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ORIGINAL RESEARCH–SLEEP MEDICINE

Radiofrequency surgery for the treatment of obstructive sleep apnea: Short-term and long-term results

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

ABSTRACT

OBJECTIVE: To compare the short-term and long-term results in patients undergoing radiofrequency (RF) for obstructive sleep apnea (OSA).

STUDY DESIGN: Case series and planned data collection.

SETTING: Tertiary referral center.

SUBJECTS AND METHODS: A study was undertaken on 72 OSA patients with palatal and tongue base obstruction based on radiography and physical findings. Multilevel RF was conducted to reduce the tissue.

RESULTS: Patients had a mean age of 35.8 ± 10.9 years and a mean body mass index (BMI) of 28.8 ± 2.4 kg/m^2. The mean follow-up was 14.2 ± 1.8 months, with a range of 12 to 16 months. Mean baseline apnea-hypopnea index (AHI), short-term AHI, and long-term AHI were 35.6 ± 9.2, 12.5 ± 4.8, and 16.8 ± 3.2, respectively. Mean baseline lowest oxygen saturation (LSAT), short-term LSAT, and long-term LSAT were 85.6 ± 3.4 percent, 88.7 ± 2.9 percent, and 88.2 ± 1.7 percent, respectively. The change in BMI was significantly different in the patients with and without recurrence (2.8 ± 1.8 vs 0.3 ± 0.2 kg/m^2, $P < 0.01$). Forty (55.6%) patients had long-term success, and eight (16.7%) patients with short-term success failed in the long term. Serious complications were not encountered.

CONCLUSION: RF is a minimally invasive and effective procedure that results in long-term success for patients with a relatively low BMI and mild to moderate OSA without nasal obstruction. However, a recommendation concerning weight control and a regular follow-up are important because some patients will relapse in the long term.

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Obstructive sleep apnea (OSA) results from the combination of a structurally small upper airway and abnormal airway collapsibility, which increases airway resistance, hyponea, and overt apnea during sleep. Because patients with OSA comprise a wide spectrum of disease severity, upper airway obstruction occurring during sleep can appear at multiple sites. It affects two to four percent of middle-aged adults.[1] Many patients respond to medical treatment with weight loss, body position training for sleep, avoidance of alcohol and sedative medicine, oral appliances, and continuous positive airway pressure (CPAP). Patients who cannot comply with medical therapy become at risk for the serious medical consequences of OSA. When medical treatment fails, surgical treatment is the alternative.

Several surgical procedures have been developed to treat OSA. Successful results of radiofrequency (RF) reduction of the palate and tongue for OSA have been reported.[2,3] Electrosurgical energy is conducted to reduce the volume of the palatal and tongue tissue by producing coagulation necrosis and healing by scar formation and musculature contraction. The treatment outcomes of RF addressing both palatal and tongue base areas of collapse have now been validated by many centers;[4-6] however, there is little information on long-term results. The purpose of this study was to compare the short-term versus long-term results and determine factors, such as age, body mass index (BMI), apnea-hypopnea index (AHI), lowest oxygen saturation (LSAT), and cephalometric measurements, that predict response in patients undergoing this procedure.

MATERIALS AND METHODS

The study was approved by the Institutional Review Board of the Faculty of Medicine, Srinakharinwirot University. Patients provided written informed consent before taking part in the study. For 10 months, 245 consecutive patients were evaluated for treatment of snoring and sleep apnea at Princess Maha Jakri Sirinthon Medical Center. Patients were advised to bring their bed partners or observers to the evaluation. The initial visit included a complete history, physical examination, and otolaryngology examination. Fiberoptic pharyngoscopy with Muller's maneuver was performed at the level of the nasopharynx and the base of tongue. Initial body weights and heights were obtained, and BMI was calculated. A lateral cephalometric radiograph was also obtained.

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After a diagnosis of OSA was made, patients were advised on various treatment options. When appropriate, patients were encouraged to lose weight, avoid sleeping supine if their problem was positional, lengthen their sleep time, and avoid alcohol and tobacco. CPAP, oral appliances, and surgical options were reviewed with each patient. Patients who had failed to respond to the conservative treatments were counseled about the benefits and risks of surgical procedures.

Eighty patients (32.7%) who had a primary complaint of snoring and OSA were found to be suitable for the RF palatal and tongue base reduction. All patients had both oropharyngeal and hypopharyngeal obstruction. They were classified as positive for oropharyngeal obstruction when, with Muller's maneuver, a redundant soft palate collapse against the posterior pharyngeal wall covered greater than half of the cross-section area, and cephalometric analysis showed elongation of the soft palate. Hypopharyngeal obstruction was positive when, with Muller's maneuver, the base of the tongue collapsed against the posterior pharyngeal wall and covered greater than half of the cross-section area and restricted visualization of the larynx, and cephalometric analysis demonstrated a narrow posterior airway space (PAS). Patients with hypertrophic tonsil and nasal obstruction (patients with significant sources of obstruction, such as inferior turbinate hypertrophy, septal deviation, polyposis, or nasal tumor) were excluded. Patients were evaluated preoperatively and postoperatively by polysomnography. OSA was diagnosed in patients who experienced daytime sleepiness or disturbed sleep and had more than five respiratory disturbances per hour of sleep on their polysomnogram. Polysomnography was performed in the sleep laboratory, with full monitoring that included an EEG, electro-oculogram, chin and leg electromyelogram, ECG (modified V_2 lead), airflow, thoracic and abdominal efforts, and pulse oximetry. The polysomnogram was analyzed according to the standards of the American Thoracic Society.[7] Baseline information was collected. The patient's bed partner or observer used a 10 cm visual analog scale (VAS) to grade the severity of snoring prior to the procedure and postoperative treatment. No snoring occupied the far left portion of the scale, while severe snoring occupied the far right of the scale. An Epworth Sleepiness Scale (ESS), which reflected both the chance of dozing in special situations as well as daytime sleepiness, was complete at baseline. Short-term results were measured at three months, and long-term results were measured at least 12 months postoperatively.

Patients with an AHI greater than 40 and an LSAT less than 80 percent were advised to receive CPAP at least two weeks prior to surgery, and to continue with CPAP postoperatively until a polysomnogram was performed to document outcome.

RF Palatal and Tongue Base Reduction

RF was performed essentially as described by Powell et al,[3,8] using the modification in which the procedure was performed with a radiofrequency BM 780 II generator (Sutter Medizintechnir, Freiburg, Germany). The soft palate and the tongue were anesthetized with xylocaine 10% topical dispersion, and 5 to 10 mL xylocaine 1% with adrenaline solution was additionally injected. This procedure was performed with the patients sitting upright.

The midportion of the palate from the uvular base to the posterior nasal spine was selected for treatment. The needle electrode was inserted midline and paramedian in the soft palate in each treatment session. RF energy was applied for 600 joules and 300 joules, respectively, in the bipolar mode. The tissue adjacent to the unprotected portion of the needle underwent ablation while the overlying mucosa was left intact.

The midline tongue anterior and posterior to the circumvallate papillae was selected for treatment. RF energy was delivered to create separate lesions in three tongue sites per one session. It was delivered for 700 joules to each site. The total number of treatment sites for RF palatal and tongue reduction was six in each patient. The procedure was performed in stages, with at least two weeks between the treatments. After the procedure, patients were observed for 20 to 30 minutes and offered hospital admission for one day. Postoperative medications included antibiotic for seven days and acetaminophen elixir and/or anesthetic lozenges as needed for pain relief. Multiple treatment sessions were required to reduce problems.[3,8] The treatment end point was determined when snoring and sleep-related breathing symptoms improved to a level that would not bother the patient and the bed partner or after a minimum of two treatment sessions. The cost of a needle electrode was $550, which was supported by the grant from the Faculty of Medicine.

Patients were seen in follow-up at one week, two weeks, four weeks, and three months, and one repeat polysomnogram was completed. A VAS for pain was completed once daily for 10 days after the procedure. The patients were asked to rate pain on a continuous scale from 0 (none) to 10 (excruciating or intense pain). Data on the patients were compared from the preoperative stage to the short-term (3 months) and long-term postoperative assessment and analyzed by the Student t test, repeated measure, and Mann-Whitney U test. A multiple logistic regression model was used to identify the independent predictors of nonresponders. Odds ratios with 95% confidence intervals were calculated. A P value of < 0.05 was considered statistically significant.

RESULTS

Seventy-two (90%) patients completed the questionnaires and polysomnographic studies at both the short-term and the long-term examination and were included in the analysis. The patients were examined at three months (short term) and 12 to 16 months (14.2 $\pm$ 1.8 mo) postoperatively. Ages ranged from 24 to 58 years (35.8 $\pm$ 10.9 yrs). Sixty-five (90.2%) patients were married, and five (9.3%) were single

or divorced; 69 (95.8%) were male. BMI was calculated (weight in kilograms divided by the square of the height in meters). BMI at the time of surgery ranged from 26.4 to 31.1 kg/m^2 (28.8 ± 2.4 kg/m^2), at short term 26.5 to 31.9 kg/m^2 (29.1 ± 2.8 kg/m^2), at long term 27.2 to 32.6 kg/m^2 (30.9 ± 2.8 kg/m^2). Patients underwent an average of 3.5 ± 0.7 and 4.8 ± 0.8 treatment sessions for the palate and the tongue, respectively. There was a significant reduction in the distance between the posterior nasal spine and the soft palate (PNS-P), from 45.4 ± 2.9 mm to 43.1 ± 2.6 mm ($P <$ 0.05). There was an increase in posterior airway space (PAS), from 6.2 ± 2.1 mm to 8.7 ± 2.3 mm ($P < 0.01$). There were no changes in skeletal measurements (sella-nasion-point A angle, sella-nasion-point B angle) or the mandibular plane to hyoid bone (MP-H) (Table 1).

The mean preoperative AHI and short-term AHI were 35.6 ± 9.2 and 12.5 ± 4.8, respectively. The mean preoperative LSAT and short-term LSAT were 85.6 ± 3.4 percent and 88.7 ± 2.9 percent, respectively. Response to the RF procedure was defined as a 50 percent reduction in AHI and a final AHI of 20 or less. By these criteria, 48 of 72 (66.7%) patients responded in the short term. The mean BMI was significantly higher in the nonresponder group, 30.2 ± 2.9 kg/m^2, as compared to the responder group, 27.9 ± 2.3 kg/m^2 ($P < 0.01$). The mean AHI was also significantly higher in the nonresponder group, 44.3 ± 3.5, as compared to the responder group, 28.7 ± 4.7 ($P < 0.001$). There was no statistically significant difference between responders and nonresponders concerning age, snoring scale, ESS, and preoperative LSAT (Table 2). No statistically significant difference in cephalometric measurements was seen between the responders and nonresponders. In multiple logistic regression, BMI ≥29 kg/m^2 and AHI ≥30 were independently associated with nonresponders (odds ratio 2.76, 95% CI 1.3-2.9, $P < 0.01$ and odds ratio 1.97, 95% CI 1.1-2.2, $P < 0.05$, respectively). The other variables were not associated with nonresponders.

The mean long-term AHI was 16.8 ± 3.2, and the mean long-term LSAT was 88.2 ± 2.4 percent. Forty (55.6%) patients had long-term clinical success (Fig 1). Eight (16.7%) patients with short-term success failed over the long term. The short-term AHI was 13.2 ± 2.8, and increased to 28.7 ± 3.2. The LSAT decreased from 88.2 ± 1.7 percent to 85.2 ± 2.4 percent. There was no significant difference between the patients who subsequently relapsed and those who did not with regard to age, preoperative BMI, AHI, and cephalometric measurements. However, the change in BMI in patients with and without relapse was significantly different (2.8 ± 1.8 kg/m^2 vs 0.3 ± 0.2 kg/m^2, $P < 0.05$).

At the three months postoperative evaluation, all patients reported a reduction in their daytime sleepiness. The subjective data measured with the ESS (0-24) showed significant improvement. The mean preoperative ESS scale was 14.2 ± 3.4, and the mean postoperative ESS was 7.9 ± 2.1 ($P < 0.001$) at the short term and 8.2 ± 2.5 ($P < 0.001$) at the long term. There was a significant difference between short-term and long-term results ($P < 0.05$). At the long-term postoperative evaluation, eight patients who were sub-

Table 1
Cephalometric measurements

Variable	Preoperative	Postoperative	*P* value
SNA (degree)	81.19 ± 1.4	81.2 ± 1.5	NS
SNB (degree)	80.2 ± 1.8	80.3 ± 1.9	NS
PNS-P (mm)	45.4 ± 2.9	43.1 ± 2.6	<0.05
PAS (mm)	6.2 ± 2.1	8.7 ± 2.3	<0.01
MP-H (mm)	19.7 ± 2.1	19.9 ± 1.9	NS

SNA, sella-nasion-point A angle; *SNB*, sella-nasion-point B angle; *PNS-P*, length from the posterior nasal spine to uvula; *MP-H*, length between the mandibular plane and hyoid bone; *NS*, not significant.

Table 2
Patient characteristics

Characteristics	Nonresponders	Responders	*P* value
Age (yrs)	35.9 ± 4.7	35.2 ± 3.8	NS
BMI (kg/m^2)	30.2 ± 2.9	27.9 ± 2.3	<0.001
AHI	44.3 ± 3.5	28.7 ± 4.7	<0.01
LSAT (%)	85.4 ± 4.3	86.6 ± 3.9	NS
Snoring scale	8.2 ± 6.1	8.5 ± 4.2	NS
ESS	13.9 ± 4.2	12.4 ± 3.8	NS

BMI, body mass index; *AHI*, apnea-hypopnea index; *LSAT*, lowest oxygen saturation; *ESS*, Epworth Sleepiness Scale; *NS*, not significant.

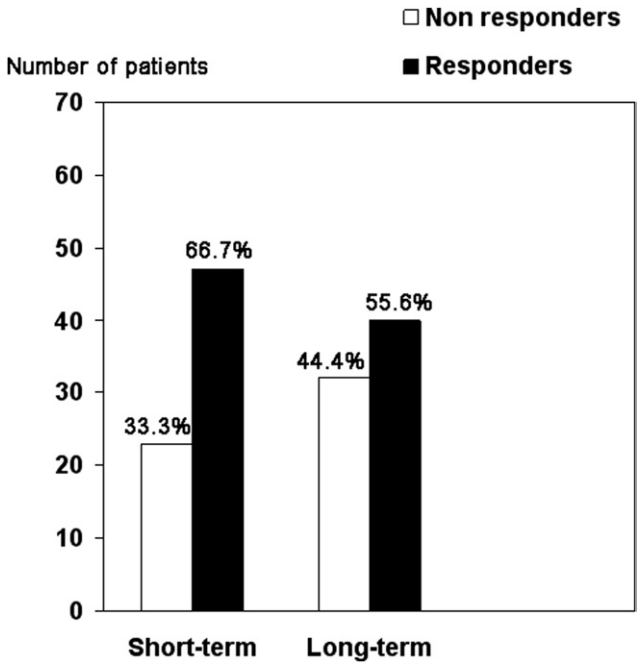


Figure 1 Responders and nonresponders at the short term and long term.

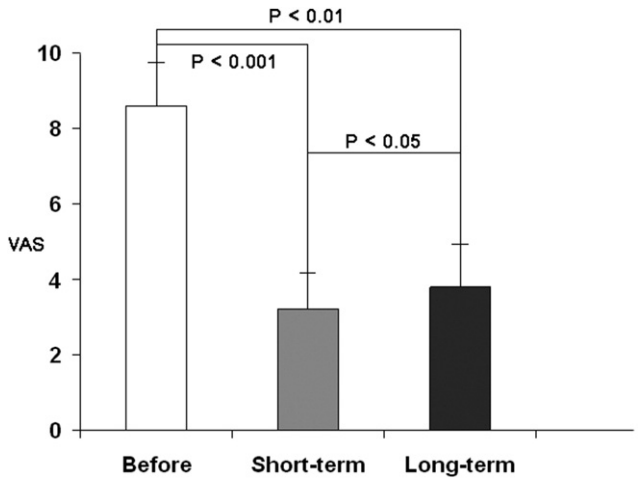


Figure 2 Mean snoring scale (VAS) before and after surgery.

sequently defined as non responders had recurrence of their daytime sleepiness (from 7.2 ± 1.8 to 13.1 ± 2.9, $P < 0.01$).

Significant improvement from the baseline (8.3 ± 1.6) was observed in the mean snoring scale (VAS) at both three months (2.7 ± 1.3, $P < 0.001$) and long term (3.1 ± 1.8, $P < 0.01$). There was a significant difference between short-term and long-term results ($P < 0.05$) (Fig 2). The average preoperative VAS was 8.3, indicating moderate to severe snoring for patients in this study. The bed partner or observer considered snoring cured if the VAS was less than half the baseline.[9] On this basis, the problem was eliminated in 77.8 percent (56 of 72) of patients at three months. Fifty (69.4%) patients reported continual success without relapse of snoring. Eight patients who were subsequently defined as nonresponders reported relapse of snoring (from 2.2 ± 1.2 to 7.1 ± 2.5, $P < 0.001$).

Complications included palatal ulcer in 8.2 percent (6 of 72), lingual ulcer in 8.2 percent (6 of 72), dysphagia in 8.2 percent (6 of 72), swelling of the floor of the mouth in 6.8 percent (5 of 72), and aspiration in 6.8 percent (5 of 72). These complications were self-limited and resolved in a few weeks. Ulceration was treated with topical and oral antibiotics and improved within one to three weeks. Dysphagia and aspiration due to pain and limitation of tongue motion were relieved with pain preparation in four to seven days. Swelling of the floor of the mouth was improved in three to five days with head elevation, administration of steroids, and application of ice to the treatment area. There were no emergent airway complications in this study. Most patients (67 of 72) had mild-to-moderate pain (VAS ≤5) for a few days. Bleeding, severe infection, and lingual nerve paralysis were not encountered.

DISCUSSION

OSA is associated with hypertension, cardiovascular diseases, daytime sleepiness, and impairment of quality of life.[10,11] Many patients respond to medical treatments such as weight loss, body position training for sleep, avoidance of alcohol and sedative medication, oral appliances, and CPAP. However, medical and behavioral managements require ongoing, prolonged follow-up, and adherence to therapy regimens. Some patients are not able to comply with these recommended treatments. Surgical treatments for OSA become particularly important when initial medical treatments have failed. The surgical concept is to stiffen and enlarge the upper airway, thereby restoring its patency during sleep. Many different approaches have been developed with the intent of better treating oropharyngeal and hypopharyngeal obstruction. Because the anatomical obstruction associated with OSA may occur at multiple sites, it is logical to focus the surgical attack on these sites.

We used the RF procedure described by Powell et al[3,8] to stiffen the pharyngeal tissue and to enlarge the upper airway. Reduction of palatal tissue and the base of the tongue is responsible for widening the pharyngeal airway space and decreasing airway resistance. In this study, there was a significant shortening of PNS-P and widening of PAS.

RF literature showed that short-term improvements in OSA occurred in 17 to 66 percent of those who received RF palatal reduction,[2,12] 20 to 68 percent of those who received RF tongue base reduction,[13,14] and 33 to 59 percent of those who received RF palatal and tongue base reduction.[4-6] The result of RF palatal and tongue base reduction in this study was comparable with the previous studies; it had a 66.7 percent success rate for decreasing AHI by 50 percent or more and postoperative AHI to less than 20 events per hour. This was quite impressive considering the patients did not have nasal obstruction and the average BMI (28.8 kg/m^2) was rather low when compared to the BMI of previous studies (29.2-30.6 kg/m^2).[3,12,14-16] The findings in this study also showed that the nonresponders had significantly higher preoperative BMI and AHI than the responders.

The short-term results of RF treatment for OSA are encouraging. Steward,[5] Blumen et al,[2] and Riley et al[14] showed a 59 to 68 percent success rate between three to 12 months after surgery. However, there are few studies on the long-term results of the RF procedure. Steward et al[15] showed the improvements in subjective and objective measurements of 29 OSA patients after RF palatal and tongue base reduction at a mean of 23 months postoperatively. Li et al,[16] reporting on the results of RF tongue base reduction, showed that there was a relapse of the AHI from a postoperative of 17.8 to 28.7, with a decrease in the LSAT from 88.3 percent to 85.8 percent, without significant deterioration in the subjective measurements at a mean follow-up of 28 months. Again, there were no obvious factors that predicted the recurrence of OSA after the RF procedure. In this study, there were significant differences between short-term and long-term results. Forty (55.6%) patients had long-term success, and eight (16.7%) patients with short-term success failed in the long term. The significant increase in BMI between the first and second postoperative recordings in the

patients with relapse confirmed that BMI was important. Patients with recurrence in the long-term follow-up also reported the relapse of snoring and daytime sleepiness. There were no serious complications after RF in this study. There were, however, cases of transient aspiration, dysphagia, and swelling of the floor of the mouth. Ulceration occurs when the lesion is too close to the mucosa. The treatment lesion must be deep in the muscle, and lesions should not be placed too close together. Pain and tongue discomfort cause dysphagia, and aspiration should be reduced with adequate pain preparation and proper energy per treatment site. Head elevation, administration of steroids, and application of ice to the treatment area are recommended to reduce the tissue swelling. Of the eight patients who relapsed, six patients underwent repeat RF treatment. Two patients underwent conservative treatment due to the pain and discomfort related to the RF procedure: one patient underwent treatment with CPAP, and the other, who had failed attempts with CPAP, used an oral appliance.

RF of the palate and tongue is a minimally invasive surgery that results in long-term success for patients with a relatively low BMI and mild-to-moderate OSA without nasal obstruction. A regular follow-up with recommendations concerning weight control is also important for preventing relapse.

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Chairat Neruntarat, primary investigator, data collection, data analysis, writer; **Suprapol Chantapant,** coordinator, data collection, literature review.

DISCLOSURES

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