CASE REPORT

Effects of Herbst-Appliance Treatment on Pharyngeal Airway Depth

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The skeletal Class II, division 1 with mandibular retrognathia is one of the most common orofacial malocclusions. After the pubertal growth spurt, a neutral occlusion can be obtained in appropriate patients with moderate retrognathia by using fixed appliances, which produce a combination of skeletal and dental effects.[1,2]

Fixed-functional appliances such as the Herbst* minimize side effects like undesired proclination of the lower incisors,[3,4] and their rigid construction ensures a maximum skeletal effect. It has been shown in clinical studies, however, that as patients age, the Herbst appliance's skeletal treatment effects diminish while its relative dental effects—distalization of the upper dentition and mesialization of the lower dentition—increase.[1,5,6] Furthermore, it is not yet clear whether the skeletal changes produced by the appliance are sufficient to bring about desirable changes in the extrathoracic airway.

A study group at Stanford University defined posterior airway space (PAS) as the distance between the base of the tongue and the posterior pharyngeal wall within the extrathoracic airway.[7] In this system, the PAS is measured on the lateral cephalogram at five vertical levels—the maxillary plane, the occlusal plane, the mandibular plane, and the second and third cervical vertebrae[8] (Fig. 1)—to record the following values:

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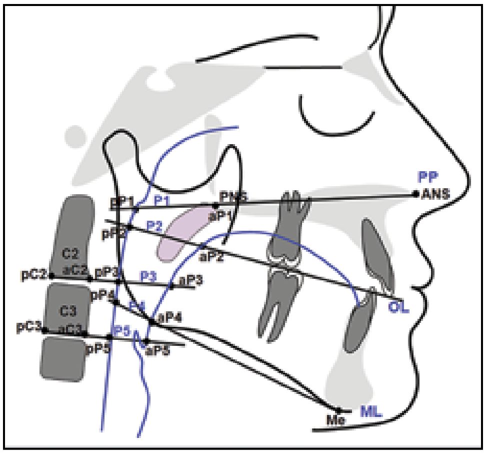


Fig. 1 Measurements of posterior airway space on lateral cephalogram.

P1 = Distance between the posterior pharyngeal wall and PNS as an extension of the maxillary plane.
P2 = Distance between the posterior and anterior pharyngeal wall and tongue base as an extension of the occlusal plane.
P3 = Distance between the posterior and anterior pharyngeal wall and tongue base as an extension of the lower aspect of the second cervical vertebra.
P4 = Distance between the posterior and anterior pharyngeal wall as an extension of the mandibular plane.
P5 = Distance between the posterior and anterior pharyngeal wall as an extension of the lower aspect of the third cervical vertebra.

This article shows an adolescent patient treated with the Herbst appliance and examines the resulting short- and long-term changes to the posterior airway space.

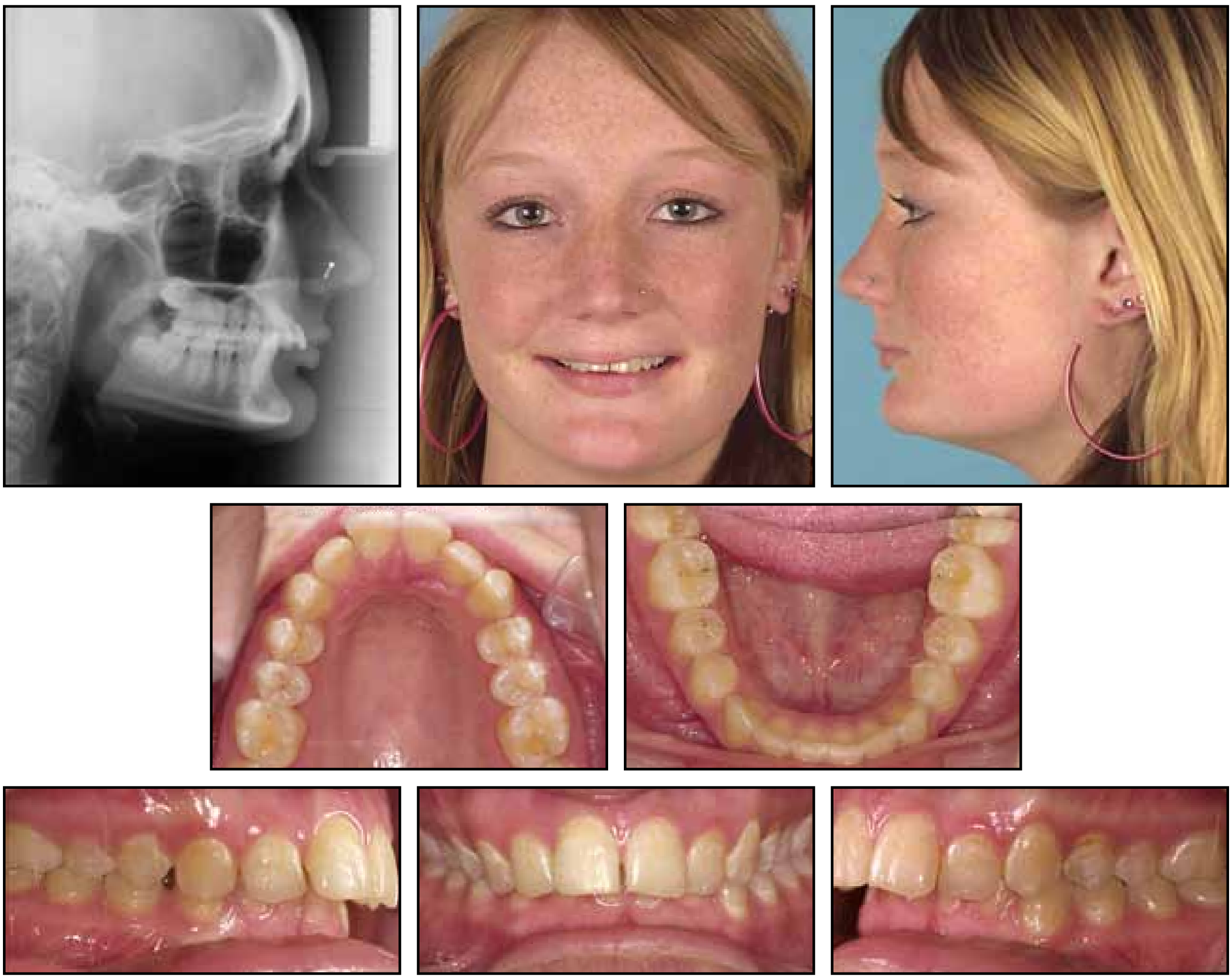


Fig. 2 15-year-old female patient with Class II, division 1 malocclusion before treatment.

Fig. 3 After initial leveling with fixed appliances.

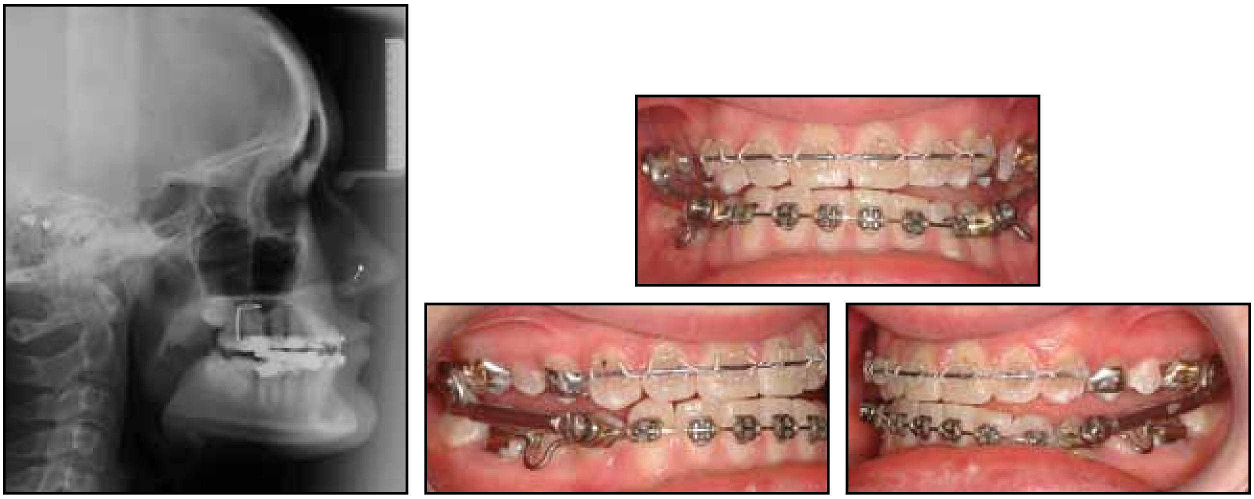


Fig. 4 Mandibular advancement into therapeutic position with Herbst appliance.

Fig. 5 After two months of Herbst treatment.

Diagnosis

A 15-year-old female presented with a Class II, division 1 malocclusion with distocclusion, mandibular retrognathia, excessive overjet and overbite, and a horizontal growth pattern (Fig. 2).

Treatment Progress

After initial leveling of the dental arches (Fig. 3), a banded Herbst appliance was placed for treatment of the retrognathic mandible (Fig. 4). Neutral occlusion was obtained after two months (Fig. 5), and the appliance was removed after seven months (Fig. 6).

Evaluation of the cephalometric tracings and dental casts before and after Herbst treatment showed a change in overjet of 9.3mm and in the molar relationship of 4.5mm. The skeletal effect contributed only 1.4mm of the change in both overjet (15.1%) and molar distalization (31.1%), when evaluated according to Kinzinger and Diedrich's method[5] (Fig. 7).

After finishing, the patient, now 18 years old, showed a bilateral neutral occlusion in the molar and canine regions (Fig. 8). Total treatment time was about two years.

Treatment Results

Magnetic resonance imaging (MRI) records were taken at four points in treatment: prior to Herbst treatment, immediately after insertion of the Herbst appli-

TABLE 1
DEPTH OF EXTRATHORACIC AIRWAY SPACE AT FIVE TREATMENT INTERVALS

Level	T0 (Pretreatment)	T1 (Pre-Herbst Treatment)	T2 (During Herbst Treatment)	T3 (Post-Herbst Treatment)	T4 (Post-Treatment)
P1	30.4mm	30.4mm	30.5mm	30.3mm	30.5mm
P2	21.9mm	20.6mm	31.5mm	21.2mm	21.1mm
P3	15.5mm	13.3mm	19.6mm	16.3mm	15.7mm
P4	13.8mm	14.0mm	16.3mm	14.5mm	14.0mm
P5	15.9mm	15.1mm	15.1mm	15.8mm	15.9mm

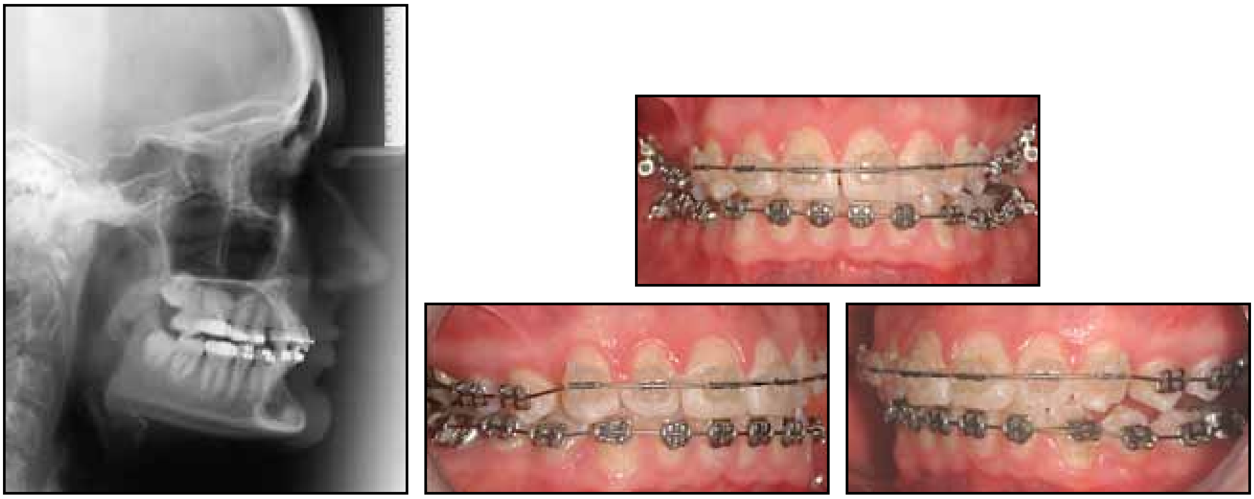


Fig. 6 After seven months of treatment and removal of Herbst appliance.

ance, after three months of Herbst treatment, and after removal of the Herbst appliance (Fig. 9). Excerpts of the parasagittal MRI sequences with the mouth closed showed that immediately after Herbst insertion, both condyles were dislocated ventrocaudally from the glenoid fossae, but that they regained their original centric positions after the completion of treatment. The bilateral disc-condyle relationships remained stable, indicating that the improved occlusal relationship was not achieved through unphysiologic displacement of the TMJs.

Cephalometric analysis demonstrated that insertion of the Herbst appliance had an immediate effect on PAS depth, increas-

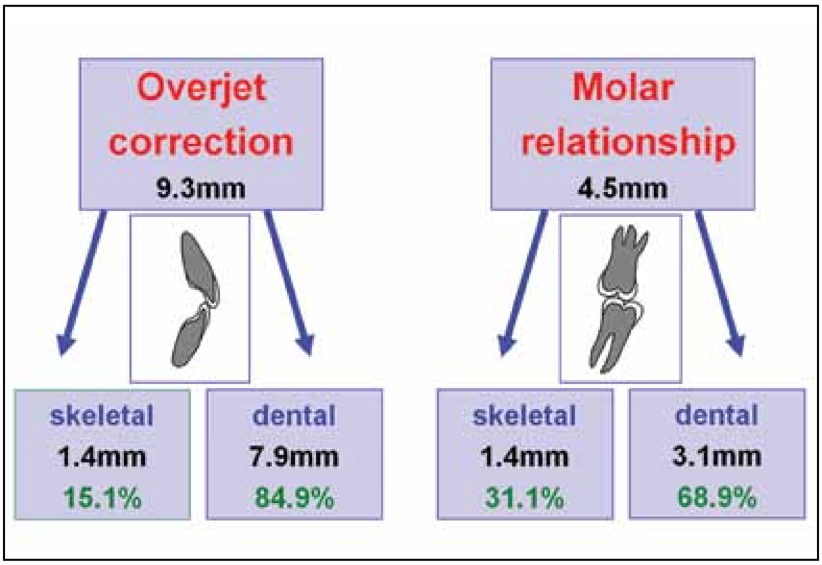
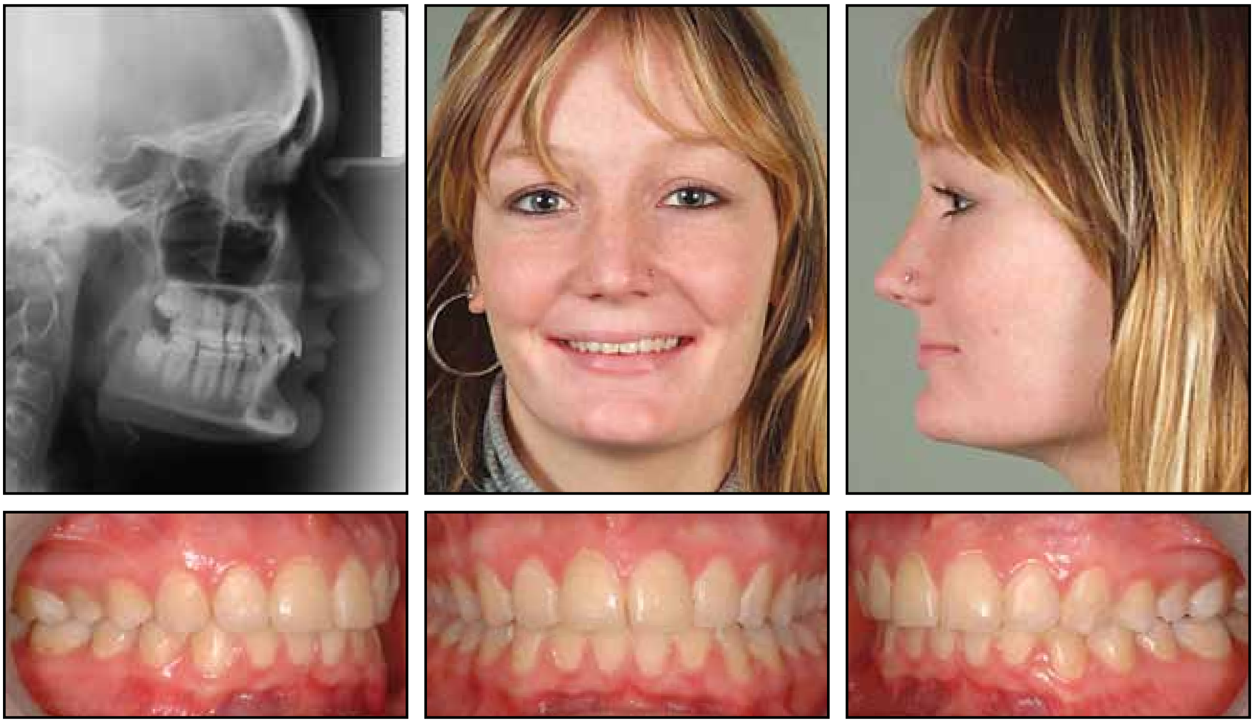


Fig. 7 Analysis of cephalometric superimpositions, showing overall improvement of 9.3mm in overjet and 4.5mm in molar relationship, with skeletal effect accounting for 15.1% and 31.1% of improvement, respectively.

TABLE 2
SHORT- AND LONG-TERM CHANGES IN AIRWAY DEPTH AT FIVE DEFINED LEVELS

Level	T0-T1	T1-T2	T2-T3	T1-T3	T3-T4	T0-T4
P1	0.0mm	0.1mm	–0.2mm	–0.1mm	0.2mm	0.1mm
P2	–1.6mm	10.9mm	–10.3mm	0.6mm	–0.1mm	–0.8mm
P3	–2.2mm	6.3mm	–3.3mm	3.0mm	–0.6mm	0.2mm
P4	0.2mm	2.3mm	–1.8mm	0.5mm	–0.5mm	0.2mm
P5	–0.8mm	0.0mm	0.7mm	0.7mm	0.1mm	0.0mm



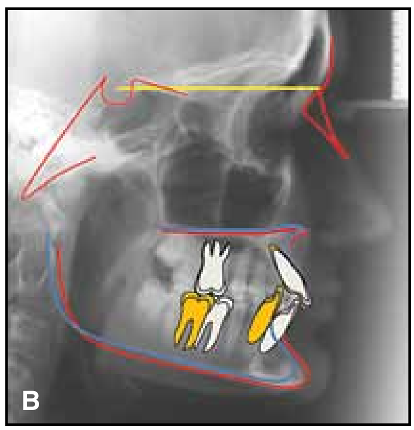


Fig. 8 A. Patient after two years of treatment, exhibiting neutral skeletal relationship and neutral occlusion in canine and molar regions. B. Superimposition of pre- and post-treatment cephalometric tracings.

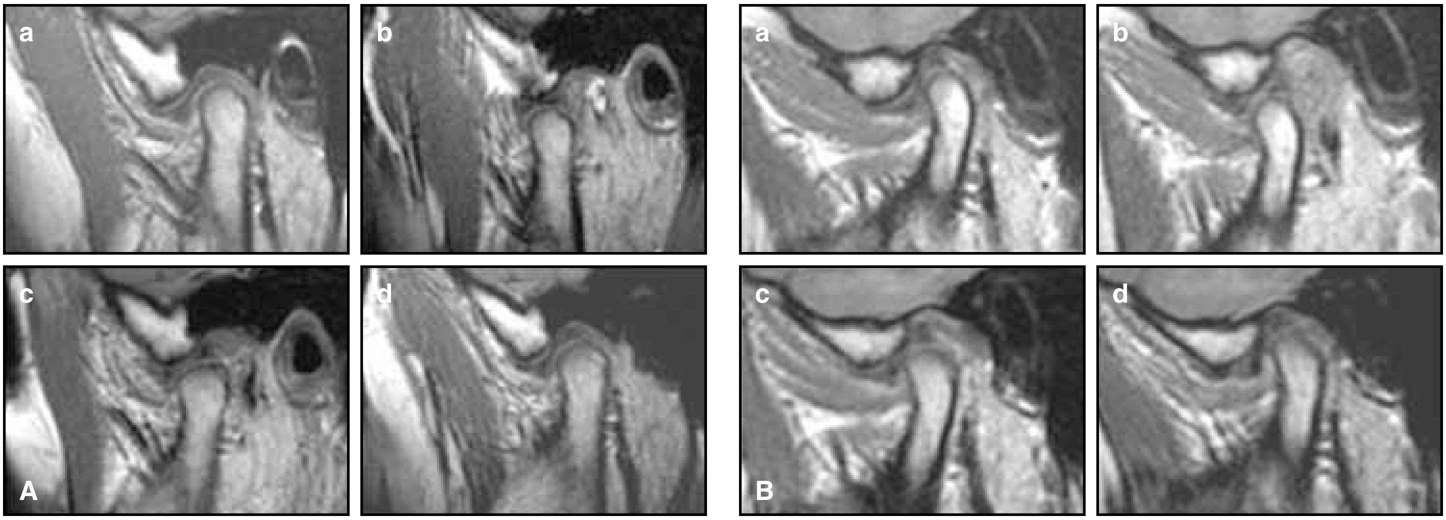


Fig. 9 Parasagittal magnetic resonance imaging (MRI) of right (A) and left (B) TMJ regions, showing physiologic disc-condyle relationships before Herbst treatment (a), after placement of Herbst appliance (b), after three months of Herbst treatment (c), and after Herbst removal (d).

ing the distances at levels P2, P3, and P4 (Fig. 10, Tables 1 and 2). These increased dimensions reverted markedly over time, even during treatment. Only the area of the second cervical vertebra showed a stable short-term effect. In other words, the successful treatment of a Class II, division 1 malocclusion with a fixed-functional appliance led to only minor changes in PAS at all measured levels.

Discussion

According to numerous studies, six to eight months of Herbst treatment can produce a neutral occlusion or even overcompensation,[5,9-14] resulting from both skeletal and dentoalveolar changes.[5,10,12] The Herbst treatment stimulates mandibular growth[10,12,14,15] and increases mandibular length.[10] Occlusal changes attributable to skeletal alterations diminish with increasing patient age and are always more pronounced in juveniles than in adolescents. Even though the adolescent TMJ has the ability to adapt, the correction of a distocclusion occurs as an alveolar compensation rather than a skeletal adaptation.[1,2,5]

The effects of treatment with fixed-functional appliances on the extrathoracic airway have thus far been investigated only in case studies.[16] The present case provides further insight into changes within the PAS because of its extensive cephalometric documentation during various treatment stages and the resulting measurements in five different planes. Our results show that the PAS remains stable in the maxillary plane throughout treatment. Substantial short-term effects may be noted in the occlusal and mandibular planes after insertion of the Herbst appliance, but these decline rapidly, even during treatment. Altogether, Class II treatment with a fixed-functional appliance does not seem to have a significant effect on the PAS. In our patient, we noted a reduction in depth of .8mm in the maxillary plane after molar distalization and an increase of .2mm at the level of the second cervical vertebra after mandibular advancement, but these distances are negligible. Long-term changes in the PAS at the five defined levels do not appear to correspond with the Herbst's dentoalveolar and skeletal effects.

Three-dimensional airway measurements from cone-beam computed tomography (CBCT) or medical CT-rendered images are undoubtedly the most precise that can currently be obtained.[17] The radiation doses needed for prospective studies using CBCT scans, however, make such measurements controversial. Grauer and colleagues reported that different anteroposterior jaw relationships yielded different airway shapes and volumes on CBCT scans, but that various vertical jaw relationships produced differ-

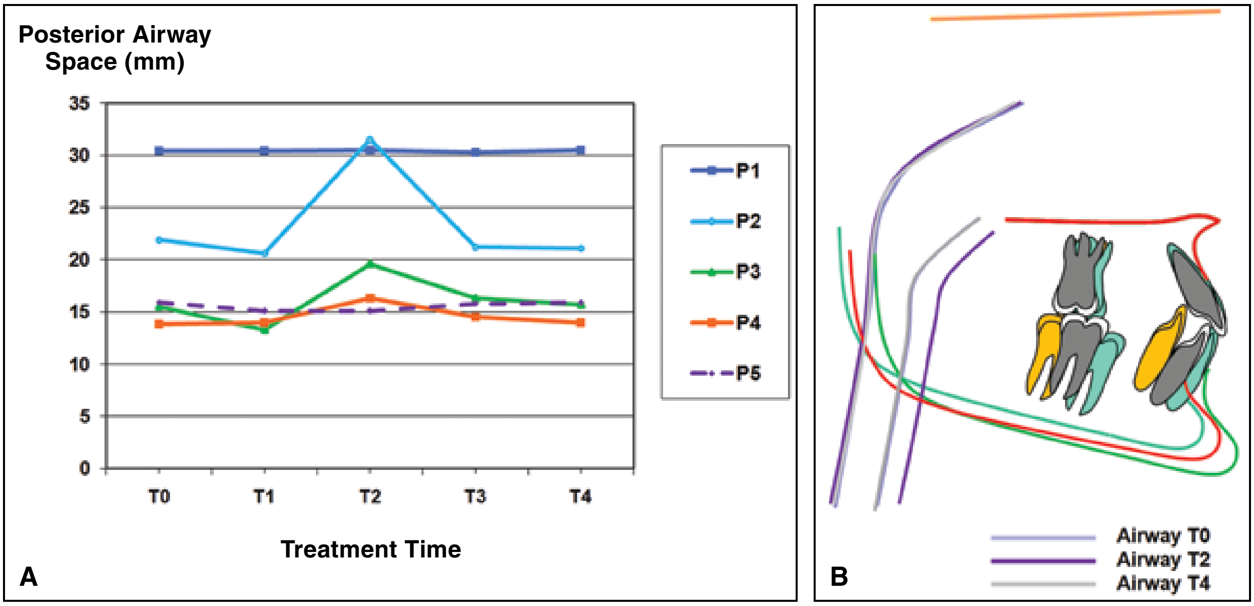


Fig. 10 A. PAS depths at five defined levels for each treatment interval. B. Superimposition of cephalometric tracings showing airway space and dentition before treatment (T0), after Herbst placement (T2), and post-treatment (T4).

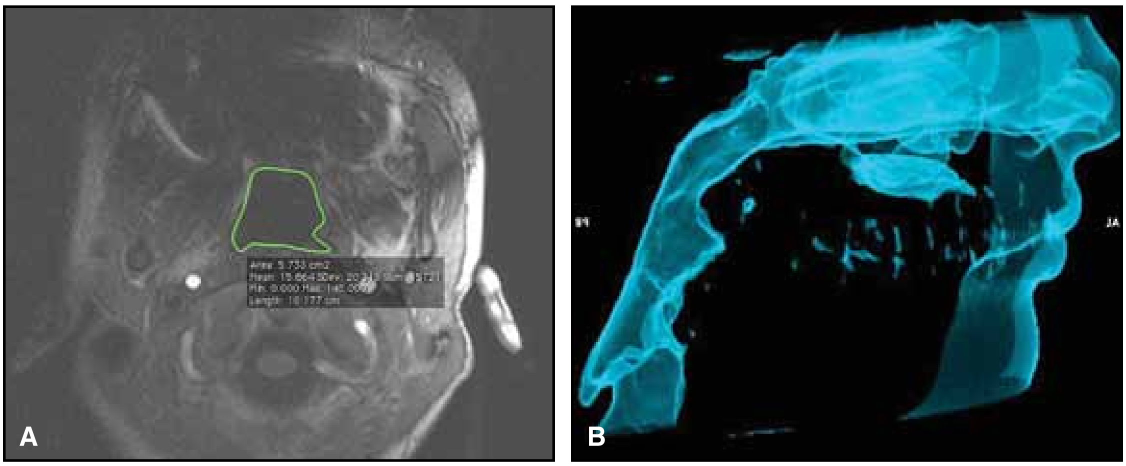


Fig. 11 A. Three-dimensional cross-section of patient's airway from MRI, involving no radiation exposure. B. Cone-beam computed tomography (CBCT) scan of airway shape and volume (different patient), requiring 45-70 microSieverts of radiation.

ent airway shapes without changes in volumes.[18] Similar effects can be detected on lateral cephalograms.

Head and body positioning is also a focus of airway research, as was shown in a study using MRI to investigate the airway in two and three dimensions.[19] As a noninvasive diagnostic technique, MRI could be used for long-term studies to detect 3D changes in airway space among larger cohorts (Fig. 11). In our patient, MRI was used only to observe changes in the TMJs. Acoustic measurement techniques are also being introduced, although there are no published airway studies to date. Researchers need to give careful consideration to the advantages and disadvantages of the available tools for measuring airway changes (Table 3).

TABLE 3
ADVANTAGES AND DISADVANTAGES OF VARIOUS AIRWAY MEASUREMENT TECHNIQUES

Airway measurement	Advantages	Disadvantages
Lateral cephalogram	Standard diagnostic tool, available in every case; able to compare generations of treated patients over long term.	Allows only linear, two-dimensional measurements; volume cannot be expressed.
Cone-beam computed tomography (CBCT) or CT scan	Allows three-dimensional measurement of volume and shape of airway.	High radiation dosage.
Magnetic resonance imaging	Allows 3D measurement of volume and shape of airway; noninvasive, with no radiation.	Less precise than CBCT scans; difficult to use for 3D rendering.
Acoustic pharyngometer	Allows 3D measurement of volume and shape of airway; noninvasive.	Less precise than other techniques.

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