Computed Tomographic evaluation of a young adult treated with the Herbst appliance

Savana Maia*, Dirceu Barnabé Raveli**, Ary dos Santos-Pinto**,
Taísa Boamorte Raveli***, Sandra Palno Gomez***

Abstract

Introduction: The key feature of the Herbst appliance lies in keeping the mandible continuously advanced. **Objective:** To monitor and study the treatment of a patient wearing a Herbst appliance by means of Cone-Beam Computed Tomography (CBCT) images for 8 months after pubertal growth spurt. The subject was aged 16 years and 3 months and presented with a Class II, Division 1 malocclusion associated with mandibular retrognathia. **Results:** The CBCT images of the temporomandibular joints suggest that the treatment resulted in the remodeling of the condyle and glenoid fossa and widening of the airway. **Conclusions:** The Herbst appliance constitutes a good option for treating Class II malocclusion in young adults as it provides patients with malocclusion correction and improves their aesthetic profile.

Keywords: Temporomandibular joint. Computed Tomography. Orthopedic appliances.

INTRODUCTION

Despite the availability of a wide range of Class II malocclusion treatment options, the actual action mechanism behind these orthopedic devices remains controversial. The effectiveness of the Herbst appliance in treating Class II malocclusions has been studied for decades. However, despite the obvious effectiveness of this therapy, the possibility of manipulating mandibular growth potential beyond what is genetically determined still fuels the debate between proponents and opponents of dentofacial orthopedics.[1] Some researchers, grounded in Functional Matrix theory, believe that local environmental factors ultimately determine the final size of the craniofacial skeleton, which could therefore be subjected to some regulation by changing its functional pattern.[1] Opponents of this view advocate that control is predominantly genetic, alterations are restricted to the dentoalveolar component and do not affect basal bone growth. It is suggested that the use of functional appliances for stimulating mandibular growth would have only a temporary impact on the dentofacial pattern and that over the long term the morphogenectic pattern would prevail.[1,2]

Nevertheless, the primary issue remains controversial: Do functional appliances cause significant changes in mandibular growth? Although these appliances have been in use for over a hundred years little is known about how they work,

* MSc in Orthodontics, PhD Student in Orthodontics, Araraquara School of Dentistry (UNESP).
** Associate Professor, Department of Orthodontics, Araçatuba School of Dentistry (UNESP).
*** MSc Student, Araraquara School of Dentistry (UNESP).

which tissue systems are affected, to what extent and how stable these effects really are.[1,2,3]

However, recent studies using computed tomography (CT)—which allows the reconstruction of anatomical areas and their display in three dimensions, revealing information about size, shape and texture—show tissue response in patients treated after pubertal growth spurt[3,4] as well as remodeling of the glenoid fossa and condyle, and TMJ adaptation.[5,6,7,8]

Some studies[9,10,11] assessed the response of the condyle, glenoid cavity and posterior mandibular ramus in adult rhesus monkeys. The results showed adaptation of the condyle and glenoid fossa during treatment with the Herbst appliance.

Advances in Imaging Technology in Dentistry and the advent of Computed Tomography (CT) scans ensure accurate diagnoses with great reliability, enabling the three-dimensional analysis of structures. As well as specific CT software, which allows measurements to be carried out in tomographic slices, a new methodology has emerged which makes for the assessment of inclinations and angulations of individual teeth, and bone remodeling, accurately reproducing the various structures.

Computed Tomography is the exam of choice for analyzing bone components and dental structures.[12] The development of this new technology has provided dentistry with the reproduction of three-dimensional images of mineralized maxillofacial tissues with minimal distortion and significantly reduced radiation doses.[13]

Its diagnostic reliability is due to the accuracy of the measurements used in different methods, which is of great importance to orthodontists since orthodontic treatment diagnosis, prognosis and planning, among other factors, depend on such measurements.

CLINICAL CASE REPORT

The case described in this article is part of a research sample collected at the Araraquara School of Dentistry, Paulista State University, aimed at evaluating and comparing orthodontic and orthopedic effects on subjects treated with tooth supported Herbst appliances using CT. This clinical case report is part of a research project approved by FOAr's Ethics in Research Committee (Protocol No. 26/06), with the support of the São Paulo Research Foundation (FAPESP).

Initial diagnosis

A Brazilian patient, male, 16.3 years old, sought orthodontic treatment at the Araraquara School of Dentistry (UNESP) complaining that his chin was positioned backwards. Front view facial analysis showed a mesofacial pattern and absence of lip seal. Lateral view analysis disclosed a convex profile associated with mandibular retrognathia (observed clinically), and a short chin-neck line (Fig 1).

Intraoral examination showed that the patient presented permanent dentition, a Class II malocclusion and 7.3 mm overjet (Fig 3). At diagnosis, functional changes were noted in swallowing. Morphological analysis of the cephalometric radiograph confirmed a convex facial pattern (Fig 2).

Skeletal age was verified by means of carpal X-ray using skeletal maturation indicators according to the Greulich and Pyle atlas.[16] The patient was nearing the end of the descending growth curve (FPut – Complete epiphyseal union in the proximal phalanx of the 3rd finger; FMut – Complete epiphyseal union in the middle phalanx of 3rd finger; and/or Rut - Complete epiphyseal union of the radius bone), i.e., at the end of pubertal growth.

Using the Herbst appliance

The patient was treated orthopedically with a banded Herbst appliance for a period of eight months. To evaluate dental and skeletal changes the patient underwent two lateral cephalometric radiographs and CBCT scans in maximal

FIGURE 1 - Initial extraoral photographs profile (**A**) and front (**B**) views.

FIGURE 2 - Initial lateral cephalometric radiograph.

FIGURE 3 - Initial intraoral photographs right (**A**), front (**B**) and left (**C**) views.

habitual intercuspation (MHI): At T1, beginning of treatment, and T2, eight months after treatment. The Cone-Beam CT scans were performed at the beginning of treatment and after removal of the Herbst appliance, and analyzed using specific software (Dolphin 10.5, Dolphin Imaging & Management Solutions, USA).

The anchorage system used in the upper and lower arches was a banded Herbst (Figs 4, 5 and 6). To cement the anchorage structures we used light cure glass ionomer cement (3M Unitek).

A telescopic mechanism was used (Flip-Lock - TP Orthodontics), composed of the following accessories: a) Tube, determines the amount of mandibular advancement, b) Piston, adapted to the length of the tube, c) Connectors, with a spherical shape.

CT examination and measurements

The CT scans were obtained with an i-CAT scanner with the patient's mouth shut and in maximal intercuspation (MHI). Scanners provide standardized images in a single 360-degree rotation, 20-second scan. It reconstructs the data in real time, automatically and immediately, yielding 460 individual 0.5 mm slices in each orthogonal plane. Data were exported in DICOM format and evaluated using Dolphin software.®

It is very important to standardize head position in the software during CT examination. 3D views of the axial, coronal and sagittal planes are used. In the front view CT scan, the sagittal midline is standardized in the vertical plane. The Frankfort plane provides guidance in the horizontal plane. In lateral view CT scans, the vertical

FIGURE 4 - Intraoral photograph showing the banded Herbst appliance without piston assembly.

FIGURE 5 - Intraoral photograph showing lower Herbst anchorage.

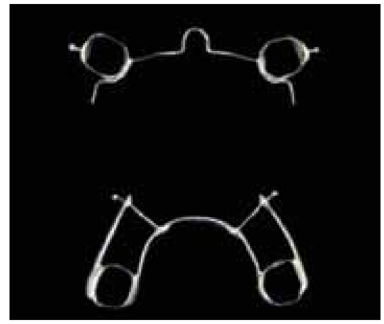

FIGURE 6 - Upper and lower banded Herbst anchorage.

plane comprises the line where the Porion crosses the Frankfort horizontal plane.

CT scan image assessment

The CT scans revealed a 0.8 mm increase in condyle diameter on the right side and 0.7 mm on the left side (Figs 7, 8 and 9). The subjective analysis of the region suggests that the area of the glenoid fossa and condyle experienced remodeling. However, analysis of a single case does not allow meaningful assessment.

Studies[14] report this change and show, by means of magnetic resonance imaging in patients treated with Herbst appliance, an adaptation of the temporomandibular joint, concluding that such remodeling of the glenoid fossa and condyle does take place. Another investigation,[7] this time using MRI in 20 adolescent patients treated with Herbst, pointed out changes in TMJ disc position and concluded that during treatment with Herbst there is an alteration in the position of the articular disc, but within normal limits. Treatment with Herbst in young adults provides bone remodeling and formation of new condylar bone. Furthermore, this newly formed bone has been shown to be stable.[3,6]

CT examinations allow anatomical areas to be reconstructed and viewed in three dimensions, disclosing information about size, shape and texture of the area under analysis. CT scanners capture body images in slices using radiation and export them to a dedicated software. Given its accuracy, CBCT contributes to scientific investigations of remodeling in the TMJ region through the use of orthopedic appliances. Studies conducted in adult monkeys treated with the Herbst appliance showed by means of histological sections that the treatment produces significant bone formation in the glenoid fossa or remodeling in the area of the fossa and condyle.

In assessing an individual's airway, the initial volumetric value of 4324.5 mm^3 can be found, whereas after treatment with Herbst, such value rises to 5108.5 mm^3 (Fig 9), indicating an increase in the nasopharyngeal region after treatment. A study[15] conducted with 26 individuals who presented with constriction of the upper airways and were treated with mandibular advancement devices, upon examination of the airways using CT scans in the Dolphin software version 11, found a significant increase in the mean oropharyngeal volume. Recent advances in software technology allow these volumetric data to be used in research. In its latest version, Dolphin shows the volumetric analysis of the airway. These technological advances allow an increase in resolution and can attest to the effectiveness

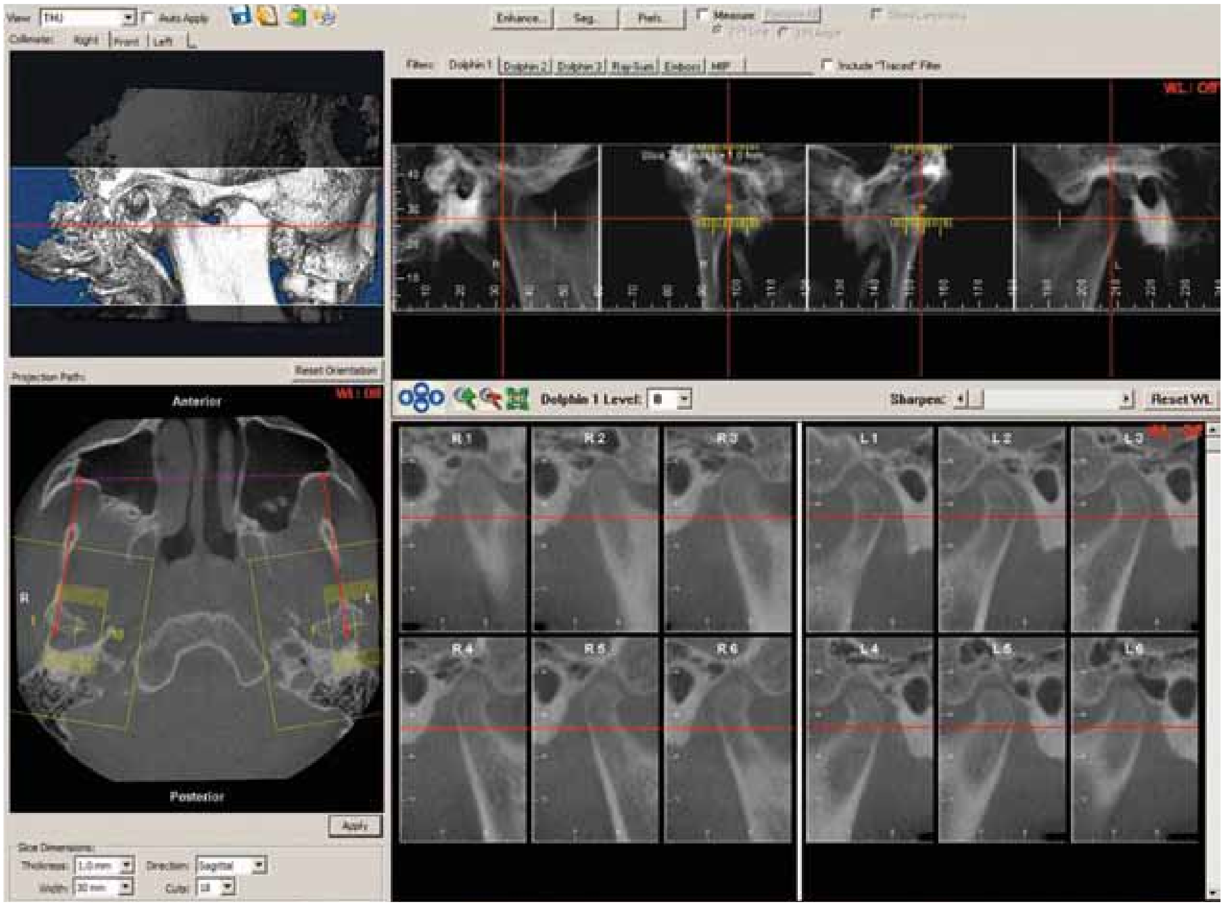

FIGURE 7 - TMJ examination method using Dolphin software.

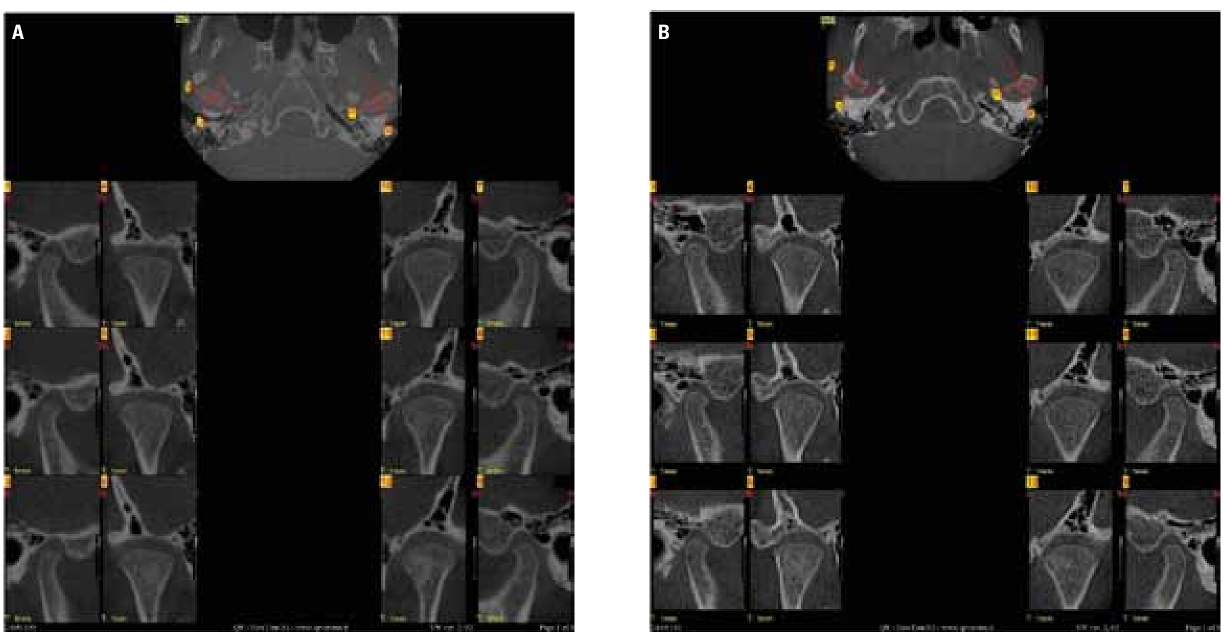

FIGURE 8 - **A**) Initial CT scan of TMJ regions. **B**) Final CT scan of TMJ regions.

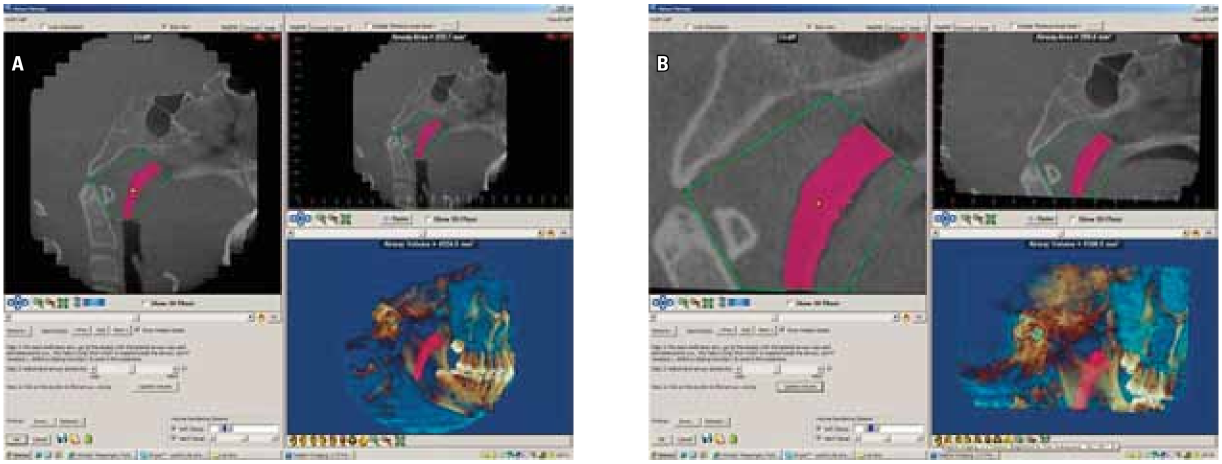

FIGURE 9 - Airway tomogram analysis: **A**) initial and **B**) final.

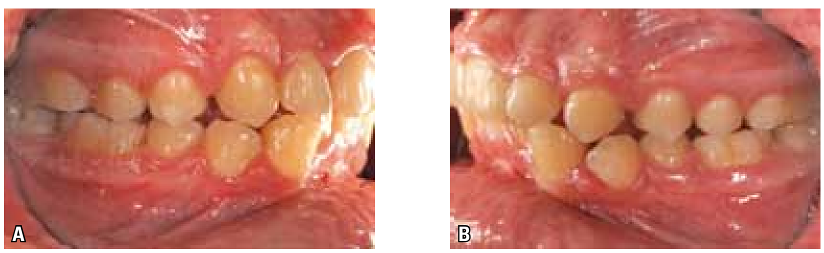

FIGURE 10 - Final intraoral photographs: Right side (**A**) and left side (**B**) views.

FIGURE 11 - Extraoral photographs after treatment with Herbst: profile (**A**) and front (**B**) views.

FIGURE 12 - Final lateral cephalogram.

of mandibular advancement devices, as in the treatment presented in this study.

After eight months of treatment with Herbst the results show (Fig 10) correction of Class II and Class I malocclusion as well as improved facial aesthetics (Figs 11 and 12) with no changes in muscles and joints.

CT studies on the influence of Herbst in the TMJ region and airways are scarce. The findings show assessments made using resonance and disc positioning since CT examinations are a more recent phenomenon.[7]

CONCLUSIONS

CT scans provide better diagnosis and orthodontic treatment planning, making it possible to view the problem in three dimensions in space. Furthermore, CBCT allows structures such as the condyle and glenoid fossa to be analyzed while enabling the evaluation of remodeling in this region after treatment with orthopedic appliances. Treatment with the Herbst appliance produces satisfactory results, providing patients with malocclusion correction and improving their aesthetic profile. After treatment with the Herbst appliance CT evaluation is suggestive of remodeling in the TMJ region and condyle, and a widened airway.

REFERENCES

1. Ursi W, McNamara JA, Martins DR. Alteração clínica da face em crescimento: uma comparação cefalométrica entre os aparelhos extrabucal cervical, Fränkel e Herbst, no tratamento das Classes II. Rev Dental Press Ortod Ortop Facial. 1999 set-out;4(5):77-108.
2. 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. 1990 May;12(2):209-18.
3. Konik M, Pancherz H, Hansen K. The mechanism of Class II correction in the late Herbst treatment. Am J Orthod Dentofacial Orthop. 1997 Jul;112(1):87-91.
4. Ruf S, Pancherz H. Orthognathic surgery and dentofacial orthopedics in adult Class II division 1 treatment: mandibular sagittal split osteotomy versus Herbst appliance. Am J Orthod Dentofacial Orthop. 2004 Aug;126(2):140-52.
5. Paulsen HU, Karle A, Bakke M, Hersink A. CT-scanning and radiographic analysis of temporomandibular joints and cephalometric analysis in a case of Herbst treatment in later puberty. Eur J Orthod. 1995;17(3):165-75.
6. Paulsen HU, Karle A. Computer tomographic and radiographic changes in the temporomandibular joints of two young adults with occlusal asymmetry, treated with the Herbst appliance. Eur J Orthod. 2000 Dec;22(6):649-56.
7. Aidar LA, Abrahão M, Yamashita HK, Dominguez GC. Herbst appliance therapy and temporomandibular joint disc position: a prospective longitudinal magnetic resonance imaging study. Am J Orthod Dentofacial Orthop. 2006 Apr;129(4):486-96.
8. Paulsen HU, Rabøl A, Sørensen SS. Bone scintigraphy of human temporomandibular joints during Herbst treatment: a case report. Eur J Orthod. 1998 Aug;20(4):369-74.
9. McNamara JA Jr, Peterson JE, Pancherz H. Histologic changes associated with the Herbst appliance in adult Rhesus Monkeys (macaca mulatta). Semin Orthod. 2003;9:26-40.
10. Voudouris JC, Woodside DG, Altuna G, Kuftinec MM, Angelopoulos G, Bourque PJ. Condyle-fossa modifications and muscle interactions during Herbst treatment, Part 1. New technological methods. Am J Orthod Dentofacial Orthop. 2003 Jun;123(6):604-13.
11. Voudouris JC, Woodside DG, Altuna G, Angelopoulos G, Bourque PJ, Lacouture CY, et al. Condyle-fossa modifications and muscle interactions during Herbst treatment, Part 2. Results and conclusions. Am J Orthod Dentofacial Orthop. 2003 Jul;124(1):13-29.
12. Firooznia H, Golimbu CN, Rafii M, Rausching W, Weinreb JC. MRI and CT of the musculoskeletal system. St. Louis: Mosby Year Book; 1992. 443-64.
13. Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. J Can Dent Assoc. 2006 Feb;72(1):75-80.
14. Ruf S, Pancherz H. Temporomandibular joint remodeling in adolescents and young adults during Herbst treatment: a prospective longitudinal magnetic resonance imaging and cephalometric radiographic investigation. Am J Orthod Dentofacial Orthop. 1999 Jun;115(6):607-18.
15. Haskell JA, McCrillis J, Haskell BS, Scheetz JP, Scarfe WC, Farman AG. Effects of Mandibular Advancement Device (MAD) on airway dimensions assessed with cone-beam computed tomography. Semin Orthod. 2009 Jun;15(2):132-58.
16. Greulich WW, Pyle SI. A radiographic atlas of skeletal development of the hand and wrist. 2nd ed. Stanford: Stanford University; 1959.

Submitted: June 2010
Revised and accepted: August 2010

Contact address
Savana Maia
Av. Djalma Batista, 1661, sala 702 – Chapada
CEP: 69.050-010 – Manaus/AM, Brazil
E-mail: savana@savanamaia.com