Three-dimensional treatment outcomes in Class II patients with different vertical facial patterns treated with the Herbst appliance

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Introduction: The aims of this study were to evaluate, using 3-dimensional superimposition techniques, the skeletal changes in Class II subjects with different vertical facial patterns treated with the Herbst appliance and to compare these skeletal changes to those of Class II controls treated with elastics. **Methods:** Sixteen Herbst patients who met the inclusion criteria were divided into 2 equal groups based on vertical facial pattern as determined by the Frankfort mandibular plane angle (brachyfacial, ≤22°; mesofacial, 23°-29°) and had cone-beam computed tomographs taken before treatment, 8 weeks after Herbst appliance removal, and after subsequent fixed appliance treatment. Eleven Class II control patients treated with fixed appliances and elastics had cone-beam computed tomographs taken before and after treatment. Three-dimensional models were generated from the cone-beam computed tomography images, registered on the anterior cranial bases, and analyzed using color maps and point-to-point measurements. **Results:** There were minimal differences in treatment response between the 2 Herbst groups across all skeletal parameters measured. The Herbst subjects showed a greater inferior displacement of anterior nasal spine compared with the Class II controls (Herbst brachyfacial, −1.44 mm; Herbst mesofacial, −1.95 mm) with other maxillary changes being clinically insignificant. The Herbst subjects showed greater inferior displacement of B-point compared with the Class II controls (Herbst brachyfacial, −2.59 mm; Herbst mesofacial, −2.75 mm). There were no statistically significant differences in mean linear mandibular measurements. All groups showed a trend toward posterior displacement of the condyles and glenoid fossae from the start to the end of treatment, with no significant differences across the 3 groups. There were minimal differences in the changes in gonial angle and Frankfort mandibular plane angle across all groups. **Conclusion:** Approximately 2 years after Herbst treatment, the Herbst subjects with different vertical facial patterns showed similar patterns of skeletal change compared with the Class II controls treated with elastics. (Am J Orthod Dentofacial Orthop 2018;154:238-48)

Management of Class II malocclusion in a growing person is a routine clinical challenge to orthodontists.[1] Mandibular retrognathism is the predominant etiologic factor in the majority of these malocclusions.[2,3]

Functional appliances have been used to correct Class II malocclusions through a combination of skeletal and dental changes,[4] and the Herbst appliance is one of the most popular fixed functional appliances because it reduces the level of compliance required.[5] However, despite the widespread use of the Herbst appliance, the exact mechanism of action, and its skeletal and dental effects, are unclear. There are claims of restriction of maxillary growth, forward positioning of the glenoid fossa, mandibular gonial angle changes, and stimulation of condylar growth,[6] with variations of the skeletal component of Class II correction ranging from 13% to 85%.[7,8]

There should be some certainty for any widely used appliance about the effects on the dentition and

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skeleton. The inconsistencies in reported treatment outcomes with the Herbst appliance may be because of differences in timing of treatment relative to peak growth, anatomic differences of the study subjects,[9,10] and use of 2-dimensional cephalometric imaging that is subject to various errors, including the superimposition process, magnification differences, geometric distortion, patient positioning, and obstruction of anatomic structures.[11-13] There can be bias in the superimposition process if the examiners are not blinded. Two-dimensional angular and linear cephalometric measurements do not adequately describe the complex 3-dimensional (3D) process of bone remodeling and skeletal change with growth and treatment.[10] Now that 3D imaging is widely accessible and able to give a more detailed and accurate picture of the skeleton and dentition, it is incumbent on the orthodontic specialty to use the available tools to determine the real effects of treatment. There has been only 1 published pilot study examining 3D outcomes with the Herbst appliance,[10] and few studies have examined the effects of the first phase of Herbst therapy followed by a further phase of fixed orthodontic appliances.[14] A more detailed study with a larger sample is necessary to enable the specialty to learn more about the effects of the appliance in 3 dimensions. Our group gained access to 3D data of a number of Herbst patients, as well as similar data from patients treated with Class II elastics who could be used as matched controls.

Therefore, the aims of this study were to use 3D imaging and superimposition techniques to assess skeletal changes associated with Class II correction in growing children with different vertical facial patterns treated with the Herbst appliance followed by a subsequent phase of fixed appliances. The changes were compared with a matched group of Class II control patients. Maxillary positional changes, differences in mandibular growth, and condylar and glenoid fossa positional changes were evaluated.

MATERIAL AND METHODS

Ethics approval for this retrospective study was obtained from the University of Melbourne Human Research Ethics Committee (ID: 1443363). All Herbst subjects were sourced from the office of a specialist orthodontist. The subjects were selected by searching the database for an item code denoting Herbst appliance insertion.

This retrospective cohort study used a convenience sample. The Herbst sample consisted of 16 patients and was divided on the basis of vertical facial pattern, as determined by the Frankfort mandibular plane angle (FMPA). The sample included 8 mesofacial (FMPA, 23°-29°) subjects (7 girls, 1 boy). The brachyfacial group (FMPA, <22°) also consisted of 8 subjects (4 girls, 4 boys). The sample size was limited by the number of available suitable records.

A control group of 11 deidentified, matched Class II control subjects (Table I) treated with Class II elastics was obtained from the University of North Carolina at Chapel Hill and the University of Michigan at Ann Arbor.

The Herbst appliance design consisted of stainless steel crowns fitted to the maxillary and mandibular permanent first molars. A cantilevered arm extended forward from the mandibular first molar to the level of the mandibular first premolar. A well-adapted 0.040-in stainless steel lingual arch connected the left and right mandibular molars, also incorporating an occlusal rest on the mandibular first premolar or second primary molar. A hyrax expansion screw was incorporated in all cases to expand the maxillary arch to accommodate the advanced position of the mandibular arch. The mandible was initially advanced by 5 mm and then progressively advanced in 2-mm increments to bring the incisors into an overcorrected edge-to-edge position. The mean Herbst treatment time in both groups was 7.6 months, which matched the Herbst protocols of other authors.[15,16] When the incisor relationship did not allow the required advancement, as in Class II Division 2 subjects, limited maxillary fixed appliances were placed to procline the maxillary incisors before placement of the Herbst appliance.

No patient was treated with extractions, and extraoral traction was not used in the control sample.

A power calculation was undertaken using the SPSS statistical software package (version 22.0; IBM, Armonk, NY). This showed that 8 subjects in each group would provide 80% statistical power in detecting a 2-mm difference for mandibular length between the control and treatment groups, assuming a standard deviation of 1.99 mm and significance of $P < 0.05$.[10] This 2-mm difference was considered the threshold for clinical relevance. A pilot study found a 0.71 mm difference between comparable treatment and control groups; however, this difference was not clinically relevant.

Cone-beam computed tomography (CBCT) scans were taken before treatment (T1) for both the Herbst and the Class II control patients, and 8 weeks after completion of the Herbst phase (T2). The Herbst patients all had a subsequent period of fixed appliance treatment. A final CBCT scan was taken once the fixed appliances were removed (T3) for both the Herbst and control subjects. The Herbst and Class II control subjects' scans were taken using an i-Cat machine (Imaging Sciences International, Hatfield, Pa) with a 16 × 22-cm field of view. All patients were instructed to bite in maximum

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