este CEP sob risco de não aprovação do relatório final. Quando da apresentação deste, deverão ser incluídos todos os TCLEs e/ou termos de doação assinados e rubricados, se pertinentes.

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Continuação do Parecer: 5.142.321

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1845275.pdf	03/11/2021 11:11:51		Aceito
Folha de Rosto	Folhaderosto.pdf	03/11/2021 11:10:11	CRISTINA BASTIANI	Aceito
Outros	Arquivodocx.docx	20/10/2021 09:22:29	CRISTINA BASTIANI	Aceito
Outros	Confidencialidade.docx	20/10/2021 09:21:36	CRISTINA BASTIANI	Aceito
Outros	Questionario.doc	20/10/2021 09:20:14	CRISTINA BASTIANI	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	Dispensa.doc	20/10/2021 09:17:28	CRISTINA BASTIANI	Aceito
Projeto Detalhado / Brochura Investigador	Projeto.docx	20/10/2021 09:14:17	CRISTINA BASTIANI	Aceito
Declaração de Pesquisadores	Pesquisador.doc	20/10/2021 09:11:43	CRISTINA BASTIANI	Aceito
Declaração de Instituição e Infraestrutura	Infraestrutura.jpg	20/10/2021 09:10:41	CRISTINA BASTIANI	Aceito
Cronograma	Cronograma.doc	20/10/2021 09:01:29	CRISTINA BASTIANI	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

BAURU, 02 de Dezembro de 2021

Assinado por:
Juliana Fraga Soares Bombonatti
(Coordenador(a))

Endereço: DOUTOR OCTAVIO PINHEIRO BRISOLLA 75 QUADRA 9
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ANNEX B. Patient´s informed consent exoneration (front).

Universidade de São Paulo
Faculdade de Odontologia de Bauru

Departamento Odontopediatria, Ortodontia e Saúde Coletiva
Disciplina de Ortodontia

DISPENSA DE TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO E TERMO DE ASSENTIMENTO

Solicitamos ao Comitê de Ética em Pesquisa, FOB-USP, a dispensa do Termo de Consentimento Livre e Esclarecido e Termo de Assentimento, do projeto de pesquisa intitulado "**Alterações das vias aéreas faríngeas, osso hioide e palato mole após o tratamento da má oclusão de Classe II com os aparelhos Twin Block e Herbst durante o período de pós pico de crescimento"** de autoria de *Cristina Bastiani* sob a orientação do *Prof. Dr. José Fernando Castanha Henriques*.

Tal solicitação justifica-se pelo fato de a amostra ser retrospectiva. Os prontuários estão sob os cuidados da disciplina de Ortodontia do Departamento de Odontopediatria, Ortodontia e Saúde Coletiva. Estes prontuários são do acervo desde 1973, constituindo uma dificuldade o contato com os indivíduos devido ao tempo decorrido desde a tomada radiográfica até a data presente. Vale ressaltar que os indivíduos assinaram a "AUTORIZAÇÃO PARA DIAGNÓSTICO E/OU EXECUÇÃO DE TRATAMENTO ORTODÔNTICO" (modelo anexo) a qual aprova tanto a execução do tratamento, se necessário, quanto seu uso para "quaisquer fins de ensino e de divulgação em jornais e/ou revistas científicas do país e do exterior", desta forma aprova-se também o uso dos dados do seu prontuário para o ensino em pesquisas cientificas.

A dispensa do termo de consentimento se deve ao fato de os indivíduos da amostra, no momento da execução do exame, serem tanto menor de 18 anos quanto adultos, não sendo diferenciado para a pesquisa, como critério de inclusão ou exclusão. Tais indivíduos também foram autorizados pelo responsável no documento "AUTORIZAÇÃO PARA DIAGNÓSTICO E/OU EXECUÇÃO DE TRATAMENTO ORTODÔNTICO". Os nomes e dados pessoais dos indivíduos não serão divulgados em nenhum momento, mantendo desta forma o sigilo profissional (Artigo 9º do Código de Ética Odontológico) e a privacidade dos participantes da pesquisa durante todas as fases e assumimos o compromisso de cumprir as exigências contidas na Resolução CNS Nº 466, de 12.12.12.

Bauru, 18 de outubro de 2021.

Cristina Bastiani
Orientada

Prof. Dr. José Fernando Castanha Henriques
Orientador

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