# Orthopedic treatment with the Herbst appliance: Do vertical changes occur in facial growth pattern?

Luís Antônio de Arruda Aidar*, Gladys Cristina Dominguez**,
Patrícia Lopes de Souza Alvarez Gonzalez***, Melissa Gusmão Dutra Mantovani***

## Abstract

**Objective:** This prospective study featured 32 adolescents with Class II, division 1 malocclusion in conjunction with mandibular retrognathia, treated using the Herbst appliance, built on metal bands and crowns, with the objective of cephalometrically evaluating any possible changes in facial growth pattern. **Methodology:** lateral cephalometric radiographs were taken at the beginning of treatment (T1) and immediately after 12 months of treatment, with the aforementioned orthopedic appliance (T2). The Jarabak ratio and Ricketts VERT index (modified) were used to determine facial pattern at T1 and T2. **Results:** using the Jarabak ratio, the results showed that 27 cases (84.4%) featured hypodivergent patterns at T1 and remained so at T2. Five cases (15.6%) featured a neutral pattern at T1 and did not change at T2. When the Ricketts VERT index (modified) was evaluated, no changes were observed in the facial patterns of 31 patients. Facial type changed in only one case. **Conclusion:** based on the obtained results, it can be concluded that, after 12 months of treatment with the Herbst appliance, no vertical changes occurred in the facial growth pattern of the studied patients.

**Keywords:** Herbst appliance. Cephalometrics. Facial type.

## INTRODUCTION

The Herbst appliance is a bilateral telescopic mechanism, anchored on the maxillary and mandibular arches, that keeps the mandible in a continuous anterior position during all mandibular functions[14]. This treatment method does not depend on patient compliance, and among other applications, it was used for TMD treatment, such as clicking or bruxism[14]. Although this appliance was proposed since the early 20$^{th}$ century, there were scarce references to it in orthodontic literature, until it was reintroduced as a treatment method in 1979[14].

According to an evaluation conducted by six of the largest laboratories in the United States, this orthopedic functional appliance has increased in popularity among[12]. In Brazil, its use increased significantly, especially after the courses presented by professor Hans Pancherz, from Germany.

* Doctoral faculty, responsible for Orthodontics at the, School of Dentistry, Santa Cecília University (Unisanta). Head of the Gradute Course in Orthodontics (Unisanta).
** Associate professor, of Orthodontics, School of Dentistry, University of São Paulo (USP-SP).
*** Specialists in Orthodontics, Associação dos Cirurgiões-Dentistas de Santos, São Vicente e Região da Costa da Mata Atlântica (ACDSSV).

This treatment method has proved to be effective in correcting Class II malocclusions[1,2,13,14,21,24]. In addition to the possible stimulating effect on mandibular growth, Herbst-based treatment results in a redirection of maxillary growth, mesial movement of mandibular teeth, and distal movement of maxillary teeth[13,25]. These factors combined are part of the mechanisms for Class II correction.

With this in mind, attention to the vertical relationship of apical bases and the manner in which different facial growth patterns respond to functional appliance therapy are extremely important for the success of Class II treatment[15,21,23]. Thus, it is vitally important to evaluate the vertical effects of this treatment method on the patient's facial pattern. The vertical relationship between the maxilla and the mandible may be affected by the dentoalveolar effects of the Herbst appliance, especially in patients with increased anterior facial height, resulting in compromised facial aesthetics[15]. On the other hand, one study revealed no significant changes in the vertical growth pattern of patients with neutral and hypodivergent growth patterns[23].

Some publications[11,23,24,25,29] describe different types of anchorage systems. Depending on the patient's facial type at the beginning of treatment, clinicians must be aware of the different dentofacial changes induced in the vertical plane by the different Herbst appliance designs[23].

The objective of this study was to cephalometrically evaluate the possible vertical effects on the vertical facial pattern in a group of adolescents with mandibular retrognathia, treated with the Herbst orthopedic appliance.

## MATERIAL AND METHODS

### Material

the study included 32 caucasian Brazilian adolescents, of both genders (16 male and 16 female), who were treated with the Herbst orthopedic appliance to correct Angle Class II, division 1 malocclusion in conjunction with mandibular retrognathia. Mean pre-treatment age (T1) was 12 years and 10 months ± 1 year and 2 months (varying from 10 years and 11 months to 15 years and 10 months of age).

The sample included patients with the following features: (1) clinical aspect of mandibular retrognathia, with ANB angle equal or greater than $4^0$; (2) Class II, division 1 malocclusion, permanent dentition and absence of anterior open bite; (3) at the stage of sesamoid bone appearance (S – Björk-Helm stage 3) until immediately after pubertal peak, having reached the beginning of the ossification of the metacarpophalangeal joint of the third finger ($FM_3$ cap – Björk-Helm stage 4º), as shown in hand and wrist radiographs.

The Committee for Ethics in Research of the Federal University of São Paulo/São Paulo Hospital analyzed and approved the research project on June 12, 2000 (Ref. CEP no. 679/00).

All patients were treated with the modified Herbst appliance, with stainless steel crowns on the maxillary first molars and mandibular first pre-molars, orthodontic bands on the maxillary first premolars and first mandibular molars, a Hyrax expander attached to the maxillary crowns and bands, and a Nance appliance attached to the mandibular crowns and bands (Fig. 1). Occlusal supports were used in cases where the maxillary and/or mandibular second molars were present. Rapid maxillary expansion was necessary in all patients, due to transverse maxillary deficiency present in Class II malocclusions[1,2,27]. Rapid maxillary expansion occurred, on average, in the first two weeks after placement of the Herbst appliance. Advancements of up to 6mm were performed at the beginning of treatment. Whenever necessary, additional advancements were done during the third month. Asymmetrical mandibular advancements were performed in some cases, with the objective of correcting skeletal midline deviation[1,2].

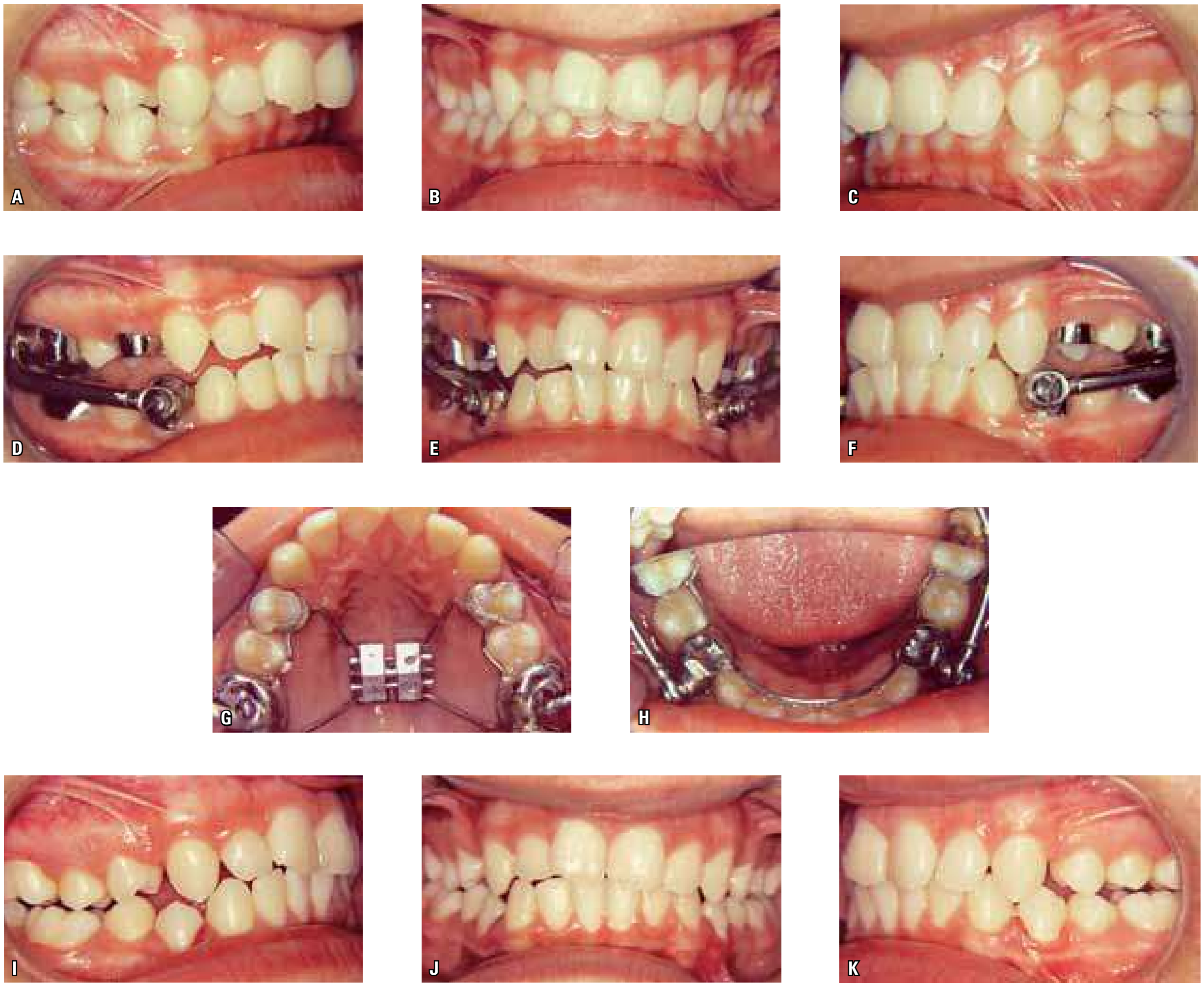


FIGURE 1 - Intraoral photos of the sequence of treatment with the Herbst appliances using stainless steel bands and crowns.

In all 32 patients, Herbst therapy resulted in Class I or overcorrected Class I occlusal relationship.

## Methods

The adolescents were evaluated using lateral cephalometric radiographs, immediately prior to the start of treatment (T1) and after Herbst orthopedic appliance therapy (T2), worn during 12 months to correct Angle Class II, division 1 malocclusion associated to mandibular retrognathia. The head cephalogrametric readiographs were taken using always the same cephalostat (B.F. Wehmer, USA) and a GE® x-ray machine (General Electrics, USA), in right lateral norm and centric occlusion. Cephalometric radiographs were manually traced on acetate paper, copying anatomical details of interest for the cephalometric tracing. To measure cephalometric variables, a protractor and a metric ruler were used, with 0.5° and 0.5mm increments, respectively. A few variables of Jarabak's cephalometric analysis[26] were used. Both the Jarabak[26] ratio and Ricketts VERT index[4] (modified) were used to evaluate the facial growth pattern of the sampled patients.

## Cephalometric variables of Jarabak's analysis[26]

The following linear cephalometric landmarks were used: S-N, (anterior cranial base, determined by connecting points sela to nasion), S-Ar (posterior cranial base, determined by connecting points sela to articulare), Ar-Goc (mandibular ramus plane, determined by connecting points articulare to constructed gonion), Me-Goc (mandibular plane, determined by connecting points menton to constructed gonion), S-Goc (posterio facial height, determined by connecting points sela to constructed gonion), N-Me (anterior facial height, determined by connecting points nasion to menton), S-Gnc (facial longitude, determined by connecting points sela and constructed gnatio) and N-Goc (facial depth, determined by connecting points nasion and constructed gonion) (Fig. 2).

## Jarabak Ratio[26] (FHR)

Several analysis are currently used to aid in the diagnosis of growth direction. Facial morphology has been characterized[26] based on three distinct patterns defined by the Facial Height Ratio (FHR) or Jarabak Ratio, meaning: Anterior Facial Height (S-Goc) divided by Posterior Facial Height (N-Me), multiplied by 100. Thus, a percentage is obtained which is representative in describing facial morphology (Fig. 3).

$$(FHR) = (S\text{-}Goc/N\text{-}Me) \times 100$$

Whenever the percentage is lower than 59%, it is classified as a hyperdivergent growth pattern; when it stands between 59% and 63%, it is considered a neutral growth pattern; and when higher than 63%, as a hypodivergent growth pattern.

## Ricketts VERT index[19]

Applying the Ricketts[19] method, three facial types can be observed: mesofacial, dolichofacial and brachyfacial, depending on whether the di-

FIGURE 2 - Cephalometric variables of Jarabak's analysis.

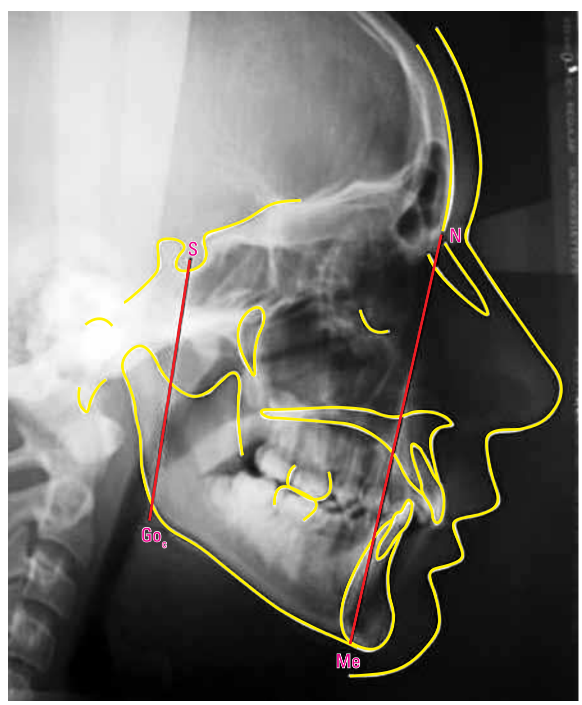

FIGURE 3 - Cephalometric variables used in the Jarabak Ratio.

rection of facial growth is downward or forward; that is, more vertical or horizontal, respectively. In this work, the Ricketts VERT index[4] (modified) was used, further subdividing dolichofacial and brachyfacial types into slight, medium and severe. Facial type is defined based on determining the VERT (amount of facial growth), using the following variables: facial axis angle –angle formed by the nasion-basion (N-Ba) plane and the facial axis (Pt-Gn); facial angle (depth) – angle formed by the Frankfort (Po-Or) and Facial planes (N-P); mandibular plane angle – angle formed by the mandibular (Go-Me) and Frankfurt planes (Po-Or); lower facial height – angle formed by the Xi-ANS and Xi-Pm lines; mandibular arch – angle formed by the codylar axis (Xi-DC) and the mandibular body axis (Xi-Pm) (Fig. 4).

After the calculations required to determine VERT were performed, as described in the literature[19,28], the patients were classified according to panel 1.

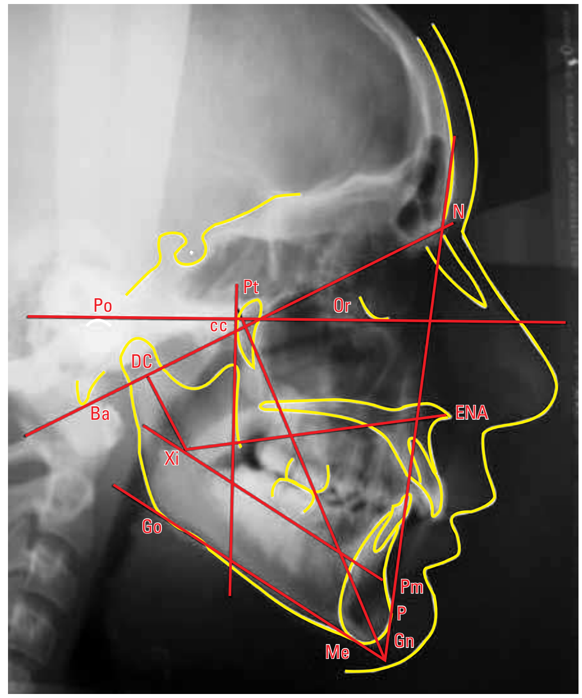


FIGURE 4 - CCephalometric variables used in the Ricketts[4] VERT index (modified).

| FACIAL TYPE | VERT |
|---|---|
| severe brachyfacial | + 2.0 |
| medium brachyfacial | + 1.0 |
| slight brachyfacial | + 0.5 |
| mesofacial | 0 |
| slight dolichofacial | - 0.5 |
| medium dolicofacial | - 1.0 |
| severe dolicofacial | - 2.0 |

PANEL 1 - Relationship between the Ricketts[4] VERT index (modified) and facial type

## Statistical method

Primarilly applied tests showed a symmetric distribution of measured values. For this reason, parametric tests were applied for statistical analysis.

In order to evaluate possible differences between linear and angular cephalometic measurements at the beginning (T1) and at the end of treatment (T2), a paired t-test was applied. Levels of significance were established at $p \leq 0.001$, $p \leq 0.01$ and $p \leq 0.05$.

## Method error

In order to evaluate method precision, radiographs of 16 patients from the studied sample (n = 32) were selected at random. All radiographs were traced and measured again by a single operator one month after the initial tracing. A paired t-test was then applied to evaluate systematic error. Using the difference between the first and second measurement of each radiograph, Dahlberg's formula was applied to estimate casual error[10]. The formula applied was $E = \sqrt{\sum d^2/2n}$, where *d* is the difference in measurements and *n* is the number of re-traced cases from the sample.

## RESULTS

Systematic error was not significant in any of the cases. Casual error is shown on tables 1 and 2.

At T1, according to the criteria by Siriwat

& Jarabak[26], 27 patients showed hypodivergent growth pattern (84.4%), while 5 presented a neutral pattern (15.6%). At T1, the Ricketts VERT index[4] (modified) showed the following distribution: 16 mesofacial (50%), 5 medium brachyfacial (15.6%), 5 slight dolichofacial (15.6%), 4 slight brachyfacial (12.5%), 1 severe dolichofacial (3.1%), and 1 severe brachyfacial (3.1%).

Not a single case, according to the Siriwat & Jarabak[26] evaluation, showed changes in facial pattern between T1 and T2. Evaluating the Ricketts VERT index[4] (modified), in only one patient did the pattern change from mesofacial in T1 to slight brachyfacial in T2.

All linear measurements of the Siriwat & Jarabak[26] analysis showed statistical differences between T1 and T2 ($p < 0.001$) (Table 1). The variables used to find the Ricketts VERT index[4] (modified) showed the following results between T1 and T2: facial plane angle (n.s.); facial angle ($p < 0.001$); mandibular plane angle (n.s.); lower facial height ($p < 0.001$); mandibular arch (n.s.) (Table 2).

## DISCUSSION

Any possible vertical changes resulting from antero-posterior corrections in the apical bases are a reason for concern when planning an orthodontic treatment, as facial types are unchangeable[19]. This means no changes take place throughout the patient's entire life – it is a natural individual trait. On the other hand, a study[9] evidenced a general trend of counterclockwise rotation of the face between childhood and adolescence in all three facial types. These facial types, however, change easily, becoming more vertical if certain precautions are not taken during planning for biomechanical treatment. Thus, it is believed that the maintenance of the patient's facial type is a factor of post-treatment

TABLE 1 - Mean, standard deviation (s.d.) of the linear cephalometric variables (mm) at T1 and T2 (comparison of quantitative evaluations with paired t-tests) and casual error (T1 and T2).

| | | T1 | T2 | SIGNIFICANCE (P) | DAHLBERG'S FORMULA CASUAL ERROR | |
|---|---|---|---|---|---|---|
| | | | | | T1 | T2 |
| S-N | mean | 72.42 | 73.72 | < 0.001 *** | 0.45 | 0.34 |
| | s.d. | 3.75 | 3.91 | | | |
| S-Ar | mean | 36.13 | 37.27 | < 0.001 *** | 0.55 | 0.48 |
| | s.d. | 3.37 | 3.56 | | | |
| Ar-Goc | mean | 45.31 | 47.28 | < 0.001 *** | 0.52 | 0.41 |
| | s.d. | 4.13 | 4.18 | | | |
| Me-Goc | mean | 70.14 | 72.86 | < 0.001 *** | 0.61 | 0.41 |
| | s.d. | 4.12 | 3.91 | | | |
| S-Goc | mean | 77.80 | 80.52 | < 0.001 *** | 0.54 | 0.43 |
| | s.d. | 5.12 | 5.66 | | | |
| N-Me | mean | 118.36 | 121.61 | < 0.001 *** | 0.40 | 0.41 |
| | s.d. | 6.06 | 6.31 | | | |
| S-Gnc | mean | 126.56 | 131.38 | < 0.001 *** | 0.45 | 0.52 |
| | s.d. | 6.19 | 6.45 | | | |
| N-Goc | mean | 119.89 | 122.38 | < 0.001 *** | 0.33 | 0.39 |

*** statistically significant at 0.1%.

TABLE 2 - Mean, standard deviation (s.d.) of the angular cephalometric variables (degrees at T1 and T2 (comparison of quantitative evaluations with paired t-tests) and casual error (T1 and T2).

| | | T1 | T2 | SIGNIFICANCE (P) | DAHLBERG'S FORMULA CASUAL ERROR | |
|---|---|---|---|---|---|---|
| | | | | | T1 | T2 |
| facial plane angle | mean | 89.27 | 89.41 | 0.534 n.s. | 0.47 | 0.56 |
| | s.d. | 3.39 | 3.67 | | | |
| facial angle (depth) | mean | 88.16 | 89.11 | *** | 0.61 | 0.53 |
| | s.d. | 3.13 | 3.49 | | | |
| mandibular plane angle | mean | 23.69 | 23.67 | 0.909 n.s. | 0.64 | 0.75 |
| | s.d. | 4.24 | 4.38 | | | |
| anterior facial height | mean | 46.23 | 46.88 | *** | 0.43 | 0.53 |
| | s.d. | 3.99 | 4.08 | | | |
| mandibular arch | mean | 32.66 | 32.66 | 1.000 n.s. | 0.61 | 0.51 |
| | s.d. | 4.01 | 3.88 | | | |

n.s. = non-significant.
*** statistically significant at 0.1%.

stability, as neuromuscular balance will be preserved in these circumstances[28].

In the present work, 27 of the 32 patients (84.4%) presented patterns with a predominant tendency for horizontal growth[26]. The Ricketts VERT index[4] (modified) showed that 26 of the 32 patients (81.2%) featured predominantly balanced patterns (50%) or with a tendency towards horizontal growth (31.2%). Six patients from the sample (18.7%) had vertical growth patterns. The same interpretation was not found for all patients between the two different methods used to determine facial type, which corroborates the results of another previous study[22]. In reality, the two methods feature different and complementary approaches. The higher prevalence of hypodivergent patterns found in the present sample does not corroborate the study[3] that found a higher prevalence of neutral facial growth patterns in a group with Class II, division 1 malocclusion. It also did not confirm the results of a study[8] in São Paulo that evaluated lateral cephalometric radiographs of a group of 157 consecutive adolescents with Class II, division 1 malocclusion and mandibular retrognathia, with mean age of 11 years and 3 months (± 1 year and 5 months) and ANB angle ≥ 4º. The authors[8] verified that, according to the Ricketts VERT index[4], most adolescents featured dolichofacial type (48%), followed by mesofacial type (33%), and less frequently brachyfacial type (19%). This difference is due to the fact that in the present study, the prognosis for long-term stability was taken into consideration when selecting patients. This factor seems to depend on a favorable post-treatment growth pattern[16]. Thus, patients with anterior open bite, which is more frequent in vertical patterns[5], were excluded from the sample.

Clinically evaluated sagittal, vertical and transverse changes were quite evident in patients in the present study during the first months of treatment using the Herbst appliance. Whenever the Herbst appliance is set on bands and crowns, mandibular advancement, which corresponds to the therapeutic position imposed by a constructive bite, creates a disocclusion in the posterior area. This disocclusion is compensated during the first months of treatment, as a result of vertical alveolar growth, which is expressed by the absence of vertical occlusal contacts. At that time, the necessary occlusal supports are made on the second molars, in order to avoid a differentiated extrusion of these teeth. In the present study, it was observed that, although these adaptive changes in dentoalveolar growth had taken place, they did not negatively influence facial type between T1 and T2.

Another aspect to consider is the crossbite that occurred at the time the Herbst appliance was placed. A great part of Class II malocclusions with retrognathic mandibles show transverse deficiencies in the maxilla, evidenced by the sagittal advancement promoted by the Herbst appliance. Moreover, maxillary expansion reduced occlusal interference and functional changes, as the wider portion of the lower arch was placed anteriorly.

On average, one week after appliance placement the Hyrax expander began to be activated, resulting in opening of the midpalatal suture, in a pre-established protocol of one complete turn in the first day and a half-turn in the following days, until overcorrection was achieved. During this stage, the bite was opened, occasionally diminishing the effect of the initial constructive bite.

With regard to the time of treatment, the patients began this study during their pubertal growth spurt, as evaluated by hand and wrist x-rays. However, clinicians should remember that there is great individual variation in skeletal and dental responses with this method of treatment[17].

In the present study, no cases showed changes in facial patterns between T1 and T2, according to the criteria set by Siriwat & Jarabak[26]. Studies were found in the literature which used different methods regarding treatment duration and type of Herbst appliance, thus hindering a comparison with the present results. In a study using the Herbst appliance in normo-hypodivergent patients, the authors[23] did not find significant changes in the vertical growth pattern, which agrees with the results of the present study. During a similar observation time of 12 months, another investigation[24], which used the version of the Herbst appliance on acrylic splints, had similar results as the present study. It is important to note that this other study could have had different results, as this type of appliance does not allow dentoalveolar growth during the active phase of treatment with the Herbst, because it covers the occlusal surfaces. Other studies[15,20,25], using different designs of the Herbst appliance, did not show changes in the mandibular plane angle, either. Evaluating the Ricketts VERT index[4] (modified), only one patient (3.1%) showed changes between T1 and T2 to a more horizontal pattern. Case no. 8 had a slight increase in the facial plane, facial depth and mandibular arch angles, going from mesofacial at T1 to slight brachyfacial at T2, and corroborating the results of a previous study[23]. However, in that investigation the authors used the Herbst appliance in conjunction with an acrylic splint and high-traction extraoral anchorage. In the present sample, no deleterious effects of the treatment were found on patients – although few patients had a vertical growth pattern at T1, according to the Ricketts VERT index[4] (modified) (6 cases = 18.75%), and some of them had overbite and excessive facial height. The increase in anterior facial height occurs with parallel downward growth of the mandibular plane[15]. Treatment with the Herbst appliance has shown an increase in condylar growth in the desired therapeutic sagittal direction[21], coinciding with the direction of condylar growth in hyperdivergent individuals[6], without resulting in downward and backward rotation of the mandible[20]. Thus, individuals with a high mandibular plane angle have a good prognosis with Herbst therapy. Significant increases ($p < 0.001$) were found in the results of this study for anterior facial height (N-Me), lower facial height (Xi-ENA.Xi-Pm) and posterior facial height (S-Goc) (Tables 1, 2), without altering the patient´s facial pattern, according to the criteria of Siriwat & Jarabak[26] and the Ricketts VERT index[4] (modified). It makes sense, especially because the increase in anterior facial height during Herbst use is due to the geometric effect of anterior repositioning of the mandible and increase in mandibular length[20] ($p < 0.001$ – Goc-Me) (Table 1).

Some studies have shown that vertical development of the ramus increases during treatment with an activator[30] and Herbst[18]. It is important to note that in the present study, growth of the posterior cranial base (S-Ar) in conjunction with mandibular ramus growth (Ar-Goc) increased significantly ($p < 0.001$) between T1 and T2, contributing to the increase in posterior facial height. The measurements S-Gnc and N-Goc also underwent significant modifications ($p < 0.001$) due to the increase in anterior and posterior facial height. Because a control group was not used, due to the timely age of the patients during the time of treatment, it becomes difficult to ascertain which effects were the result of the treatment or of natural growth. Treatment with the Herbst appliance would be more useful in Class II cases with lack of vertical development in anterior facial height[15]. On the other hand, the results of one study [21] showed that the skeletal and dental changes that contributed to correcting Class II did not depend on the vertical relationship of the apical bases.

Although no significant vertical changes occurred with the correction of Class II in the treated cases, it is extremely important to have a longitudinal follow-up of this group of adolescents, to evaluate the stability of obtained results.

Finally, all patients in this work were subjected to a second phase of orthodontic treatment, with the placement of upper and lower fixed appliances, with the objective of refining the occlusion. After that stage, new evaluations will be made in order to verify facial pattern stability of the studied patients from beginning to end of orthodontic treatment.

## CONCLUSION

Based on the obtained results, it can be concluded that, after 12 months of treatment with the Herbst appliance, no vertical changes occurred which altered the facial growth patterns of the studied patients.

Submitted: February 2007
Revised and accepted: June 2008

## REFERENCES


1. AIDAR, L. A. A. **Posição do côndilo e disco das articulações temporomandibulares à ressonância magnética em adolescentes com retrognatismo mandibular tratados com aparelho de Herbst**. 2003. Tese (Doutorado)-Escola Paulista de Medicina, Universidade Federal de São Paulo, São Paulo, 2003.
2. AIDAR, L. A. A.; ABRAHÃO, M.; YAMASHITA, H. K.; DOMINGUEZ, G. C. Herbst appliance therapy and temporomandibular joint disc position: A prospective longitudinal magnetic resonance imaging study. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 129, no. 4, p. 486-496, Apr. 2006.
3. AIDAR, L. A. A.; SCANAVINI, M. A. Estudo comparativo cefalométrico radiográfico dos padrões de crescimento facial em pacientes portadores de oclusão normal e maloclusões de Classe I; Classe II, divisão 1; Classe II, divisão 2 e Classe III de Angle de acordo com Siriwat & Jarabak. **Ortodontia**, São Paulo, v. 22, n. 2, p. 31-52, maio/ago. 1989.
4. ALBUQUERQUE, C. M.; VIGORITO, J. W. Estudo cefalométrico radiográfico empregando a análise de Ricketts na avaliação dos padrões dentofaciais de pacientes portadores de maloclusão de Classe II, divisão 1, tratados durante a fase de dentição mista. **Ortodontia**, São Paulo, v. 23, n. 2, p. 11-28, 1990.
5. ALMEIDA, R. R.; URSI, W. J. S. Anterior open bite: Etiology and treatment. **Oral Health**, Don Mills, v. 80, no. 1, p. 27-31, Jan. 1990.
6. BJÖRK, A. Prediction of mandibular growth rotation. **Am. J. Orthod.**, St. Louis, v. 55, no. 6, p. 585-599, Jun. 1969.
7. BJÖRK, A.; HELM, S. Prediction of the age of maximum pubertal growth in body height. **Angle Orthod.**, Appleton, v. 37, no. 2, p. 134-143, 1967.
8. CARVALHO, P. L.; DOMINGUEZ-RODRIGUEZ, G. C. Estudo cefalométrico radiográfico da correlação entre o tipo facial e as variações da inclinação do plano oclusal em adolescentes com maloclusão de Classe II, divisão 1ª e retrognatismo mandibular. **Ortodontia**, São Paulo, v. 36, n. 3, p. 16-26, 2003.
9. COTRIM-FERREIRA, F. A.; PANELLA, J.; FERREIRA, F. V.; SCAVONE JÚNIOR, H.; MARTINS, D. R.; LIBERTI, E. A. Os tipos faciais e suas correlações com a base do crânio: estudo cefalométrico longitudinal. **Ortodontia**, São Paulo, v. 34, n. 3, p. 8-17, set./dez. 2001.
10. HOUSTON, W. J. B. The analysis of errors in orthodontic measurements. **Am. J. Orthod.**, St. Louis, v. 83, no. 5, p. 382-390, 1983.
11. McNAMARA, J. A. Clinical management of the acrylic splint Herbst appliance. **Am. J. Orthod.**, St. Louis, v. 94, no. 2, p. 142-149, Aug. 1988.
12. PANCHERZ, H. History, background, and development of the Herbst appliance. **Semin. Orthod.**, Philadelphia, v. 9, no. 1, p. 3-11, 2003.
13. PANCHERZ, H. The mechanism of Class II correction in Herbst appliance treatment: A cephalometric investigation. **Am. J. Orthod.**, St. Louis, v. 82, no. 2, p. 104-113, 1982.
14. PANCHERZ, H. Treatment of Class II malocclusions by bite jumping with the Herbst appliance: A cephalometric investigation. **Am. J. Orthod.**, St. Louis, v. 76, no. 4, p. 423-441, 1979.
15. PANCHERZ, H. Vertical dentofacial changes during Herbst appliance treatment: A cephalometric investigation. **Swed. Dent. J.**, Jönköping, v. 15, p. 189-196, 1982. Supplement.
16. PANCHERZ, H.; FACKEL, U. The skeletofacial growth pattern pre- and post-dentofacial orthopaedics: A long-term study of Class II malocclusions treated with the Herbst appliance. **Eur. J. Orthod.**, Oxford, v. 12, no. 2, p. 209-218, 1990.
17. PANCHERZ, H.; HÄGG, U. Dentofacial orthopedics in relation to somatic maturation: An analysis of 70 consecutive cases treated with the Herbst appliance. **Am. J. Orthod.**, St. Louis, v. 88, no. 4, p. 273-287, 1985.
18. PANCHERZ, H.; LITTMANN, C. Morphologie und Lage des Unterkiefers bei der Herbst-Behandlung. Eine kephalometrische Analyse der Veränderungen bis zum Wachstumsabschlub. **Inf. Orthod. Kieferorthop.**, München, v. 21, p. 493-513, 1989.
19. RICKETTS, R. M. **Orthodontic diagnosis and planning**. Philadelphia: Saunders, 1982. v. 1, p. 107-125.
20. RUF, S.; PANCHERZ, H. The effect of Herbst appliance treatment on the mandibular plane angle: A cephalometric roentgenographic study. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 110, no. 2, p. 225-230, 1996.
21. RUF, S.; PANCHERZ, H. The mechanism of Class II correction during Herbst therapy in relation to the vertical jaw base relationship: A cephalometric roentgenographic study. **Angle Orthod.**, Appleton, v. 67, no. 4, p. 271-276, 1997.
22. SCANAVINI, C.; VIGORITO, J. W. Estudo cefalométrico-radiográfico das possíveis correlações existentes entre as análises de Vigorito, Ricketts e Siriwat & Jarabak na definição dos tipos faciais, em indivíduos leucodermas. **Ortodontia**, São Paulo, v. 34, n. 3, p. 27-41, 2001.
23. SCHIAVONI, R.; GRENGA, V.; MACRI, V. Treatment of Class II high angle malocclusions with the Herbst appliance: A cephalometric investigation. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 102, no. 5, p. 393-409, 1992.
24. SCHÜTZ, T. C. B.; VIGORITO, J. W.; DOMINGUEZ-RODRÍGUEZ, G. C. Avaliação cefalométrica-radiográfica das modificações esqueléticas e do perfil facial decorrentes do tratamento com o aparelho de Herbst em adolescentes com maloclusão de Classe II, divisão 1ª de Angle. Parte II. **Ortodontia**, São Paulo, v. 36, n. 1, p. 44-61, 2003.
25. SIDHU, M. S.; KHARBANDA, O. P.; SIDHU, S. S. Cephalometric analysis of changes produced by a modified Herbst appliance in the treatment of Class II division 1 malocclusion. **Br. J. Orthod.**, Oxford, v. 22, no. 1, p. 1-12, 1995.
26. SIRIWAT, P. P.; JARABAK, J. R. Malocclusion and facial morphology is there a relationship? **Angle Orthod.**, Appleton, v. 55, no. 2, p. 127-138, 1985.
27. TOLLARO, I.; BACCETTI, T.; FRANCHI, L.; TANASESCU, C. D. Role of posterior transverse interarch discrepancy in Class II, division 1 malocclusion during the mixed dentition phase. **Am. J. Orthod. Dentofacial Orthop.**, St. Louis, v. 110, no. 4, p. 417-422, 1996.
28. VIGORITO, J. W. **Ortodontia clínica**: diagnóstico e terapêuticas. 1. ed. São Paulo: Santa Madonna, 2004. p. 49-98.
29. WIESLANDER, L. Intensive treatment of severe Class II malocclusions with a headgear-Herbst appliance in the early mixed dentition. **Am. J. Orthod.**, St. Louis, v. 86, no. 1, p. 1-13, 1984.
30. WILLIAMS, S.; MELSEN, B. The interplay between sagittal and vertical growth factors: An implant study of activator treatment. **Am. J. Orthod.**, St. Louis, v. 81, no. 4, p. 327-332, 1982.



**Contact Address**
Luís Antônio de Arruda Aidar
Rua Luís Suplicy 35, Gonzaga
CEP: 11.055-330 – Santos / SP
E-mail: luisaidar@uol.com.br