Maxillofacial Surgery and Nasal CPAP*
A Comparison of Treatment for Obstructive Sleep Apnea Syndrome


Nasal continuous positive airway pressure (CPAP) is the primary therapy for obstructive sleep apnea syndrome (OSAS). Recent reports have indicated, however, that there is a small but significant number of failures related to patient compliance. Primary surgical treatment, which has been uvulopalatopharyngoplasty (UPPP), has declined because of poor results. A reviewed of UPPP failures has shown that while UPPP eliminated palatal obstruction, it failed to eliminate base of tongue obstruction. Maxillofacial surgery has been reported as treatment of OSAS by correcting base of tongue obstruction. Thirty patients with severe OSAS were evaluated to compare nasal CPAP and maxillofacial surgery. The goal was to determine if our surgical protocol was as effective as nasal CPAP. All patients initially underwent baseline diagnostic polysomnography to document OSAS. A nasal CPAP study was performed to determine the appropriate positive end-expiratory pressure. The patients in this study were using nasal CPAP, but they found it unacceptable as long-term treatment and elected surgery. Maxillofacial surgery consisted of maxillary, mandibular, and hyoid advancement. Polysomnography was performed six months following surgery and compared with the night 2 CPAP results. The parameters included in the investigation were the respiratory disturbance index (RDI), lowest SaO2, number of SaO2 falls below 90 percent, total sleep time (TST), REM sleep percent, stage 3-4 sleep percent, and wake after sleep onset. The mean RDI before treatment was 72.0 (SD 25.7). After completing therapy, the RDI from surgery and CPAP was 8.8 (SD 6.0) and 8.6 (SD 4.1), respectively. The mean low SaO2 prior to treatment was 61.0 (SD 13.5), and the CPAP results and postsurgical results were 86.2 (SD 5.5) and 86.1 (SD 4.3), respectively. An analysis of variance was used to examine the results, and there was no statistical difference between nasal CPAP and surgery for all respiratory variables. (Chest 1990; 98:1421-25)

OSA = obstructive sleep apnea syndrome; UPPP = uvulopalatopharyngoplasty; CPAP = continuous positive airway pressure; PAS = posterior airway space; MMHO = maxillary, mandibular, and hyoid advancement; RDI = respiratory disturbance index; TST = total sleep time; BMI = body mass index; EDS = excessive daytime sleepiness

The treatment of obstructive sleep apnea syndrome (OSAS) dates back to 1969 when Kuhlo et al1 showed that tracheostomy eliminated the obstructive events during sleep. The concept of bypassing the obstruction was simple; however, the local problems (infection, drainage, tracheal irritation) and psychological factors made it an undesirable form of treatment.

For editorial comment, see page 1315

In 1981, Fujita et al2 reported their initial results of uvulopalatopharyngoplasty (UPPP). It was a modification of the surgical procedure published by Ikematsu3 in 1964 to correct snoring. The surgical concept of UPPP was to remove redundant tissue of the posterior soft palate and lateral pharyngeal wall. While it remains an excellent procedure for improving snoring, several retrospective reviews report improvement in only 50 percent of the patients and complete control of the syndrome in 25 percent or less.4,5

In 1981, Sullivan and colleagues6 reported the use of nasal continuous positive airway pressure (CPAP) to maintain upper airway patency during sleep; several follow-up studies have confirmed his results.7,8 Like tracheostomy, the daytime hypersomnolence is reversed and the cardiopulmonary sequelae are eliminated with nasal CPAP9. Because of its effectiveness, nasal CPAP has become the primary form of therapy for OSAS. The concern that remains, however, deals with the realistic expectations of long-term patient compliance. Sanders et al9 analyzed long-term home nasal CPAP therapy and found a compliance rate of 75 percent. Waldhorn et al10 recently reported a long-term compliance rate of 76 percent in a group of 96 patients followed up for a mean of 14.5 months. The 76 percent compliance rate did not include 19 patients who agreed to a nasal CPAP trial but were intolerant of the machine in the laboratory and declined its use. If they are included in study, the overall compliance rate drops to 63 percent.

It would appear that while the long-term compliance rate of home nasal CPAP is good, there is a small but significant number of patients who remain without treatment. In light of the recent reports on increased mortality and OSAS, there is a need for an alternative treatment in patients who fail nasal CPAP.10,11

*From the Stanford University Sleep Disorders Center, Stanford, CA.
Manuscript received March 21; revision accepted June 4.
Reprint requests: Dr. Riley, 7150 West Welch Road, Palo Alto, CA 94304

CHEST / 98 / 6 / DECEMBER, 1990
To investigate surgical alternatives, we reviewed UPPP failures and concluded that the base of tongue was the cause of persistent obstruction. In fact, it is now generally accepted that there are multiple sites in the upper airway, including the soft palate, pharyngeal walls, and base of tongue, which contribute to the obstructive process. To correct these multiple sites of obstruction, we have explored the use of maxillofacial surgery. The surgical concept is to advance the maxilla, mandible, and hyoid bone; as a result, the pharyngeal muscles and base of tongue are advanced and the airway is expanded.

A study was undertaken to evaluate a group of patients treated with nasal CPAP and maxillofacial surgery. The question we wanted to answer was whether our surgical protocol could be as effective as nasal CPAP, and hence could be offered as an alternative to the failures of nasal CPAP.

Methods

Thirty patients with clinical symptoms of OSAS were included in this study. All patients initially underwent a pretreatment examination that included a systematic clinical evaluation and baseline diagnostic polysonmography. The objective was to document the presence of OSAS and isolate the areas causing obstruction. A two-night nasal CPAP study was performed to determine the appropriate positive end-expiratory pressure to clear the obstruction. A specific nasal CPAP system (Respironics, Monroeville, Pa) was used in all patients. The patients in the study were compliant in the short-term use of home nasal CPAP, but they experienced problems with chronic nasal obstruction, nasal bleeding, mask irritation, and inconvenience that would have resulted in long-term failure of nasal CPAP. The patients were required to continue nasal CPAP following surgery. Two weeks prior to the postoperative polysomnogram, nasal CPAP was discontinued. Tracheostomy was not performed because perioperatively nasal CPAP has been found, in a controlled study, to be as protective of the airway.

The selection criteria included patients who were noncompliant of nasal CPAP with evidence of hypopharyngeal-base of tongue obstruction with or without oropharyngeal palate obstruction. The study group represented 30 consecutive nasal CPAP failures. In general, this was a younger group of patients with severe OSAS, but they did not otherwise differ from the compliant nasal CPAP group.

Surgical Evaluation

The presurgical evaluation includes a physical examination, fiberoptic pharyngoscopy, and cephalometric analysis. It is one of the most important aspects in treating patients with OSAS. The goal is to identify the sites of obstruction in the upper airway so that treatment can be logically directed. Failure to identify the sites of obstruction increases the risk of failure. The physical examination emphasizes evaluating the head and neck region. It includes a close examination of the nasal cavity to identify obstructing deformities; oropharyngeal obstruction from a long soft redundant palate or hypertrophic tonsils; and hypopharyngeal obstruction from the base of tongue. The fiberoptic pharyngoscope, which is positioned transnasally to examine the oropharyngeal and hypopharyngeal areas, is a supplement to the physical examination. Particular attention is given to the area of the soft palate and base of tongue.

The cephalometric analysis further confirms the findings from physical examination and fiberoptic pharyngoscopy. Figure 1 shows a cephalometric tracing with its important anatomic landmarks. The techniques and norms have been previously described. The

![Figure 1](http://journal.publications.chestnet.org/pdaccess.ashx?url=/data/journals/chest/21622/) Cephalometric analysis used for evaluation of patients with OSAS, SNA 82° (SD ± 2), maxilla to cranial base; SNB 80° (SD ± 2), mandible to cranial base; PAS 11 mm (SD ± 1), posterior airway space; PNS-P 37 mm (SD ± 3), length of soft palate; MP-H 15.4 mm (SD ± 3), distance of hyoid from inferior mandible.

![Figure 2](http://journal.publications.chestnet.org/pdaccess.ashx?url=/data/journals/chest/21622/) Diagram showing advancement of the maxilla by Le Fort I osteotomy with rigid fixation and of the mandible by a bilateral sagittal ramus split. Also note the hyoid advancement and suspension.
the posterior pharyngeal wall and restricted visualization of the larynx during the physical and fiberoptic examinations, or the cephalometric analysis demonstrated a narrow posterior airway space (PAS). OSAS patients with mandibular skeletal deficiency (SNB <78°) on cephalometric analysis almost uniformly have a narrow PAS and base of tongue obstruction.

Once the diagnosis of OSAS has been made and the sites of obstruction identified, the reconstruction of the upper airway can be logically directed to the obstructing sites. Patients with type 2 obstruction (soft palate and base of tongue) are treated in two stages. The first stage is a UPPP to eliminate oropharyngeal obstruction. The second stage is maxillary, mandibular, and hyoid advancement (MMHO). Patients with type 3 obstruction (hypopharynx/base of tongue) are treated in one stage with an MMHO. The surgical concepts and techniques have been previously described29 (Fig 2).

Polysomnographic Analysis

Polysomnograms were performed six months following MMHO and were compared with the results of the baseline diagnostic polysomnogram and night 2 CPAP study. Patients with type 2 obstruction (soft palate and base of tongue) who were first treated with UPPP received a polysomnogram prior to the MMHO to document persistence of abnormal breathing as seen during the baseline polysomnogram. The interval polysomnogram was performed three to six months after UPPP. The following variables were systematically monitored: EEG (C3/A1, C4/A2), electro-oculogram, chin and leg electromyograms, ECG (modified V1 lead), airflow, thoracic, and abdominal efforts, pulse oximetry, and positive end-expiratory pressure at the nose. The parameters included in this investigation were respiratory disturbance index (RDI), lowest SaO2, number of SaO2 falls below 90 percent, total sleep time (TST), percentage of REM sleep, percentage of stage 3-4 sleep, and wake after sleep onset. The body mass index (BMI = kg/m²) was calculated at each recording. A multifactorial analysis of variance was used to compare the polygraphic results.

**RESULTS**

The baseline characteristics of the 30 patients are displayed in Table 1. The mean (±SD) age was 44.8±10.4 years and included seven women and 23 men. The group was morbidly obese with a mean BMI of 32.6±6.0 kg/m². The group, as a whole, had severe OSAS with a mean RDI of 72.0±25.8 and a baseline minimum SaO2 mean of 61.0±13.5 percent. All patients subjectively complained of loud, heroic snoring and excessive daytime sleepiness (EDS) prior to treatment. At the conclusion of therapy, all the patients reported marked improvement in their EDS. Snoring was controlled in 28 patients (93 percent); two patients continued to complain of moderate snoring.

The individual baseline characteristics are shown in Table 2. As a result of the pretreatment evaluation, five patients (No. 8, 13, 17, 21, and 30) were considered to have only base of tongue or type 2 obstruction. These patients were generally nonobese with significant mandibular deficiency (SNB <75°). Twenty-five patients were considered to have type 2 obstruction, which includes involvement of both the soft palate and the base of tongue. The patients with type 2 obstruction initially underwent UPPP to correct the obstruction at the level of the oropharynx. All these patients remained symptomatic, and an interval polysomnogram (Table 2) documented no significant change from the findings on their baseline study. The type 2 group characteristically consisted of patients who were either morbidly obese or mandibular deficient. Patients who had a worsening of their OSAS after UPPP commonly showed an interval weight gain. All patients then received MMHO to correct hypopharyngeal or base of tongue obstruction.

**Table 1—Pretreatment Characteristics**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>44.8±10.4</td>
</tr>
<tr>
<td>Sex</td>
<td>23-M/7-F</td>
</tr>
<tr>
<td>Weight, BMI kg/m²</td>
<td>32.6±6.0</td>
</tr>
<tr>
<td>RDI</td>
<td>72.0±25.8</td>
</tr>
<tr>
<td>Minimum SaO2</td>
<td>61.0±13.5</td>
</tr>
</tbody>
</table>

*Values are mean±SD. BMI = body mass index; RDI = respiratory disturbance index.

---

**Table 2—Pretreatment Characteristics and Results**

<table>
<thead>
<tr>
<th>Pretreatment Characteristics</th>
<th>Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 Mean</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>RDI</td>
<td>68 67 62 42 60 115 87 68 20 75 90 69 65 58 90 23 105 61 83 56 36 51 45 118 57 54 102 71 122 70 72 0</td>
</tr>
<tr>
<td>AI</td>
<td>49 54 42 30 60 115 70 61 20 71 92 62 52 55 71 23 60 55 70 30 36 43 40 79 44 84 106 55 85 40 59 1</td>
</tr>
<tr>
<td>Low SaO2</td>
<td>56 61 61 68 44 53 51 60 90 60 76 58 44 50 62 80 75 82 63 60 60 74 63 64 10 83 76 81 87 61 0</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>30.3 32.8 33.1 37.3 30.5 36.4 30.4 30.6 34.9 31.7 37.1 36.8 34.9 34.0 34.0 30.0 25.8 25.8 25.7 31.6 36.8 47.6 33.6 33.5 45.3 30.4 32.6</td>
</tr>
<tr>
<td>SNB*</td>
<td>80 70 73 75 73 75 72 70 67 75 77 90 71 73 70 74 63 73 70 74 77 75 70 74 77 74 50 70 73</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Posttreatment RDI</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>UPPP</td>
<td>64 73 80 61 74 100 75 71 57 68 61 51 70 30 65 80 90 43 43 44 90 80 85 74 107 68.8</td>
</tr>
<tr>
<td>MMHO, mo</td>
<td>6 14 6 24 6 4 20 9 24 14 19 9 2 11 2 11 9 17 5 16 1 1 16 5 4 1 5 7 5 8 5 5 4 2 3 9 8.8</td>
</tr>
</tbody>
</table>

*RDI = respiratory disturbance index; BMI = body mass index; UPPP = uvulopalatopharyngoplasty; MMHO = maxillary, mandibular, and hyoid advancement.
The objective evaluation included an analysis of changes in sleep architecture and in sleep-disordered breathing. Figure 3 contains the analysis of sleep architecture. The overall quality of sleep improved markedly in both the nasal CPAP and surgery studies. At the baseline study, REM sleep was 8.7±5.0 percent. After nasal CPAP was begun, REM sleep improved to 21.7±8.4 percent and at the postoperative study, REM sleep remained at 21.1±5.2 percent. The stage 3-4 percent showed similar improvement. At the baseline study, the stage 3-4 was 2.3±4.2 percent, and at the nasal CPAP study and postoperative study, the stage 3-4 was 8.3±3.7 percent and 8.4±3.2 percent, respectively. In comparing the nasal CPAP and surgery results with the baseline study, the difference is significant (p<.00001), but there is no significant difference between the nasal CPAP and surgery studies.

The evaluation of the sleep-disordered breathing is displayed in Figure 4. The BMI was calculated at the baseline polygraphic recording and at the six-month postsurgical study. While all patients lost between 4 and 8 kg initially after surgery, at the six-month postoperative recording, the BMI had returned to baseline. The mean pretreatment BMI was 32.6±6.0 and at the six-month follow-up study, the mean BMI was 32.4±5.9. There was no significant change in the BMI between these two studies. As previously stated, the mean pretreatment RDI was 72.0±25.8. The follow-up results of nasal CPAP and surgery showed almost complete correction of the sleep-disordered breathing. The mean RDI for nasal CPAP and surgery was 8.6±4.3 and 8.8±6.1, respectively. Table 2 shows that all patients had significant improvement as a result of surgery. Oximetry, similarly, showed marked improvement in the minimum SaO₂ and the number.
of desaturation events below 90 percent in both the nasal CPAP and postoperative studies. The minimum SaO₂ prior to treatment was 61.0 ± 13.5. The results of the minimum SaO₂ at the completion of therapy for nasal CPAP and surgery was 86.2 ± 5.5 and 86.1 ± 4.1, respectively. The analysis of variance showed no significant difference between the nasal CPAP and surgery studies in all respective parameters.

The concept of surgical advancement of the facial skeleton, at first glance, would seem to be an aggressive form of therapy. The postoperative morbidity, however, was very low. The mean hospital stay for MMHO was 2.4 ± 0.8 days. There were no problems with postoperative bleeding or infection. All patients had development of transient anesthesia of the cheek and chin area. There was an 87 percent resolution between 6 and 12 months. There were no motor nerve deficits as a result of the surgical procedures. Two of the patients have had development of a surgical relapse of approximately 20 percent. This represents a slippage of the mandibular advancement secondary to muscular pull. They remain free of symptoms, and polysomnography documents continued control of their OSAS. All patients were treated in conjunction with orthodontics to correct changes in occlusion that occurred with the surgery. Jaw fixation was necessary for two to three weeks and a soft diet was necessary for a total of six weeks.

**Discussion**

Maxillofacial surgery has proved to be an effective method for controlling OSAS. It is equally as effective as nasal CPAP in improving sleep architecture and correcting sleep-disordered breathing. While there have been some concerns about the potential problem of surgical relapse, and therefore the return of OSAS, follow-up polysomnographic testing of this group continues to show that OSAS is controlled. The mean follow-up to date in this group is 12.6 months. The overall results remained unchanged (Table 2). In light of the recent retrospective reviews reporting increased mortality for the untreated patient with OSAS, maxillofacial surgery should be considered as an alternative for nasal CPAP failures.

**References**