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ORIGINAL ARTICLES

Combined uvulopalatopharyngoplasty and radiofrequency tongue base reduction for treatment of obstructive sleep apnea/hypopnea syndrome

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OBJECTIVE: **In this study, we compare the objective results of uvulopalatopharyngoplasty (UPPP) combined with tongue base radiofrequency reduction (TBRF) with standard UPPP treatment of obstructive sleep apnea/hypopnea syndrome (OSAHS).**

STUDY DESIGN: **We conducted a retrospective study of 277 patients who had stage I, II, or III OSAHS based on the Friedman staging system previously presented.**

METHODS: **One hundred thirty-four patients who had treatment with UPPP only were used as a control group. This included 31 patients with stage I, 29 patients with stage II, and 74 patients with stage III OSAHS. An additional 143 patients with Stage II (n = 52) and III (n = 91) OSAHS were treated with combined UPPP and TBRF, initially and followed by additional TBRF treatments (up to 9000 J) as necessary. Subjective results were collected based on questionnaires and the Epworth Sleepiness Scale score for the experimental group, but these subjective measures were not available for the control group. Objective results were compared based on the polysomnographic findings before and after surgery.**

RESULTS: **Subjectively, the study group did extremely well. Based on objective measures of successful treatment, UPPP plus TBRF resulted in a significantly higher percentage of patients who were "cured" of OSAHS compared with the control group.**

CONCLUSIONS: **Stage I patients were usually successfully treated with UPPP only. However, patients allocated to stage II or III will benefit from the addition of TBRF to standard UPPP. Many UPPP-plus-TBRF patients in this study aborted further recommended TBRF treatments after subjective improvement and therefore objective results for this group, although improved in comparison to stage II and III patients treated with UPPP only, may not represent maximal potential improvement.** (Otolaryngol Head Neck Surg 2003;129:611-21.)

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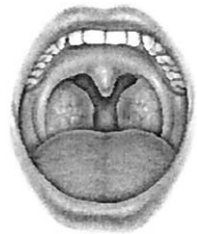
Obstructive sleep apnea/hypopnea syndrome (OSAHS) is a common condition that, if left untreated, results in significant health risks. In addition to weight gain, cardiovascular risks, and other medical sequelae, the cost of the excessive daytime somnolence and decreased alertness produced by OSAHS is immense.[1] For example, the

contribution of excessive daytime somnolence to motor vehicle and industrial accidents goes largely unrecognized but represents a major justification for treatment of the underlying disorder.[2] In addition to the sequelae of untreated OSAHS, the associated snoring is a major social issue that brings most patients in for treatment.

The preferred method of treatment for OSAHS is continuous positive airway pressure (CPAP) breathing. However, compliance varies but ranges around 50%. Those patients not using CPAP are therefore candidates for surgical intervention. Classic uvulopalatopharyngoplasty (UPPP) is the most common surgical intervention but has limitations. Although reducing obstruction caused by the soft palate and tonsils, UPPP does not improve obstruction of the hypopharynx. Meta-analysis of reported success rates for UPPP hovers around 40%.[3] These disappointing results led to a wide variety of procedures to alleviate obstruction at the hypopharynx level, including genioglossus advancement, hyoid advancement, partial glossectomy, and maxillary mandibular advancement. Although many of these procedures have shown promise,[4] the complexity of many of these procedures is a disadvantage. Radiofrequency tongue base reduction (TBRF) was introduced as a simplified solution to decrease hypopharyngeal obstruction in OSAHS.[5]

Early studies on TBRF were disappointing for 2 major reasons. A multicenter study showed large differences in success rates from center to center and the overall success rate was poor.[6] The results of the study, however, did establish that the technique can be far more effective if electrolyte solution is injected into the tongue before radiofrequency ablation. In addition, Friedman et al[7,9] previously presented a staging system for patients with OSAHS based on palate position, tonsil size, and body mass index (BMI) that stratifies patients with obstruction caused by the palate and tonsils from those whose obstruction is at the level of the tongue base. Use of this staging system not only identifies those patients who will not benefit from UPPP as a sole surgical treatment to improve their sleep apnea but also distinguishes those in need of additional treatment to the hypopharynx, such as TBRF.

Table 1. Modified Friedman staging system for patients with obstructive sleep apnea/hypopnea syndrome

Stage	Friedman palate position	Tonsil size	Body mass BMI index (kg/m^2)
I	1	3, 4	<40
	2	3, 4	<40
			
II	1, 2	1, 2	<40
	3, 4	3, 4	<40
III	3	0, 1, 2	<40
	4	0, 1, 2	<40
			
IV	1, 2, 3, 4	0, 1, 2, 3, 4	≥40

All patients with significant craniofacial or other anatomic deformities

Since January 2000, patients with stage II or III disease were treated with TBRF in addition to any other procedure on the palate or tonsils deemed necessary. The present study was designed as a retrospective review of this large group of patients with OSAHS, all treated with combined UPPP plus TBRF (with electrolyte injection), and compares the objective results with those obtained in a previously reported group of patients with OSAHS, all treated with UPPP only.

METHODS

Study Design

This is a retrospective study designed to compare the results of 2 different treatment protocols that were used to treat patients with OSAHS. Friedman et al[7,9] proposed a staging system that establishes a stage based on 3 physical findings and is unrelated to severity of disease. The staging system is based on Friedman palate position (FPP)

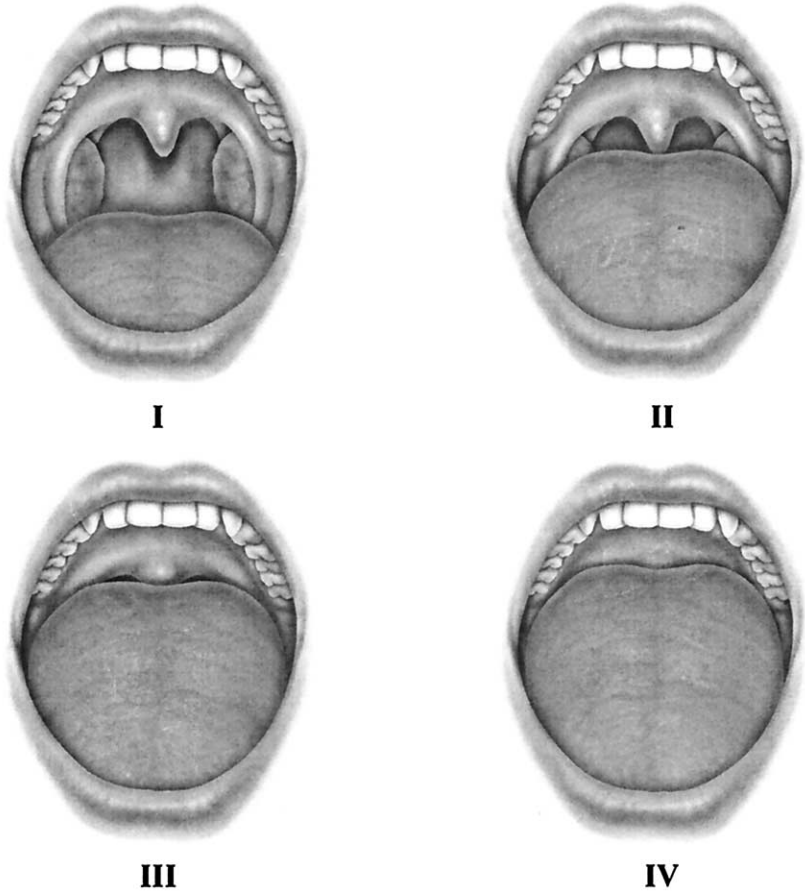


Fig 1. The Friedman palate position is based on visualization of structures with the mouth open widely without protruding the tongue. Palate grade I allows the observer to visualize the entire uvula and tonsils. Grade II allows visualization of the uvula but not the tonsils. Grade III allows visualization of the soft palate but not the uvula. Grade IV allows visualization of the hard palate only.

score, tonsil size, and body mass index (Table 1). Because this was a retrospective chart review study, it was granted an exception by the local institutional review board and no informed consent was obtained specifically for this study. Patients' records were identified by random number only on the data sheets. The objective results of treatment of patients with stage II or III disease treated with UPPP only (control group) were compared with those treated with UPPP and TBRF (study group).

Based on the staging system, stage I patients with OSAHS have a better than 80% success rate when treated with UPPP only.[6] However, a majority (75%) of the patients seeking treatment for OSAHS or excessive daytime somnolence have stage II or III disease, with only 40% and 8% success rates, respectively, when treated solely with UPPP.[6] Before January 2000, 134 patients with stage I, II, or III disease were treated with UPPP only. Between January l, 2000, and January 1, 2001, 235 new patients with stage II or III disease were treated with UPPP and TBRF. Selection criteria for treatment required significant symptoms of snoring, excessive daytime somnolence, and an apnea/hypopnea index (AHI) of greater than 15. All patients had to attempt CPAP use at home after a CPAP titration study was completed. Only patients who were deemed CPAP treatment failures were operated on. One hundred forty-three of the patients had posttreatment polysomnography at least 6 months after completion of treatment. These 143 patients composed the "experimental group" in this retrospective study. The

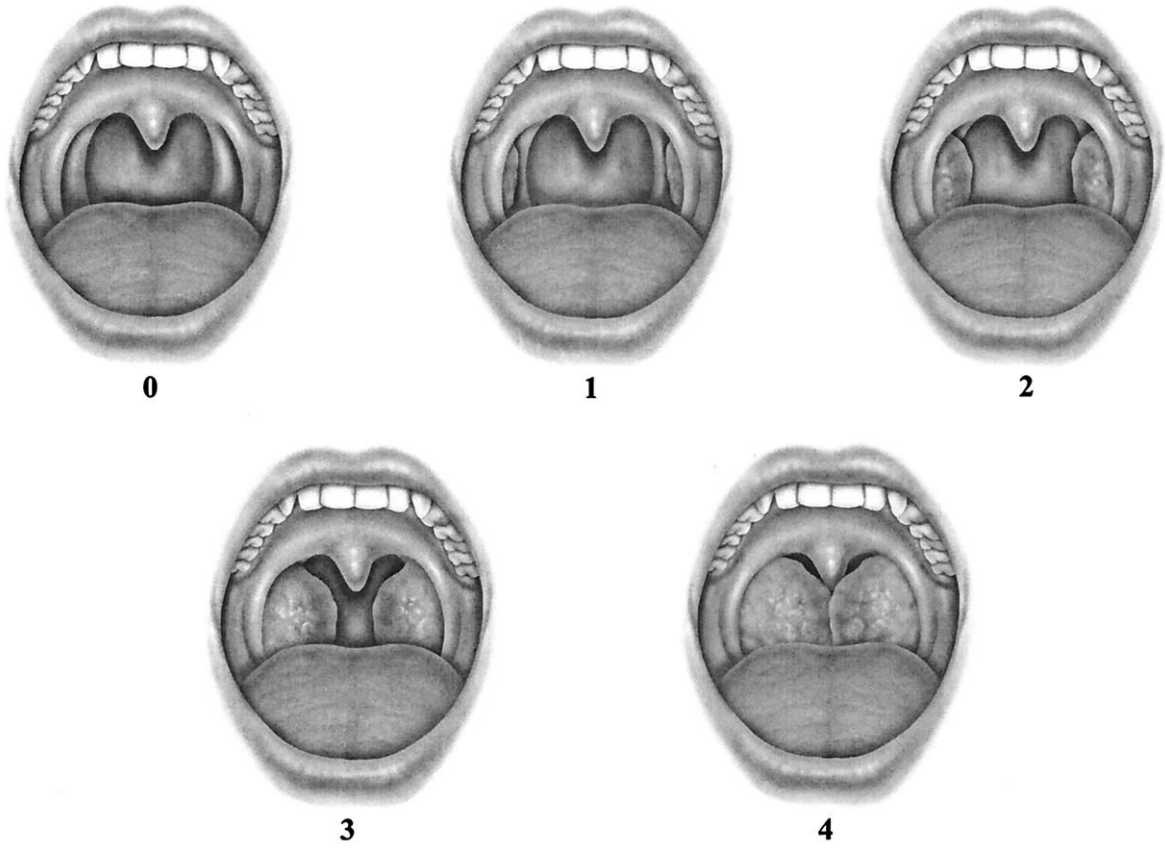


Fig 2. Tonsil size is graded from 0 to 4. Tonsil size 0 denotes surgically removed tonsils. Size 1 implies tonsils hidden within the pillars. Tonsil size 2 implies the tonsils extending to the pillars. Size 3 tonsils are beyond the pillars but not to the midline. Tonsil size 4 implies tonsils extend to the midline.

92 patients who had treatment but incomplete follow-up were excluded. None of these excluded patients had complications other than those reported in the series.

Staging System

Palate position had been previously studied and found to be a clinical indicator of OSAHS.[7] This palate classification is based on observations by Mallampati et al,[8] who previously suggested palate position as an indicator of the ease or difficulty of endotracheal intubation by standard anesthesiologists' techniques. We have incorporated 2 modifications into the Mallampati classification to create our own staging criteria: 1) The anesthesiologist's assessment is based on the patient sticking out their tongue and the observer then noting the relationship of soft palate to tongue. Our grading is based on the tongue in a neutral, natural position inside the mouth (Fig 1). 2) The original grading system had only 3 grades, and we believe that 4 grades are essential (Fig 1).

The reason for the first modification is that the tongue during OSAHS is certainly not related to a protruded position. Therefore, we chose to assess the tongue inside the mouth. The reason for adding a fourth grade is that the majority of patients fall into the intermediate grades (grades II and III), but patients with extreme position (grades I and IV) seem to have extreme behavior with respect to bothpresence and treatability of OSAHS. Because this is a modified palate position grading system, we hereafter refer to FPP grades I to IV. We do, however, credit Mallampati et al[8] for bringing this important physical finding to light.

The FPP grade was assessed as previously described.[7] The procedure involves asking the patient to open their mouth widely without protruding their tongue. The procedure is repeated 5 times so that the observer can assign the most accurate

level. At times there can be some variation with different examinations, but the most consistent position is assigned as the palate grade. Palate grade I allows the observer to visualize the entire uvula and tonsils or pillars (Fig 1). Palate grade II allows visualization of the uvula but not the tonsils. Palate grade III allows visualization of the soft palate but not the uvula. Palate grade IV allows visualization of the hard palate only (Fig 1).

Tonsil size was graded from 0 to 4. Tonsil size 0 implies previous tonsillectomy (Fig 2). Tonsil size 1 implies tonsils hidden within the pillars. Tonsil size 2 implies the tonsil extending to the pillars. Size 3 tonsils are beyond the pillars but not to the midline. Tonsil size 4 implies tonsils that extend to the midline (Fig 2).

Weight and height were recorded at the initial visit, and the BMI (kg/m^2) was calculated. The BMI was graded as grade 0 (<20 kg/m^2), grade I (20 to 25 kg/m^2), grade II (25 to 30 kg/m^2), grade III (30 to 40 kg/m^2), and grade IV (>40 kg/m^2).

Earlier studies by Friedman et al[7,9] have proposed a staging system based on 3 physical findings and is unrelated to severity of disease. The staging system is based on the FPP score, tonsil size, and BMI[7,9] (Table 1). The staging system has been modified, and the number of stages has been expanded from 3 to 4. The need for the expansion became evident once the system was used in a prospective manner because some patients should not be candidates for pharyngeal surgery.

Stage I disease was arbitrarily defined as those patients with FPP I or II, tonsil size 3 or 4, and BMI of less than 40 kg/m^2 (Table 1). Stage II disease is defined as FPP I or II and tonsil size 0, 1, or 2, or FPP III and IV with tonsil size 3 or 4 and BMI of less than 40 kg/m^2. Stage III disease is defined as FPP III or IV and tonsil size 0, 1, or 2 and BMI less than 40 kg/m^2. All patients with a BMI of 40 kg/m^2 or greater and those with significant craniofacial or other anatomic deformities were classified as stage IV disease (Table 1).

Exclusion Criteria

Severity of disease varied from mild to very severe OSAHS and was not a criterion for exclusion. Patients with severe morbid obesity with a BMI of 40 kg/m^2 or greater (stage IV) were directed away from surgical treatment of the airway and urged to seek bariatric treatment. Patients with obvious micrognathia or bony anatomic abnormalities were not included (stage IV). Patients who had previously failed surgical treatment with UPPP or were otherwise candidates for TBRF treatment only were not included in the study. Only patients who were willing to actually use CPAP at home for a reasonable trial were considered for surgery. Patients without obvious palatal obstruction were not included. Also excluded were patients lost to follow-up before posttreatment evaluation and polysomnography.

Surgical Technique

Temperature-controlled radiofrequency rhinometric tissue reduction of the tongue base was performed using a Somnoplasty system (Gyrus, Inc, Memphis, TN) previously described by Powell et al.[5] Because the initial procedure was combined with UPPP, general anesthesia was required. The early patients were treated with a single-probe electrode, whereas most of the later patients were treated with a double-probe electrode. The double-probe electrode proved easier to use and more efficient by delivering 1500 J in 2 to 5 minutes. After completion of the UPPP, the Crow-Davis retractor was removed and a bite block was inserted. Many of these patients received an oral antiseptic prep with a chlorhexidine gluconate (Peridex; Zila Pharmaceuticals, Phoenix, AZ)–soaked gauze. This was instituted in the middle of 2000 and thus approximately half of the patients did not receive this oral prep. The anterior tongue was held forward with gauze, and the midline just anterior to the circumvallate papillae was clearly marked with a pen to avoid treatment more than 1 cm away from the midline. The presence of an endotracheal tube can distort the tongue, making accurate identification of the midline tongue base difficult. The midline of the tongue and the junction of the middle third and tongue base were identified and marked. Before application of the Somnoplasty electrode, 4 to 5 mL of electrolyte solution was injected into each side. Either xylocaine with or without epinephrine or bupivacaine with epinephrine was used. Bupivacaine (0.25%) was eventually adopted as the standard. The first 2 lesions were applied 1 cm posterior to the junction

and just to the right and left of the midline. Subsequent lesions were applied along the midline, anterior and posterior to the circumvalate papillae. In theory, all treatments should be new sites, but in reality treatment points were not precisely identified enough to assume that the same area was not re-treated. We do not believe that re-treating the same region is a problem. The space between the 2 probes of the double electrode is 10 mm. Most patients who were not diabetic were given 8 to 12 mg of decadron intravenously during the procedure. They also received postoperative oral steroids in a tapered dose for 6 days. All patients were observed overnight in the surgical intensive care unit. Nasal trumpets were always available and frequently used in the initial postoperative period for patients with difficult airways, most commonly encountered with the FPP III or IV. All patients received intravenous antibiotics at surgery and oral antibiotics and steroids after discharge. Additional TBRF treatments, when necessary, were performed on an outpatient basis under local anesthesia.

Each site received 750 to 1000 J, although the vast majority were treated with 750 J/site. The total amount of energy delivered to the tongue base depended on the number of treatments and varied between 3000 and 9000 J. The initial treatment combined with UPPP varied from 1500 to 4500 J. Subsequent treatments were recommended on a monthly basis until the patient was symptom free and polysomnographic results were improved. Polysomnograms were performed before and approximately 6 months after treatment. Successful treatment was defined as 50% reduction in AHI and an AHI of less than 20. Many patients, however, discontinued treatment before polysomnographic results were in the "cured" range.

Outcome variables for the UPPP/TBRF group included subjective clinical measures of snoring and daytime somnolence and objective full night attended polysomnographic studies. The subjective measures included the reported Epworth Sleepiness Scale (ESS) on a 0-to-24 scale and snoring level measured between 0 and 10 by an observer. For the UPPP group, only objective data were available. Complete nocturnal polysomnography was used for assessment of sleep and respiratory outcomes. Virtually all posttreatment testing was performed in the same laboratory as the preoperative testing. Measures of sleep include electroencephalogram, electro-oculogram, chin and leg muscle electromyogram, electrocardiogram, measures of respiratory effort, nasal oral airflow, thoracic and abdominal efforts, and pulse oximetry. Obstructive apnea was defined as a loss of nasal airflow for 10 seconds with evidence of continual respiratory effort. Hypopneas were defined as a 50% reduction in respiratory effort with a 4% drop in oxygen saturation.

Table 2. Number of radiofrequency tongue base treatments in Joules stratified by Friedman obstructive sleep apnea/hypopnea syndrome stage

Joules delivered*	Stage II	Stage III	All
3000	25	53	78
4000	0	1	1
4500	18	31	47
6000	4	4	8
7500	2	3	5
9000	1	1	2

*Each site received 750 J, except for rare exceptions that received 1000 J per site.

Statistical Analysis

The Student's *t* and Mann-Whitney *U* tests were used to evaluate significant differences between UPPP- and UPPP-plus-TBRF–treated patients. The paired Student's *t* test was used to compare preoperative with postoperative mean values within each group. The 1-way analysis of variance and the Student-Newman-Keuls tests were used to compare success rates by stage in patients treated with UPPP only. Statistical significance was accepted when $P < 0.05$. Statistical analysis was performed using SPSS software version 11.0.1 (SPSS, Chicago, IL).

RESULTS

The charts of 277 patients with OSAHS for whom CPAP treatment failed, who underwent corrective surgical treatment, and who had adequate follow-up were included in this study. Patients presenting before January 1, 2000, were treated with UPPP only (n = 134); whereas those presenting after June 1, 2000, and allocated to stage II

Table 3. Patient demographics and polysomnography data

	UPPP only	UPPP + TBRF	*P*
n	134	143	
Gender			
Males	98	104	NS
Females	36	39	NS
Age (y)	40.2 ± 13.7	47.0 ± 11.7	0.01
Body mass index (kg/m^2)	30.0 ± 5.6	31.5 ± 4.8	NS
Preoperative AI	10.0 ± 19.6	10.1 ± 17.2	NS
Postoperative AI	5.1 ± 15.5*	3.9 ± 9.3*	NS
Preoperative AHI	35.4 ± 25.0	43.9 ± 23.7	0.001
Postoperative AHI	26.5 ± 25.8*	28.1 ± 20.6*	NS
Preoperative minimum SaO_2	83.8 ± 12.5	81.4 ± 10.4	NS
Postoperative minimum SaO_2	87.0 ± 9.9*	85.9 ± 9.8*	NS

UPPP, Uvulopalatopharynoplasty; *TBRF*, radiofrequency ablation of base of tongue; *AI*, Apnea Index; *AHI*, Apnea/Hypopnea Index; *SaO_2*, arterial oxygen saturation.
*Significantly different from the preoperative value ($P < .05$).

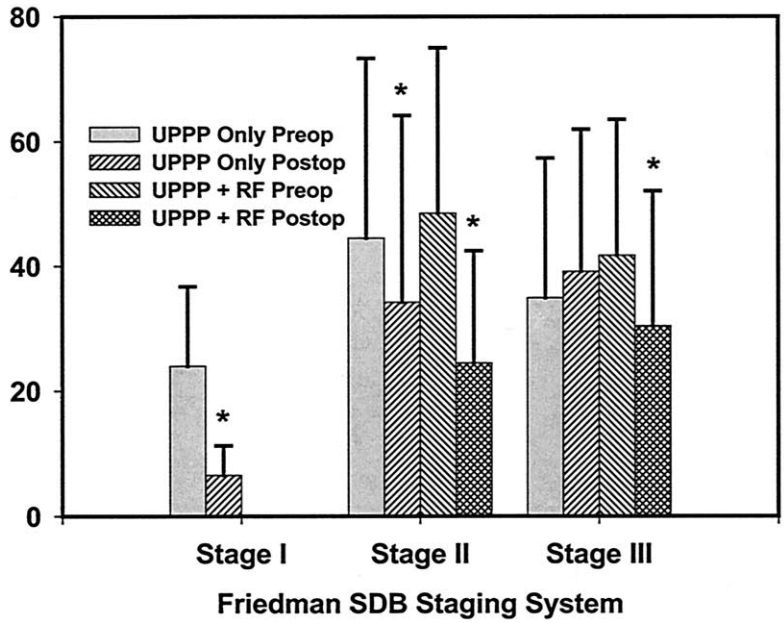


Fig 3. AHI data displaying preoperative and postoperative values for both UPPP and UPPP-plus-TBRF groups stratified into stages based on the Friedman staging system for OSAHS. The asterisks indicate significant differences from preoperative values.

or III (n = 143) were treated with UPPP and TBRF initially and additional treatments of TBRF (≤4) when necessary. Overall, 221 TBRF treatments were performed. Table 2 displays the number of TBRF treatments in joules delivered and stratified by Friedman OSAHS stage. Demographic data and comparisons of preoperative and postoperative polysomngraphic data are presented in Table 3. The mean age of patients undergoing UPPP plus TBRF was slightly, but significantly, older than that of those undergoing UPPP only (40.2 ± 13.7 versus 47.0 ± 11.7 years). In addition, mean preoperative AHI was higher in the UPPP-plus-TBRF patients than in the UPPP-only patients (35.4 ± 25.0 versus 43.9 ± 23.7). Also, objective indices of efficacy of treatment such as improvement in postoperative Apnea Index (AI), AHI, and minimum arterial oxygen saturation

Table 4. Comparison of subjective estimates of symptoms after UPPP plus TBRF treatment versus AHI, an objective measure of disease severity

	Preoperative ESS	Postoperative ESS	Preoperative snoring	Postoperative snoring	Preoperative AHI	Postoperative AHI
Stage II UPPP + BTRF	15.1 ± 3.0	7.0 ± 3.0*	7.8 ± 0.8	1.6 ± 1.8*	48.5 ± 26.5	24.5 ± 18.0*
Stage III UPPP + BTRF	15.2 ± 3.2	9.1 ± 4.2*	7.6 ± 1.2	2.3 ± 2.4*	41.7 ± 21.8	30.4 ± 21.7*
All UPPP + BTRF	15.2 ± 3.1	8.3 ± 3.9*	7.6 ± 1.1	2.1 ± 2.2*	44.0 ± 23.7	28.1 ± 20.6*

ESS, Epworth Sleepiness Scale; *AHI*, Apnea/Hypopnea Index; *UPPP*, uvulopalatopharyngoplasty; *TBRF*, radiofrequency ablation of base of tongue.
*Significantly different from preoperative value ($P < .05$).

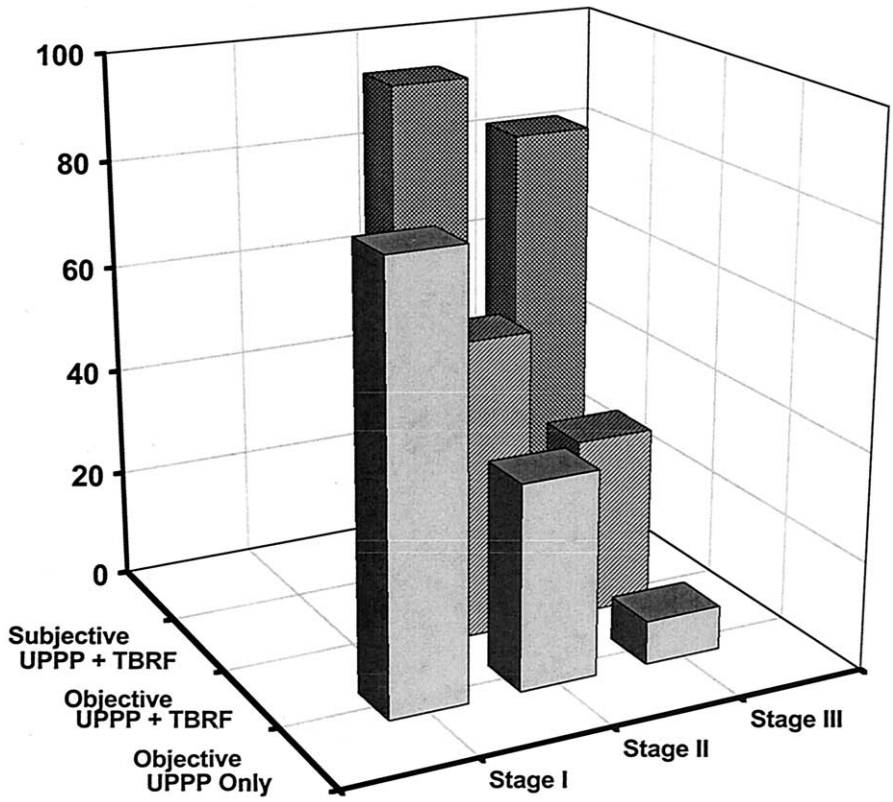


Fig 4. Subjective and objective measures of successful treatment of OSAHS for UPPP (objective only; n = 134) and UPPP-plus-TBRF groups (subjective and objective; n = 143) stratified into stages based on the Friedman staging system for OSAHS.

(Sa_{O_2}) versus preoperative values were demonstrated in both UPPP and UPPP-plus-TBRF patients. Figure 3 further breaks down AHI data by displaying preoperative and postoperative values for both UPPP and UPPP-plus-TBRF groups by stage. Stage I and II patients treated with UPPP demonstrated significantly lower postoperative AHI compared with the preoperative values, as did stage II and III patients for UPPP plus TBRF. Stage III patients were not significantly improved by UPPP (control group) but were significantly improved by UPPP plus TBRF (experimental group).

Table 4 contrasts preoperative versus postoperative subjective assessments of symptoms (ESS and snoring level) with AHI obtained at preoperative and postoperative polysomnograms in patients undergoing UPPP plus TBRF. Postoperative values for ESS, snoring level, and AHI were significantly reduced afterg treatment for both stages

Table 5. Comparison of improvement of AHI from the preoperative value after treatment with either UPPP or UPPP plus TBRF for the treatment of OSAHS

Stage	UPPP only, mean change AHI	UPPP + TBRF, mean change AHI	*P*
I	−17.5 ± 11.0	—	—
II	−10.3 ± 35.2	−24.0 ± 22.7	NS
III	4.2 ± 20.2	−11.3 ± 18.6	NS

Patients were stratified according to the Friedman OSAHS Stage.
OSAHS, Obstructive sleep apnea/hypopnea syndrome; *UPPP*, uvulopalatopharyngoplasty; *TBRF*, radiofrequency ablation of base of tongue; *AHI*, Apnea/Hypopnea Index.
*Significantly different from preoperative value ($P < .05$).

Table 6. Analysis of subjective and objective success rates of 143 patients undergoing UPPP plus TBRF for the treatment of OSAHS as a function of severity of disease based on preoperative AHI

Severity of OSAHS Criteria	UPPP + TBRF (n = 143)
Mild (AHI <20)	
Subjective	90.5%
Objective	42.9%
Moderate (AHI = 20 to 40)	
Subjective	89.3%
Objective	37.5%
Severe (AHI >40)	
Subjective	87.9%
Objective	42.4%

OSAHS, Obstructive sleep apnea-hypopnea syndrome; *UPPP*, Uvulopalatopharyngoplasty; *TBRF*, radiofrequency ablation of base of tongue; *OSAHS*, obstructive sleep apnea/hypopnea syndrome.

II and III. Similar subjective data on the severity of symptoms were not collected during the time the UPPP-only patients were treated.

Figure 4 illustrates subjective measures of treatment success of stage II and III patients treated with UPPP plus TBRF. Objective results are also illustrated and, for stages II and III, are compared with objective results from patients treated with UPPP only. Objective success was assessed using the classic criteria of a 50% or greater reduction in AHI and a postoperative AHI of greater than 20. As previously reported, UPPP demonstrated objective success rates 80.6% in stage I patients, 37.9% in stage II patients, and 8.1% in stage III patients. These values were all different from each other ($P < 0.0001$). In stage II and stage III patients treated with UPPP plus TBRF, success rates were 55.1% and 33.0%, respectively. Objective success rates for stage II and III patients were significantly better after treatment with UPPP plus TBRF compared with stage II and III patients treated with UPPP only ($P < 0.0001$). Table 5 illustrates the mean AHI change for each stage in the UPPP (control) and UPPP-plus-TBRF (experimental) groups. Although the experimental group had better surgical success based on classic criteria, there was no difference between the 2 groups in either stage II or stage III when only mean AHI change was considered. Subjective success, only available in UPPP-plus-TBRF patients, was defined as a decrease in both ESS and snoring levels postoperatively. These rates were significantly higher for both stage II and III patients (95.9% and 84.1%, respectively) compared with the objective success rate ($P < 0.0001$). Only patients who had posttreatment subjective and objective assessments were included in the study.

Table 6 illustrates the subjective and objective results of UPPP-plus-TBRF treatment of OSAHS stratified by severity of disease using polysomnographic data. Using an AHI of less than 20 as mild disease, an AHI between 20 and 40 as moderate disease, and an AHI greater than 40 as severe disease, there were no differences in subjective or objective success rates between mild, moderate, or severe disease.

Complications

There were no airway complications in the series of patients. Four patients developed increased pain after postoperative day 3. Two of the patients also complained of malodorous discharge at the base of tongue and, although no abscess was identified or drained, it was assumed that the patients had an abscess that spontaneously drained itself. Two other patients had identifiable abscesses that spontaneously drained. None of these patients required drainage or hospitalization or had airway compromise. One patient developed hypoglossal nerve paralysis; this patient received 4000 J at the initial treatment with the older single probe electrode. It was thought that one lateral lesion was too far off midline. Two other patients had transient paralysis that cleared within 1 week.

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DISCUSSION

Successful treatment of OSAHS syndrome requires normalization of polysomnographic results. It is well known that subjective improvement of patients' symptoms often does not correlate well with objective measurements. Particularly in the treatment of OSAHS, many studies have reported subjective improvement rates that are far higher than objective improvement rates.[10] Our data in patients treated with UPPP plus TBRF are in agreement with these previous studies. Clearly, our patient population showed that combined treatment including UPPP and TBRF is highly successful in eliminating symptoms that most commonly prompt the patients to seek treatment. Specifically, 88.3% of our patients had significant reduction in daytime somnolence as is evidenced by a reduction in their ESS scores and snoring levels. Unfortunately, we did not collect similar information on subjective improvement patients' symptoms when data on the UPPP treatment group were collected. Thus, we are unable to comment further on this detail.

Previous data suggested that stage I patients can usually be successfully treated with only UPPP.[9] Thus, no stage I subgroup was included in the UPPP-plus-TBRF group study. Objective evidence of successful treatment was obtained in 51.1% and 33.0% of stage II and III patients treated with UPPP plus TBRF compared with 37.9% and 8.1% of stage II and III patients treated only with UPPP, respectively. Our results were based on fairly well-matched groups of patients as demonstrated in Table 3. Although age and preoperative AHI were significantly different between the 2 groups as a whole, when only stage II and III patients (in the UPPP group) were considered, the values did not differ compared with their respective stages in the other group. Thus, the significant difference in cure rate can be likely attributed to a difference in treatment.

The fact that success rates for treating mild OSAHS were no better than those for treating severe OSAHS is not surprising. Our own experience and previous studies have demonstrated that the severity of disease is not a prognostic indicator of success of surgical treatment.[7,9,11] In fact, the basis of the Friedman staging system is that anatomic findings are the most significant factors, rather than the severity of disease.[9] Senior et al[11] also demonstrated that success with classic UPPP in treatment of mild OSAHS is only 40%. This success rate is not different than the treatment of severe OSAHS.[11]

This study is limited by many factors resulting from its retrospective nature. Any treatment that is staged is likely to become less appealing if symptoms have resolved. Although additional TBRF treatments were recommended for most patients, many patients discontinued treatment when symptoms improved or resolved. We considered these patients to have completed their treatment program, provided they were not lost to follow-up. Because all patients not completing treatment were excluded, the number of patients in each stage entered into the study did not change throughout. This seems important because it reflects patient compliance in a staged treatment program. We cannot predict, however, if the overall "objective success" rate would improve had all patients submitted to all recommended treatments. In addition, patient selection for the second group of patients, those treated with UPPP plus TBRF was restricted to new patients, staged as II or III, who presented with symptoms of OSAHS and had their diagnoses confirmed by polysomnography. Because patients who received TBRF as the only treatment were excluded, we cannot remark on TBRF as a rescue procedure for failed UPPP or as a sole procedure for treatment of OSAHS.

Postoperative discomfort after TBRF was not studied in this review because the initial procedure was combined with UPPP. Clearly, the postoperative pain and discomfort related to swallowing could not be separately assigned to either procedure. The vast majority of the patients, however, who had subsequent TBRF treatment(s) alone tolerated both the procedure and the postoperative period extremely well. Except for those patients who developed clinical symptoms of abscess formation, almost no patient complained of pain or dysphasia for more than 24 hours.

Our complication rate was extremely low and no airway complications developed. This contrasts with previously reported complications of airway compromise by Pazos and coworkers.[12] They studied only 25 tongue base procedures compared with 221 treatments in our series. Possibly, the

newer technology available may be a contributing factor to our low complication rate.

The treatment region of 1 cm lateral to midline was observed from the beginning of the series. It is much more difficult to drift away from this area using the double-probe handpiece compared with the older single-probe handpiece. This is further aided by marking of the midline before any injection. Treatment lateral to this 1-cm radius from midline is the likely cause of the single case of hypoglossal nerve paralysis seen early in the series. This patient was treated with a single-probe handpiece.

The use of chlorhexidine gluconate–soaked gauze to swipe the base of the tongue was instituted after formation of a base of tongue abscess was suspected. Overall, the incidence of abscess formation was thought to be extremely low, especially because the first case developed after treatment of more than 100 patients. The etiology of abscess formation may be secondary to the documented myotoxicity associated with bupivacaine use,[13] rather than simple contamination of the treatment site. Aside from the one incident of abscess formation, no lasting effects of bupivacaine use were identified.

That so many patients refused further treatment or were lost to follow-up when symptoms subsided is a disturbing, but common occurrence in medicine. In the case of OSAHS, a large number of patients seek treatment at the insistence of a bed-partner for snoring, and a diagnosis of OSAHS is made only after physical examination and polysomnography. The snoring aspect of the disease was often successfully treated with UPPP plus TBRF at the first treatment. As snoring abated, patients often weighted the benefits of further treatment against such factors as physical discomfort, risk, out-of-pocket costs, and time away from work. However, despite alleviation or amelioration of symptoms, many of the associated risks of OSAHS may remain if polysomnographic data are not normalized.

CONCLUSIONS

Despite some limitations, this study provides valuable information in many respects. It is the largest group of patients studied, to date, with TBRF. It shows the safety of the procedure and that it is well tolerated. It shows a very high success rate in improving symptoms. It is clearly a better technique for treating stage II and III patients than UPPP only. Although subjective improvement rates are very high, objective evidence of "cure" is far from perfect. Clearly further studies on the value of TBRF are indicated.

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