The Efficacy of Oral Appliances in the Treatment of Persistent Sleep Apnea After Uvulopalatopharyngoplasty*

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Twenty-four patients who failed uvulopalatopharyngoplasty (UPPP) for obstructive sleep apnea (OSA) had an adjustable oral (Herbst) appliance made to treat the persistent apnea. Six patients discontinued the device prior to sleep evaluation. Eighteen patients had polysomnographic evaluations at baseline, post-UPPP, and with the Herbst appliance in place. The apnea-hypopnea index baseline (AHI) and arterial oxygen saturation (SaO₂) nadir were 42.3±6.1 and 83.6±1.8%, respectively. There was no significant change in either parameter with surgery. With the oral appliance, the AHI fell to 15.3±4.4 (p≤0.01) and the SaO₂ nadir increased to 87.9±1.2% (p≤0.05). Ten of the patients had control of the OSA with the Herbst appliance with a fall in the AHI to <10. There were, in addition, two partial responders as defined by an AHI of <20 and a >50% fall in AHI compared with baseline and post-UPPP values. All but one of the responders and partial responders had complete resolution of subjective symptoms of daytime sleepiness with the appliance. An adjustable oral appliance appears to be an effective mode of therapy to control OSA after an unsuccessful UPPP. *(CHEST 1998; 113:992-96)*

Key words: mandibular advancement; obstructive sleep apnea; oral appliance; uvulopalatopharyngoplasty

Abbreviations: AHI=apnea-hypopnea index; BMI=body mass index; CPAP=continuous positive airway pressure; GAHM=genioglossal advancement with hyoid myotomy; OSA=obstructive sleep apnea; SaO₂=arterial oxygen saturation; UPPP=uvulopalatopharyngoplasty

The uvulopalatopharyngoplasty (UPPP) is the most common surgical procedure for treatment of obstructive sleep apnea (OSA). A recent review of the literature has shown that only 40.7% of patients who have undergone this procedure actually have had a favorable response. A favorable response was defined as either an apnea index of <10 episodes per hour or an apnea-hypopnea index (AHI) of <20 episodes per hour as well as a 50% decrease in the AHI from baseline.¹ Reasons for a poor response include collapse of the pharynx in the retrolingual region, the region of the pharynx posterior to the vertical portion of the tongue, and/or persistent collapse in the velopharynx at the level of the soft palate.¹

Surgical attempts to open the retrolingual region include surgery to reduce tongue volume, such as laser midline glossectomy and lingualplasty, as well as procedures to advance the mandible and the tongue.¹ Riley and associates⁸ from Stanford developed a mandibular osteotomy/genioglossal advancement with hyoid myotomy/suspension procedure, (GAHM) that advances the genial tubercle of the mandible and the hyoid bone. When this procedure was combined with the UPPP, they found a 61% overall success rate.² They defined a response as an AHI equivalent to that reached with nasal continuous positive airway pressure (CPAP) or an AHI of <20 with at least a 50% reduction in the AHI from baseline.

Oral mandibular advancement devices have recently been shown to be an effective alternative treatment for OSA.³ Previous work from our laboratory demonstrated that an adjustable mandibular advancement Herbst appliance reduced the AHI in 18 of 19 patients from 34.7±5.3 to 12.9±2.4 (p<0.002). Ten of these patients had control of their OSA with an AHI of <10 episodes per hour.⁴ Part of the mechanism for improvement appeared to be forward and upward movement of the hyoid bone with shortening of the distance from the hyoid bone to the midmandibular plane. There was a mean

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advancement of the mandible forward by a minimum of 7 mm and retraction of the soft palate and uvula.4

Since the GAHM is a relatively new procedure that until recently was not available at our center, and since some patients who failed UPPP were reluctant to undergo additional surgery, we began to offer the Herbst appliance as a conservative alternative to additional surgery to patients with OSA who had failed the UPPP. This report summarizes a retrospective review of our results.

MATERIALS AND METHODS

Sleep Testing

The records of all OSA patients who had been seen at the Sleep Disorders Center of Rhode Island Hospital and had been treated with a UPPP and subsequently with the Herbst appliance from 1989 through 1996 were reviewed. All patients underwent polysomnography testing at the Sleep Disorders Center at baseline, an average of 9 months post-UPPP, and an average of 13 months later with the Herbst appliance in place. One patient was fitted with the Herbst appliance prior to surgery and had a sleep study performed with the Herbst appliance before and after surgery.

Atepsias were defined as the total cessation of airflow for \( \geq 10 \) s. An obstructive hypopnea was defined as an event that met two of the following three criteria: (1) a decrease in airflow of \( \geq 50\% \); (2) an EEG arousal as defined by recent American Sleep Disorders Association scoring criteria5 or (3) oxygen desaturation of \( \geq 2\% \). OSA syndrome was defined as an AHI of \( \geq 10 \) episodes per hour of sleep in patients with symptoms of the disorder.

Oral Appliance

Upon referral to the orthodontist (C.L.B.), the patients underwent a detailed oral examination. Patients were excluded from having an appliance made if there was evidence of moderate-to-severe periodontal disease or if there were not enough teeth to adequately anchor the appliance. Dental impressions were taken on eligible patients for fabrication of a custom-made removable Herbst appliance that attaches to both the upper and lower dentition in the mouth. An occlusive bite registration was taken on each patient to position the mandible forward relative to the maxilla. When the Herbst appliance is worn, the degree of mandibular advancement is 66 to 75% of each patient’s maximum mandibular protrusive maneuver measured during the initial evaluation. After fabrication and fitting of the appliance, the patient was seen again in 2 to 3 weeks for any necessary adjustments. Once the appliance was comfortable and the patient was able to keep it on all night, another polysomnographic evaluation was performed to assess efficacy.

Statistical Analysis

Data are expressed as mean±SEM. Baseline values vs post-UPPP and mandibular advancement with the Herbst appliance results were analyzed using repeated measures analysis of variance with a post hoc Scheffé F test. Statistical significance was considered to be a p value \( \leq 0.05 \). Patients were classified as responders if the AHI was <10 with the oral appliance. Based on the criteria employed by Riley et al.,2 a partial responder was considered to have a decrease in the AHI to <20 with at least a 50% fall in the AHI with the Herbst appliance compared both to baseline and to the post-UPPP sleep studies. All other patients were classified as nonresponders. Unpaired t tests were used to compare responders plus partial responders to nonresponders in regards to age, baseline body mass index (BMI), baseline AHI, arterial oxygen saturation (\( \text{SaO}_2 \)) nadir, and AHI post-UPPP. Statistical analysis was performed using a computer program (StatView SE Plus Graphics, Abacus Concepts; Berkeley, Calif) for MacIntosh.

RESULTS

Patient Characteristics

Twenty-four patients (22 men, 2 women) had a Herbst appliance made after failure of UPPP to correct OSA. Six of the patients (five men, one woman), discontinued using the device. The reasons they gave for discontinuing use of the device prior to repeated sleep evaluation included discomfort, inability to get through a single night without it falling out, or lack of subjective improvement. This left 18 patients (17 men, 1 woman) who completed the protocol. The mean age for this group was 42.7±2.6 years and their BMI was 29.3–1.1 kg/m². Thirteen of the patients had tried nasal CPAP and 12 did not like this form of therapy. One patient in the nonresponder group continues to receive CPAP. Five other patients did not try CPAP since they preferred a surgical option.

Polysomnographic Results

The baseline AHI was 42.3±6.1 events per hour and the baseline \( \text{SaO}_2 \) nadir was 83.6±1.8% for the 18 patients. There was no significant change in either parameter with surgery. Post-UPPP, the AHI was 37.2±7.1 events per hour and the \( \text{SaO}_2 \) nadir was 83.9±1.6%. With the Herbst appliance, the AHI fell to 15.3±4.4 events per hour and the \( \text{SaO}_2 \) nadir was 87.9±1.2%. This represented a significant change in the AHI from baseline (p=0.01, F=16.8 by Scheffé analysis) and from surgery (p=0.01, F=11.0). Similarly, there was a significant change in the \( \text{SaO}_2 \) nadir with the oral appliance compared with baseline (p=0.05, F=3.9 by Scheffé analysis) and post-UPPP (p=0.05, F=3.4). Complete all-night data were available in 10 patients, shown in Table 1.

The OSA was controlled in 10 patients classified as responders (Table 2) with a fall in AHI to <10. Two patients could be classified as having a partial response if one used the criteria employed by Riley et al.2 The first patient had a baseline AHI of 52 events per hour; post-UPPP, the AHI was 21. The second patient had a baseline AHI of 58 and a post-UPPP AHI of 32. These patients had an AHI of 10 and 12, respectively, with the Herbst appliance in place. The baseline AHI for this group of responders, including
partial responders, was 37.8±4.9. Postsurgery, the AHI was 30.8±5.3 and with the Herbst appliance it was 6.4±1.0. This latter value represented a significant change from both baseline (p<0.01, F=22.3 by Scheffé analysis) and from surgery (p≤0.01, F=13.6). There was also a tendency for improvement in the SaO2 nadir in this group (Table 3). All but one patient had resolution of their daytime sleepiness. This patient’s sleepiness persisted probably due to depression. There was no appreciable change in weight in this group of patients.

Six of the patients were nonresponders. There was no significant change in the AHI and the SaO2 nadir with therapy. None of the patients had a subjective improvement. Weight was unchanged in this group as well.

If one combined the 2 partial responders with the 10 responders and compared this group with the 6 nonresponders, there was no difference between these two groups in regards to age, baseline polysomnographic parameters, or the AHI postsurgery. In this comparison, the nonresponders had a higher BMI of 32.6±1.4 kg/m² compared with the responder/partial responder group with a BMI of 27.9±1.4 kg/m² (p≤0.05). Two of the responders and three of the nonresponders had removal of tonsils at the time of their UPPP.

One of the patients was a 71-year-old man with a baseline AHI of 43 episodes per hour who was fitted with the Herbst appliance as a first treatment since he could not tolerate nasal CPAP. It was believed that at his age, the appliance would be preferable to UPPP. The AHI with the Herbst appliance in place was 56 episodes per hour. Since the oral appliance did not work, he underwent pharyngeal surgery. After UPPP, the follow-up AHI was 29 episodes per hour. He was then restudied with the Herbst appliance in place and the AHI fell to eight episodes per hour.

**Discussion**

This study indicates that an adjustable mandibular advancement device such as a Herbst appliance is a conservative alternative to mandibular advancement surgery in patients with OSA who failed to respond to the UPPP and who had previously refused or were intolerant to nasal CPAP. In our study, 10 of 18 patients (56%) were able to use the appliance and had control of their sleep apnea with a fall in the AHI to <10. Two additional patients (11%) could be considered partial responders using the criteria of Riley and associates.2 These two patients had an AHI of <20 with the appliance in place. In addition, the AHI with the appliance was 50% less than both the baseline and post-UPPP AHIs. This combined success rate of 67% would drop to 50% if one included the original six patients who were unable to use the device.

The results using the Herbst appliance are similar to the success shown using an adjustable Herbst appliance in nonsurgical patients.4,6,8 One

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**Table 1—Percent Sleep Stage Distribution**

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Post-UPPP</th>
<th>Herbst</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awake</td>
<td>14.6±3.1</td>
<td>5.0±1.3</td>
<td>7.3±2.1</td>
</tr>
<tr>
<td>Stage 1</td>
<td>10.8±1.6</td>
<td>7.9±1.7</td>
<td>3.4±1.2</td>
</tr>
<tr>
<td>Stage 2</td>
<td>47.7±4.0</td>
<td>48.2±3.1</td>
<td>56.0±3.4</td>
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<tr>
<td>Stage 3/4</td>
<td>11.3±2.4</td>
<td>18.3±2.4</td>
<td>16.2±2.2</td>
</tr>
<tr>
<td>REM</td>
<td>16.0±2.2</td>
<td>21.5±3.2</td>
<td>18.5±2.0</td>
</tr>
</tbody>
</table>

*Sleep stage percent is calculated as a percent of sleep period time from the first epoch of sleep to the last epoch of sleep. REM=rapid eye movement.

1Comparison between baseline and Herbst (p≤0.01, F=6.5).

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**Table 2—AHI in Responders and Nonresponders**

<table>
<thead>
<tr>
<th>Responders</th>
<th>Nonresponders</th>
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</thead>
<tbody>
<tr>
<td><strong>Patient No.</strong></td>
<td><strong>Baseline</strong></td>
</tr>
<tr>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>52</td>
</tr>
<tr>
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<td>10</td>
<td>33</td>
</tr>
<tr>
<td>11</td>
<td>43</td>
</tr>
<tr>
<td>12</td>
<td>62</td>
</tr>
</tbody>
</table>

Mean±SEM 37.8±4.9 30.8±5.3 6.4±1.0 51.5±15.6 49.8±18.4 33.0±10.0

*Post hoc comparisons revealed p≤0.01 for baseline to Herbst and post-UPPP to Herbst in responders only.*
could argue that the patients presented in this study would have had just as good a response if they had been treated with the appliance alone. This question is impossible to resolve with the retrospective data that are available. There was only one subject in whom a sleep study was available with the Herbst appliance prior to surgery. Presumably in this patient, a deep-set palate and a long uvula prevented adequate opening of the pharynx with the appliance alone.

The results are also similar to the success of the combined UPPP plus GAHM procedures advocated by Riley et al.\(^2\) Using different criteria for cure, they found a 61% success rate in their patients with combined surgery. They found that the likelihood of success fell to 42% when the AHI was >60. Three of our patients had a baseline AHI >60 and the combined approach of UPPP plus oral appliance successfully controlled the sleep apnea in only one patient. The small sample size makes it difficult to make any conclusion about whether patients with severe sleep apnea at baseline are less likely to have a favorable outcome with this combined approach. Since the nonresponders had a higher BMI than the responders/partial responders group, it appears that obesity may have a negative impact on treatment success. A prospective study would be necessary to determine whether a positive response to therapy could be predicted prior to the device being made.

As with the GAHM procedure, one possible mechanism for the improvement in the sleep apnea with the Herbst appliance post-UPPP is an increase in pharyngeal size at the level of the retrolingual region. The Herbst appliance advances the mandible and shortens the distance from the hyoid bone to the mandible.\(^4\) It is also possible that the Herbst appliance is working by further enlarging the velopharynx. In our previous study, the Herbst appliance led to a shortening of the uvula and soft palate.\(^4\) Preliminary work by Ryan et al.\(^9\) has demonstrated a greater increase in cross-sectional area in the velopharynx as compared with the lingual region with an oral appliance. They used upper airway endoscopy in the supine position in 10 awake patients with mild-to-moderate sleep apnea to assess the impact of an oral appliance on pharyngeal size. The changes in the velopharynx shown by our previous article\(^4\) and this preliminary work from Ryan et al.\(^9\) suggest that there is a mechanical linkage between the soft palate and the tongue.

Some patients with incompletely controlled OSA post-UPPP may opt to go for a surgical cure with a GAHM-type procedure. One wonders whether a positive response to an oral appliance could be used to predict the subsequent success of genioglossal/mandibular advancement procedures in patients who have failed to respond to the UPPP.

Despite the fact that this is a retrospective study, the results support the use of an oral appliance as an adjuvant therapy after unsuccessful UPPP. A prospective study needs to be done using cephalometric radiographs, fiberoptic laryngoscopy, or videofluoroscopy to assess the mechanism of improvement and to determine the best candidates for this appliance.

### References

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