



## Surgical treatment of snoring and mild obstructive sleep apnea

Mansoor Madani, MD, DMD\*

*Department of Oral and Maxillofacial Surgery, Capital Health Medical Center, 750 Brunswick Avenue, Trenton, NJ 08638, USA*

*Department of Oral and Maxillofacial Surgery, Temple University, 3401 North Broad Street, Philadelphia, PA 19140, USA*

*Center for Corrective Jaw Surgery, 15 North Presidential Blvd., Suite 301, Bala Cynwyd, PA 19004, USA*

Snoring has plagued individuals and societies for centuries. It is just within the past few decades that it was recognized as a sign of a more serious illness of sleep-disordered breathing known as sleep apnea [1–7]. Recent understanding of the pathophysiology of snoring, daytime sleepiness, restless sleep, and obstructive sleep apnea has allowed for successful treatment involving both nonsurgical and surgical intervention [8–11]. The nonsurgical management of snoring includes exercise, weight loss, decreased alcohol consumption, smoking cessation, altered sleeping position, and dental or nasal appliances [12]. Patient compliance has persistently been the drawback in these types of management. Major studies shows that over half the patients will not follow the conservative treatment for an extended period or patients do not obtain sufficient relief from their snoring with conservative methods and look for surgical modalities to correct their problem. In this article, we look at several surgical modalities to treat snoring and mild obstructive sleep apnea. The surgical goal should be to find a simple, safe, effective, and economical surgical procedure, which benefits the patient and allows a speedy recovery and return to normal daily activities.

During the past several decades, a variety of methods have been advocated for treatment of snoring and mild sleep apnea. No single procedure has been proven to have the ideals that justify its sole use over others. In order to choose an appropriate method of treatment, we must first review the pathophysiology of snoring and sleep apnea.

### Pathophysiology of snoring and sleep apnea

Snoring and obstructive sleep apnea occur in at least eight different sites; nasal (deviated septum, enlarged nasal turbinates), soft palate and uvula (retropalatal) [13], tonsils (obstructive tonsils), tongue base (retrolingual), jaws (retrognathism), lateral pharyngeal walls (pharyngeal muscle hypertrophy), and hyoid and epiglottis (Fig. 1). Turbulent airflow and subsequent progressive vibratory trauma to the soft tissues of the upper airway are important factors contributing to snoring [14–16]. Anatomic obstruction leads to greater negative inspiratory pressure, propagating further airway collapse and partial airway obstruction (hypopnea) or complete obstruction (apnea) (Fig. 2). Beside the upper airway anatomy, there are two other factors involved in the development of obstructive sleep apnea, and they are decreased dilating forces of the pharyngeal dilators and negative inspiratory pressure generated by the diaphragm.

When surgical procedures are proposed to a patient, all of these factors must be kept in mind, and no guarantee of a cure for sleep apnea should be given based on corrective surgery of only one or two of these factors. The same concept is true for reduction of the snoring sound and not total elimination of the sound, as snoring sound is multifactorial as well.

### Clinical evaluation and patient selection criteria

One of the most important aspects of surgical treatment is patient selection. Each patient will have a very specific problem, and some may need a combina-

\* Center for Corrective Jaw Surgery, 15 North Presidential Blvd., Suite 301, Bala Cynwyd, PA 19004, USA

*E-mail address:* drmadani@snorenet.com (M. Madani).

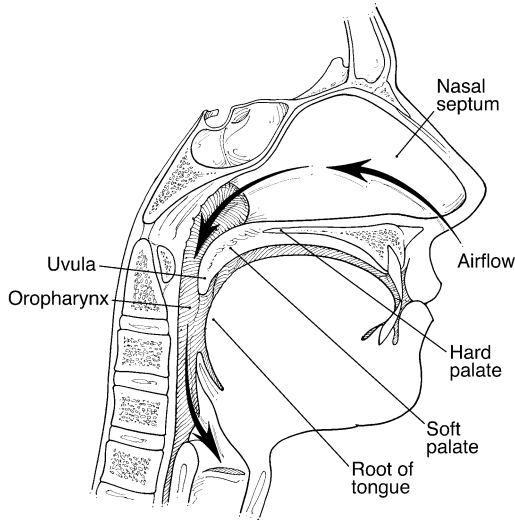


Fig. 1. Snoring and obstructive sleep apnea occurs in at least eight different sites. They include nasal septum, nasal turbinate, adenoids, tonsils, base of the tongue, uvula, soft palate, and epiglottis.

tion of procedures, whereas others may not be candidates for surgery at all. History of snoring, daytime sleepiness, gasping for air, and period of witnessed apnea, as reported by the patient and the patients' bed partner, are important indications for treatment.

Most patients with sleep apnea are overweight with short, thick necks. In the head and neck region, the upper airway should be examined for a number of abnormalities (Table 1).

Decreased muscle tone during sleep contributes to airway collapse as well. Direct fiberoptic examination or indirect mirror examination may reveal a mass or tumor somewhere in the upper airway, epiglottis enlargement, or vocal cord problems. As we will describe later in this article, the clinical examination of every individual will determine which types of procedures will suit them best.

A simple test the author uses to determine the possible origin of the sound of snoring is to ask the patient to imitate the snoring sound with the mouth slightly open. Usually, a loud sound will be detected from the vibration of the soft palate and the uvula. The patient is then asked to make the snoring sound with the lips completely sealed and from the nose. Generally, patients with a nasal problem can make the sound. This is most commonly related to an obstruction in the nasal passage. In our experience, up to 70% of snoring sounds in men come from the vibration of the uvula and the soft palate. Women, in more than 60% of occasions, have a nasal component of snoring.

## Imaging and radiographic studies

Two of the most common radiographs taken by oral and maxillofacial surgeons are panoramic and cephalometric radiographs [17]. The values of cephalometric studies are discussed elsewhere in this publication. But, when deciding to choose radioablation treatments, it is a crucial tool for measuring the thickness of the soft palate. A simple panoramic radiograph can show the uvula and the airway, and, in addition, the presence of any cysts or tumors of the maxillary sinus. Some panoramic films show deviated septum and enlarged turbinates. The advantages of these types of radiographs are their simplicity, clarity, and low cost. There are controversies in the literature as to the value of these radiographs, but for surgeons who frequently use them as an adjunct to their clinical examination, it should be a routine matter. MRI studies of the airway, although very precise, are rarely performed [18].

## Surgical modalities

Several surgical procedures are available to correct each type of snoring (ie, nasal, palatal, tonsillar,

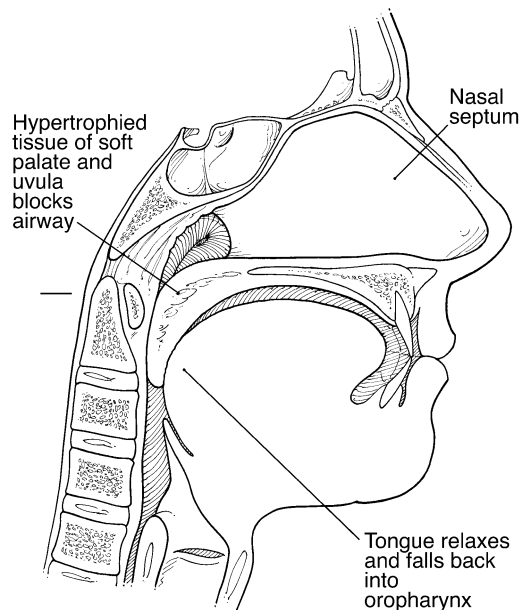


Fig. 2. Anatomic obstruction leads to greater negative inspiratory pressure, propagating further airway collapse and partial airway obstruction (hypopnea) or complete obstruction (apnea).

Table 1  
Upper Airway Abnormalities in Sleep Apnea

Enlarged, elongated or edematous uvula	Prominent oropharyngeal folds
Hyperplastic or thick soft palate	Obstructive tonsils Adenoids
Constricted oropharynx	Deviated septum
Macroglossia	Enlarged nasal turbinates
Enlarged tongue base (noting any posterior collapse)	Presence of nasal polyps or any other obstructive masses

base of the tongue). The retrolingual procedures, such as partial glossectomy and orthognathic surgeries, such as bimaxillary osteotomies, sagittal split osteotomy, and genioglossal advancements with hyoid myotomy, are most effective and discussed elsewhere in this publication [19–21]. They are certainly more invasive and complicated than the palatal and nasal procedures, however.

Nasal surgeries, such as septoplasty and inferior turbinate resection, rarely provide relief from snoring when used alone. In our experience, they reduce the sound of snoring only up to 25%, and they do not cure sleep apnea to any greater degree. Nasal procedures, however, often improve patient tolerance and response to nasal continuous positive airway pressure (CPAP). They are best used as an adjunct to more definitive surgical procedures. For these reasons, we initially offer most patients who desire surgical treatment a palatal procedure in combination with turbinate radio-ablation procedures.

In this article, we review the use of radiofrequency (RF), Harmonic Ultrasound, and laser procedures in the treatment of habitual snoring and mild sleep apnea. Additionally, new techniques will be discussed for treating obstructive tonsils and enlarged nasal turbinates. The advantages as well as disadvantages and potential problems of some of the newer devices will be explored as well.

Following FDA clearance of radio-ablation in the United States in 1997, the author has utilized three different RF generator systems, two laser systems (CO<sub>2</sub> and Nd Yag laser), and also the latest device used to treat these conditions, the Harmonic Ultrasound. They were all used in a large group of patients for treatment of snoring and sleep apnea. The results were varied and the techniques were modified significantly to achieve the best results. Patient selection, procedural details, and device utilization will be discussed later in this article. But in order to understand the use of radiofrequency, ultrasound, and laser, we should first review the history and physics of these devices.

## Radiofrequency usage in treatment of snoring and mild sleep apnea

RF has been used in medicine for over a century in the form of electrosurgery. The French physicist d'Arsonval first used RF energy in 1891. He reported that altering current at frequencies of 2 kHz–2 MHz could be applied to tissues, causing heat effects without muscle and nerve stimulation [22]. At this point, the development of diathermy and electrosurgery began. In 1928, the physicist, W.T. Bovie, and the neurosurgeon, Harvey Cushing, created the very first electrocautery unit capable of cutting and coagulating tissues [23,24].

RF energy has gained wide usage during this century in many areas of medicine, particularly because of its ability to produce discrete lesions in the central and peripheral nervous systems [25,26]. It has also been used in a variety of dermatological cases as well as for malignancies [27] and for the control of chronic pain syndrome [28]. Collings introduced transurethral electrosurgery for the relief of prostate obstruction in 1932 [29]. In the mid-1980s, RF energy was first used during the experimental treatment of cardiac arrhythmia in animal models by Huang et al, where it safely produced a lesion in the V node, as well as the atrial and ventricular myocardium [30]. RF is also being extensively used now in orthopedic surgery [31–35].

The concept of RF tissue ablation or volumetric tissue reduction is not new. Ellis et al presented their preliminary work on stiffening of palatal tissue using the Nd. YAG laser in 1993 [36]. Whinney et al described their approach for stiffening of the soft palate by using 10–15 penetration sites on the palatal mucosa using diathermy in 1995 [37]. Powell et al initiated the use of RF for the treatment of snoring and sleep apnea in an animal model in 1996. Investigative animal and human studies by Powell and others showed that using RF energy could safely reduce tongue and soft palate volume in a controlled manner [38]. The author's studies also showed the effective usage of RF for volumetric reduction of enlarged turbinates and obstructive tonsils [39–41].

## Physics of radiofrequency

The introduction of RF generators to the field of medicine, particularly by William Bovie and Harry Cushing, had an impact on many surgical procedures in the twentieth century. Four types of RF generators are: grounded, isolated, balanced, and returned-electrode monitoring systems. There are many types

of RF generators advocated and used in the treatment of snoring and sleep apnea.

### Advantages of radio-ablation

Radiofrequency treatments are certainly less invasive than traditional surgeries. They are designed, when properly used, to reduce patients' discomfort, tissue damage, mucosal ulceration, and external scar formation. These devices are capable of creating submucosal lesions (also known as ablation) while simultaneously controlling bleeding. The clinical advantages of these procedures are intended to include more precise operative results, reduced surgical time, and rapid recovery. The lesions created by these procedures are naturally resorbed in approximately 8–10 weeks, reducing excess tissue volume. Procedures are generally performed in an outpatient setting, and no general anesthesia is required for most of them. The effectiveness of each procedure depends on patient selection, site of the lesions, number of repeated procedures, and the surgeon's experience. At present, the three most commonly utilized RF devices are Somnoplasty<sup>TM</sup>, Coblation<sup>®</sup>, and Ellman/Ellmad<sup>®</sup>. We will briefly describe each system and then review the relevant procedures.

### Somnoplasty<sup>TM</sup>

One of the most sophisticated RF systems available to surgeons for the treatment of snoring and sleep apnea is Somnoplasty<sup>TM</sup> (Somnus Medical Technologies, Inc., Sunnyvale, CA). It is an isolated and monopolar type RF system with floating output and is not designed to cut or cauterize tissues. Its main purpose is to create a submucosal coagulative lesion by heating tissue within a temperature range of 50–95° C around the active portion of the electrode. This generator uses a ground pad to complete the electrical circuit. In Somnoplasty<sup>TM</sup>, a current from the electrode causes electrical arcs to form across the physical gap between the probe and the target tissue. At the contact point of these arcs, rapid tissue heating occurs. Consequently, cellular fluid rapidly vaporizes into steam, causing the release of cellular fragments and producing a layer of necrosis, or dead cells, along the pathway of the probe. As a result of this heating, collateral tissue ablation is produced in regions surrounding the target tissue site. This leads to the creation of vacuolar degeneration in the affected tissue. Over a course of several weeks following the initial treatment, a firmer, fibrous tissue forms, reducing the tissue volume and, thus, resulting in less

vibration. This system consists of a programmable RF generator with temperature and impedance monitoring and a disposable surgical hand piece containing a needle electrode, which delivers RF energy to selected areas. An insulating sleeve at the base of the needle electrode protects the tissue external to the treated area from thermal damage. This prevents tissue sloughing and minimizes patient discomfort. Thermocouples provide monitoring of tissue temperature, providing the surgeon with the ability to protect the mucosa from inadvertent treatment.

### Coblation<sup>®</sup>

Coblation<sup>®</sup> (Arthrocare Corporation, Sunnyvale, CA) was originally designed for use in orthopedic arthroscopy surgeries, and later modified for use in treatments of snoring and nasal congestion and tonsillar radio-ablation. It is a sophisticated bipolar device that does not require a return pad. The return electrode is within the hand piece and requires saline gel as a conductive medium. It is designed to cut and coagulate as well as ablate the treated tissues on command. The Coblation<sup>®</sup> method replaces the extreme heat of laser surgery and standard electro-surgery with a gentle heating of the tissues, causing physical reduction and shrinkage of the affected site. This is achieved by molecular disintegration via a radio-ablation process most closely resembling that of Excimer lasers. Coblation<sup>®</sup> occurs when the tip of the probe is merged in a saline gel as a conductive medium and placed over the tissue. Upon applying a sufficiently high-voltage difference between the probe and the tissues, the electrically conducting fluid is converted into an ionized vapor layer, or plasma. As a result of the voltage gradient across the plasma layer, charged particles are accelerated toward the tissue. At sufficiently high-voltage gradients, these particles gain adequate energy to cause dissociation of the molecular bonds within tissue structures. This molecular dissociation produces volumetric removal of tissue. Because of the short range of the accelerated particles within the plasma, however, this dissociative process is confined to the surface layer of the target tissue but produces minimal necrosis of collateral tissue. The advantages of this system are its simplicity, short duration of procedures, and effectiveness of its radio-ablation property.

### Ellman<sup>®</sup>, Surgitron<sup>®</sup>, and Ellmad<sup>®</sup>

These systems are basic electrocautery devices that have a less sophisticated hand piece and are the

least studied in the treatment of snoring and sleep apnea. These units are readily available in most surgical practices, easy to use, and are less expensive than the other RF systems. They can also be used to cut, coagulate, and ablate the tissues. The Elman<sup>®</sup> unit has an easily adjustable power range to “dial-in” the level of RF energy suitable for any given procedure. The probe temperature rapidly rises and has the potential for mucosal tissue surface damage. As with all other radio-ablation devices, care must be taken to insert the needle directly into the palatal muscle, because superficial placement leads to mucosal sloughing. Also, because the needle is extended into the palate without direct visualization, it might inadvertently be placed through the palate into the nasopharynx.

### Procedures

There are several procedures that can be performed utilizing any of the above RF devices. For the sake of simplicity, we divide them into four distinct areas: palatal, tonsillar, inferior turbinate, and base-of-tongue radio-ablation. Patient preparation and selection is crucial, as mentioned previously; otherwise, there is the likelihood of treatment failure. In our experience, patients should not be given guarantees that sleep apnea will be totally cured. The procedures may need to be done in repeated sessions, and patients' compliance is an important factor. The anatomy of the structures treated is also a crucial factor. Patients with excessively long and bulky uvulas, or severely hypertrophic soft palates, will not benefit from palatal radio-ablation for an extended time period. Relapse was noted within 2 years of treatment in 60% of our patient population, and the base-of-tongue procedure in our patient population required an average of five treatments. Because of patients' tongue movement or weight gain, the lost tongue bulk returned by 70%. On the other hand, inferior nasal turbinates and tonsillar radio-ablation seem to be much more stable even after a single treatment and at 2 years following the surgery. With this in mind, we will review each procedure and advise our readers to use common sense in careful procedure selection as well as patient selection.

### General preoperative preparation

Prior to the procedure, the patient's medical history is reviewed, and a careful oral and nasal airway assessment is done. Using nasopharyngoscopy, the

nasal cavity and nasopharynx are examined. Oral cavity exams include evaluation of the size and position of the uvula, soft palate, tonsils, and tongue. The patient's occlusion is also recorded. The collar size, body weight, and height are assessed. A snoring questionnaire is given the patient to answer. Patients who utilize any types of anticoagulant including aspirin are asked to stop taking them 5 days prior to surgery, with consent from their primary care physician or cardiologist. Patients at risk of subacute bacterial endocarditis are advised to take the appropriate prophylaxis as recommended by the American Heart Association prior to surgery. Bleeding, infection, prolonged pain, and impaired healing are extremely rare but are the potential complications of these procedures. Generally, pain medications and antibiotic treatment are not required following the procedures with the exception of tonsillar radio-ablation. Nasal regurgitation following this procedure has not been observed as a complication, but as with any palatal surgery, these are potential complications requiring discussion with patients. In our experience, a second procedure has been generally required 4 months following the initial treatment in severe habitual snorers.

### Palatal radio-ablation

The patient is brought into an outpatient office setting while blood pressure and other necessary monitors are attached. The best patient position is sitting in a dental or ENT chair. The Coblation<sup>®</sup> unit does not require any conductive pad, but the other monopolar RF systems require a conductive pad placed on the lower back area. Topical anesthesia (Benzocaine 20%) is applied to the palate, and the patient is asked to swish that around the mouth for 30 seconds. The topical anesthesia should reduce gagging and also any pain at the injection sites. Then, using a 27–30-gauge dental needle, 2.5–3.0 ml of Marcaine (or Xylocaine) is injected at the junction of the hard and soft palate, continuing down and on the sides of the soft palate and the base of the uvula. Unlike the CO<sub>2</sub> laser, the RF procedures require an adequate amount of local anesthesia to avoid discomfort. It also allows tissue expansion and better conduction of current to the area of the internal ablation.

The desired angle of the radiofrequency electrode is 35–45°, depending on the anatomy of the hard and soft palate. Placement of the electrode is extremely important. The electrode is entered high in the soft palate so that the end point of the electrodes is just

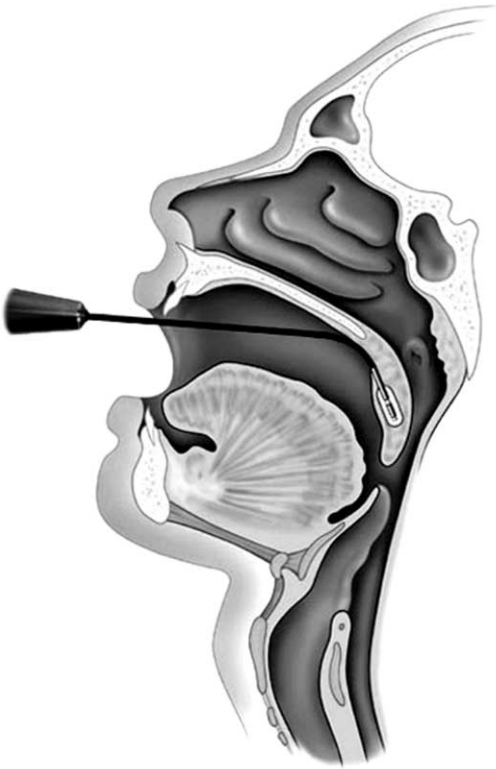


Fig. 3. The radiofrequency electrode is entered high in the soft palate so that the end point of the electrodes is just above the uvula but not in the uvula itself.

above the uvula but not in the uvula itself (Fig. 3). In order to assure the proper placement of the electrode, it can be placed over the soft palate to visualize clinically the exact location and position of the electrode entry point prior to insertion. Care must also be taken to deploy fully the active component of the electrode into the patient's soft palate (Fig. 4).

The Coblation<sup>®</sup> Reflux wand 55 is used for palatal radio-ablation. It comes prebent and only needs to be dipped in saline gel as its conductive medium. The unit is generally set at # 6 and the probe is kept in place for 10–12 seconds. It must not be kept for more than 15 seconds as the surface temperature rises and will cause mucosal erosion and ulceration. The probe temperature reaches approximately 85° C within 10 seconds. The distal end of the probe is the active end, and the proximal end is coated to avoid unwanted mucosal burn. After the single midline lesion is created, two additional sites just lateral to the first lesion are selected, aiming the probe at a 30° angle from the center and toward the side corners of the soft palate (Fig. 5).

The Somnoplasty<sup>®</sup> electrode tip has two sections, each one centimeter in length. The very tip of the electrode is not insulated and is the point where the heat is generated around it. It is maintained at a constant temperature of 85° C. The proximal end of the electrode near the hand piece is coated to avoid thermal burning of the palatal mucosa. As the tip temperature approaches body temperature, impedance should be less than 500 ohms. The generator will automatically shut down if the impedance exceeds 500 ohms, an indication that the electrode is improperly placed or is outside of the tissue. Once the electrode is in the proper position, the foot pedal is depressed and the amount of energy (up to 750 joules) is monitored. After the appropriate amount of energy is delivered, the foot pedal is depressed again to stop the procedure; the electrode is fully retracted and removed from the patient's oral cavity. The lateral electrode placement is generally 10 mm away from the midline on both sides and at the same temper-

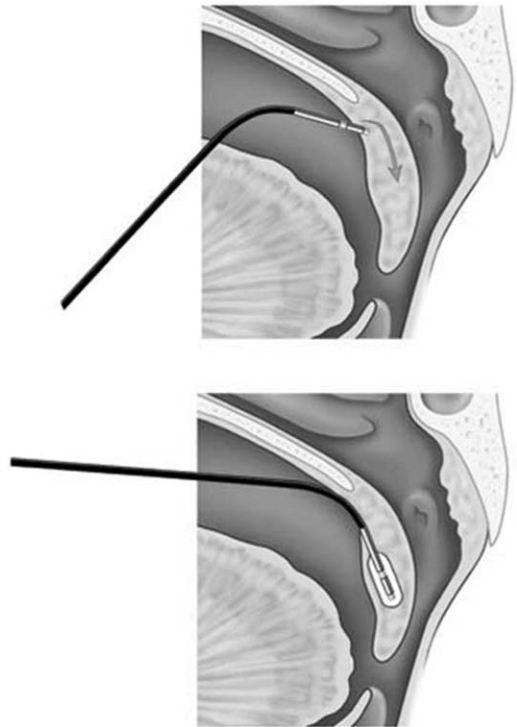


Fig. 4. To ensure proper placement of the radiofrequency electrode, it can be placed over the soft palate to visualize clinically the exact location and position of the electrode entry point prior to insertion. Care must also be taken to deploy the active component of the electrode fully into the patient's soft palate.

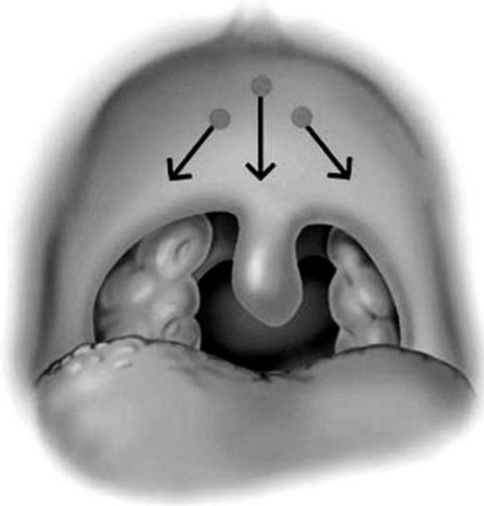


Fig. 5. After the single midline lesion is created, two additional sites just lateral to the first lesion are selected, aiming the probe at a 30° angle from the center and toward the side corners of the soft palate.

ature, but less energy is applied. In our experience, 350 joules is sufficient energy for the lateral lesions. We have experienced even better results by placing two additional far lateral lesions with 300 joules, making a total of five submucosal lesions, 10–15 mm apart from other lesions. Similar procedures have been followed using the Ellman unit, but as mentioned earlier, no extensive research has been published on the use of this system to treat snoring and sleep apnea.

The patient has to be carefully monitored during the first 24 hours following the radio-ablation procedure. No postoperative antibiotics or narcotic pain medication is needed. Normally, patients experience a feeling of fullness in the back of the throat. Patients must be advised to sleep on a reclining chair or with the head elevated at a 45° angle for the first night after surgery.

The soft palate and uvula will become edematous to a variable degree during the first 24–48 hours following the procedure. Usually, a minimal sore throat is noted after the procedure and an over-the-counter pain medication will be sufficient for pain management. The palatal stiffening and volumetric reduction process takes 8–10 weeks and patients notice a change in the intensity of snoring, but not complete elimination of snoring after the first procedure. A second procedure is usually needed in severe snoring patients 4 months after the initial treatment.

### Palatal radio-ablation results

During the past 3 years, 463 patients were treated with radio-ablation using Coblation<sup>®</sup> and Somnoplasty<sup>®</sup>, 271 (58%) male and 192 (42%) female. The men's average collar size was 16, and the average body weight was 175 lbs. The average RDI (respiratory disturbance index) was less than 15 per hour. Not all patients, however, had a sleep study prior to the procedure. One of the most crucial aspects of this procedure was patient selection. The reduction in snoring following the first treatment averaged 30–40%. Improved nasal breathing was reported by 60% of patients. No incidences of major pain, nasal reflux, voice changes, or bleeding were noted. Mucosal blanching was noted in 9% of patients but required no treatment. Patients with three or more lesions had a moderate amount of edema postoperatively; but no treatment was needed. Although patients with the larger number of lesions had more edema immediately after the procedure, they showed much better results in the reduction of snoring and improved breathing 10 weeks following surgery. Patients with a short uvula and floppy soft palate responded the best to this procedure.

During a 3-year follow-up period, 234 (50.5%) patients out of the 463 decided to proceed with the laser-assisted uvulopalatopharyngoplasty (UPPP) because of continued loud snoring. These patients experienced less postoperative pain compared with the group that did not have the radio-ablation procedure done. More instant relief of snoring and significant improvement in nasal breathing and sleeping pattern was achieved, however. One of the major reasons for this change in our treatment modality was our limited knowledge of patient selection for these procedures. If a patient has a very large edematous uvula and excessively hypertrophic soft palate, the laser assisted UPPP is the best treatment in our opinion. Now, our success rate has drastically improved as we only perform palatal radio-ablation on habitual snorers with a very thick soft palate and shorter uvula, and on nonsmokers. The success is higher by a ratio of 3:1 in women versus men. This is mostly because of the anatomical differences we have observed in our female population. Subjectively, the snoring intensity reduction in the successful cases was over 68% on average; improved breathing and sleeping was 72%.

### Tonsillar radio-ablation

Although there has been a significant drop in number of tonsillectomies performed annually in

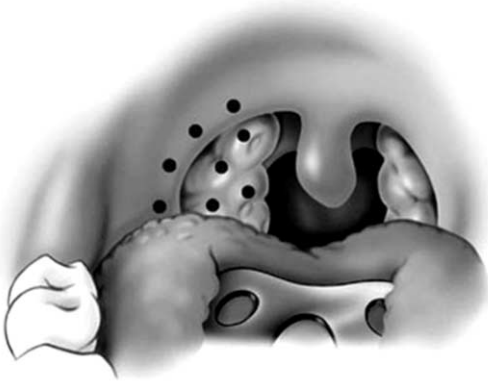


Fig. 6. 2–3 ml local anesthesia is injected into the base of the tonsil, starting in the lateral part of the soft palate and extending to the area of the lateral wall of the pharynx (tonsillar bed). Four radio-ablation sites demonstrated within the tonsillar mass.

children, there are millions of adults that suffer from chronic irritation of the tonsils. Enlarged tonsils is one of the contributing factors in obstructive sleep apnea [42–49]. Many complications have been reported with traditional tonsillectomies, including infection, bleeding, dehydration, angular cheilitis, dysgeusia, pulmonary edema, and loss of time from work or school [50–58]. There have been varieties of methods advocated to resect the tonsils, including use of guillotine, electrocautery, laser, and bipolar scissor [59–62]. In early 1999, the author introduced tonsillar radio-ablation. Hundreds of patients were treated with a similar procedure as described above for palatal radio-ablation. Patients were seen for the treatment of enlarged tonsils because of chronic inflammation, (multiple) tonsillitis, multiple Strep throat infections requiring frequent antibiotic treatment, obstruction of the airway, and snoring problems. Other considerations were chronic tonsillar hyperplasia, with tonsillar crypt causing further accumulation of food and bacteria leading to infection and halitosis. It must be emphasized to patients that RF procedures primarily reduce the tonsillar size and are not designed to remove the tonsils. The debulking process may require repeat sessions later for further reduction of the tonsils.

There are certain precautions that are recommended with this procedure to avoid complications. Starting 2 days prior to the surgery, patients are placed on antibiotic prophylaxis, or IV administration of antibiotics 1 hour prior to surgery for a noninfected and noninflamed tonsil. Chlorhexidine (Peridex<sup>®</sup>) mouth rinse is given several days prior to surgery,

and patients are asked to continue to use it twice daily for at least 2 months postoperatively. Assurance is made to identify and manage any preexisting infection, fever, and sore throat.

The patient is placed in the supine position. Chlorhexidine (Peridex<sup>®</sup>) mouth rinse is given to the patient to keep in the mouth, gargle, and rinse for 1 minute. Marcaine 0.5% (2–3 ml) with 1:200,000 pinephrine is injected into the base of the tonsil starting in the lateral part of the soft palate and extending to the area of the lateral wall of the pharynx (tonsillar bed) (Fig. 6). A plastic double-cheek retractor is placed on the inside of the cheek to give the best visualization and also to protect the patient's lips.

The Coblation<sup>®</sup> unit is set to 6, and the Coblation<sup>®</sup> Reflex wand 55 is used to deliver the appropriate energy. A conductive saline gel is used and applied to the entire uninsulated portion of the probe and is placed on the most prominent surface of the tonsil (Fig. 7). The foot pedal is used for a short period of time to activate the unit and to insert the probe into the tonsil. Superficial heating of the tonsillar mucosa must be avoided to prevent superficial erosion. This procedure is a submucosal procedure and does not include resection of the tonsils. Once the uninsulated probe is completely inserted in a horizontal direction, the energy is applied for approximately 10–15 seconds. The same procedure is repeated two to four additional times on that side. This step is repeated on the other side.

Patients are carefully monitored and evaluated for need of additional procedures. The patients are

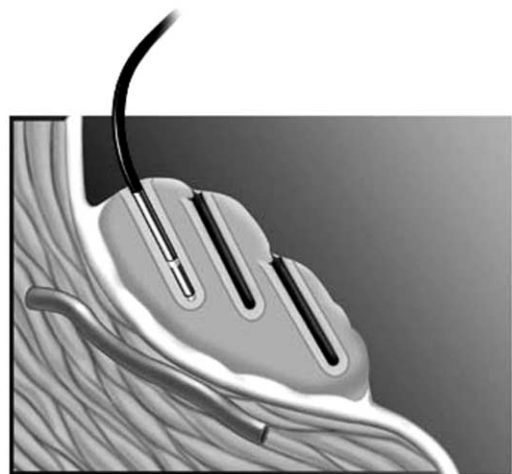


Fig. 7. Tonsillar channeling, with the direction of the probe parallel to the tonsillar artery and away from the surface.



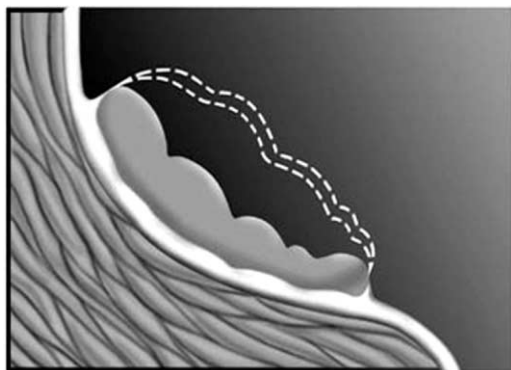


Fig. 8. When properly done, the tonsil volumetric reduction can be up to 60% 10 weeks after the procedure.

advised that the healing process takes up to 8 weeks postoperatively, and additional treatments may be necessary (Fig. 8). These procedures do not remove the tonsils in their entirety nor do they cure sleep apnea. They will not necessarily prevent a common cold or future Strep infections. The patients are discharged after assurances are made that there is no bleeding and the detailed explanation of the postoperative instructions are given. With the exception of the first day after the procedure, patients can eat anything they can tolerate.

Generally, a prophylactic antibiotic, such as Cipro<sup>®</sup> (ciprofloxacin hydrochloride, Bayer Corp, West Haven, CT), Keflex<sup>®</sup> (cephalexin, Dista Products Co., Indianapolis, IN) or Cleocin<sup>®</sup> (clindamycin hydrochloride, Pharmacia & Upjohn, Peapack, NJ), is given to the patient prior to surgery, and patients must continue to take it for a period of 10 days after the procedure. Additionally, they are asked to use a chlorhexidine mouth rinse twice daily for a period of 2 months postoperatively, and a regular mouth wash as often as possible. Pain medication is generally limited to an over-the-counter pain reliever. A sensation of tightness in the back of the throat is normal for the first week after the procedure. Patients are advised to return in 1 week unless there was a need to return earlier and weekly then after.

### Tonsillar radio-ablation results

One-hundred eighty-seven patients, with age range of 13–56 years were treated in an office setting with the Coblation<sup>®</sup> channeling to reduce tonsillar bulk. The group was comprised of 124 (66%) male and 63 (34%) female patients. Thirty-nine percent of patients were treated because of frequent tonsillar

infections, and 61% were treated to alleviate the symptoms of obstructive sleep apnea. Patients were followed from 3 months up to 2 years with an average of 15 months. There was no bleeding during or after the procedures. None of the patients treated developed any infection. The discomforts were minimal and, if needed, patients were advised to take over-the-counter pain relievers. All procedures were done in an office setting with average duration of procedures under 6 minutes. All patients treated reported no voice changes or fluid reflux. The day after the procedures, 100% of patients returned to work or school.

### Nasal radio-ablation

Chronic nasal obstruction, or a stuffy nose, is often caused by enlargement of the inferior nasal turbinates. The nasal turbinates, small, shelf-like structures composed of thin bone, covered by mucous membranes (mucosa), protrude into the nasal airway and help to warm, humidify, and cleanse air as it is inhaled and before it reaches the lungs. Chronic enlargement (hypertrophy) of the turbinates and the accompanying symptom of nasal obstruction affect people throughout the day, as well as during sleep. A chronic stuffy

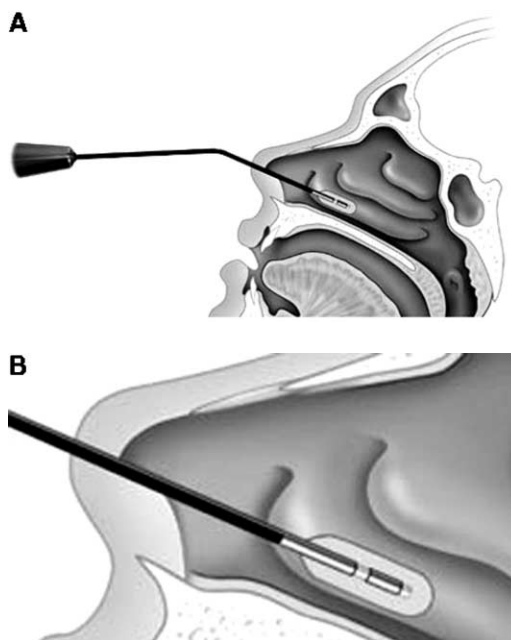


Fig. 9. The correct placement of the radiofrequency probe (A, B) will ensure satisfactory results and prevent complications of bleeding and mucosal ulceration.



Fig. 10. For excessively large turbinates, 2 lesions may be required.

nose can impair normal breathing, force patients to breathe through the mouth, and often affects daily activities. Enlarged turbinates and nasal congestion can also contribute to headaches and sleep disorders such as snoring and obstructive sleep apnea, as the nasal airway is the normal breathing route during sleep. Chronic turbinate hypertrophy is often unresponsive to medical treatment such as nasal sprays; thus, surgical treatment is required. It is commonly



Fig. 11. The nasal turbinates are out-fractured to allow bony expansion at the same time as mucosal radio-ablation. The complete healing process takes 10 weeks.

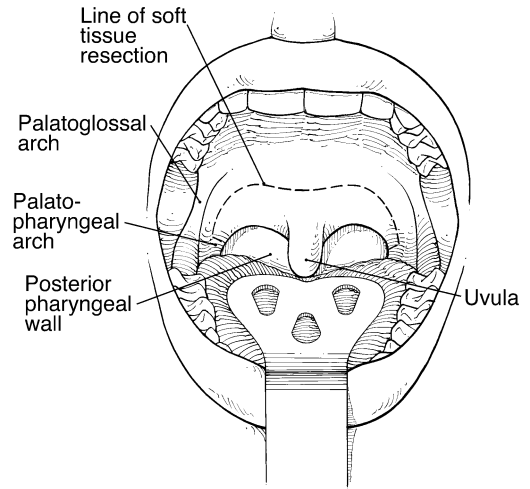


Fig. 12. In uvulopalatopharyngoplasty (UPPP), the incision line must be marked on the soft palate to avoid excessive tissue removal.

associated with rhinitis, the inflammation of the mucous membranes of the nose. When the mucosa becomes inflamed, the blood vessels inside the membrane swell and expand, causing the turbinates to become enlarged and obstructing the flow of air through the nose. Current surgical treatments include nasal septum reconstruction and turbinectomies. They can be associated, however, with lengthy recovery periods, crusting, edema, scab formation, bleeding,

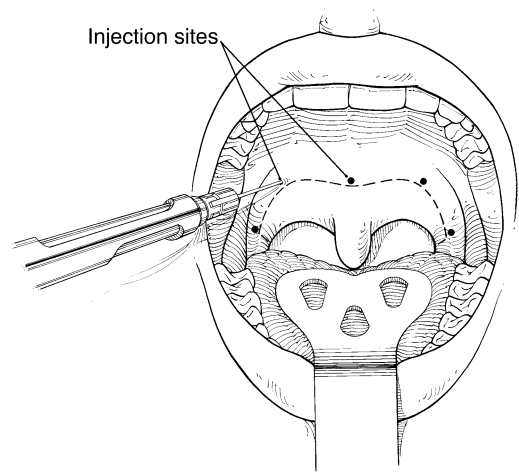


Fig. 13. About 2.5 cc of local anesthesia is infiltrated in the soft palate.

and significant patient discomfort. Additionally, the nose must be packed for several days with gauze containing an antibiotic ointment. Another method for improving nasal obstruction is outward fracture of the turbinate bone(s), which moves the turbinate away from its obstructive position in the airway. This approach, however, does not address the usual source of obstruction; enlarged submucosal tissue and the fractured turbinate often return to the previous position. Bleeding, which can usually be managed by packing the nose, is the greatest risk for patients undergoing standard turbinate resection.

Nasal turbinate radio-ablation is a simple outpatient procedure similar to the other ablation techniques. First, a cotton role soaked with 50% Xylocaine (4%) and 50% with a nasal decongestant is placed in the nasal cavity for a period of 1 minute. Approximately 2 ml of Xylocaine with epinephrine is injected in the inferior turbinate with a 27-gage needle. A reflex wand 45 is used with a setting of 6

for a period of 10 seconds in each nostril (Fig. 9). For excessively large turbinates, two lesions may be required (Fig. 10). Repeated ablation may lead to scab formation, bleeding, and dryness. At the conclusion of this procedure, the nasal turbinates are out-fractured as well. This technique will allow both bony expansions as well as mucosal ablation. The nasal cavity is then packed with a small cotton role soaked with a nasal decongestant. The packing is removed 2 days later by the patient at home. The complete healing process takes 10 weeks (Fig. 11).

#### Nasal radio-ablation results

The author has treated over 1,450 patients for chronic nasal congestion, using either nasal Coblation<sup>®</sup> or Somnoplasty<sup>®</sup>. One of the greatest advantages of Coblation<sup>®</sup> when performing this procedure is that it requires only 10 seconds to do and is least

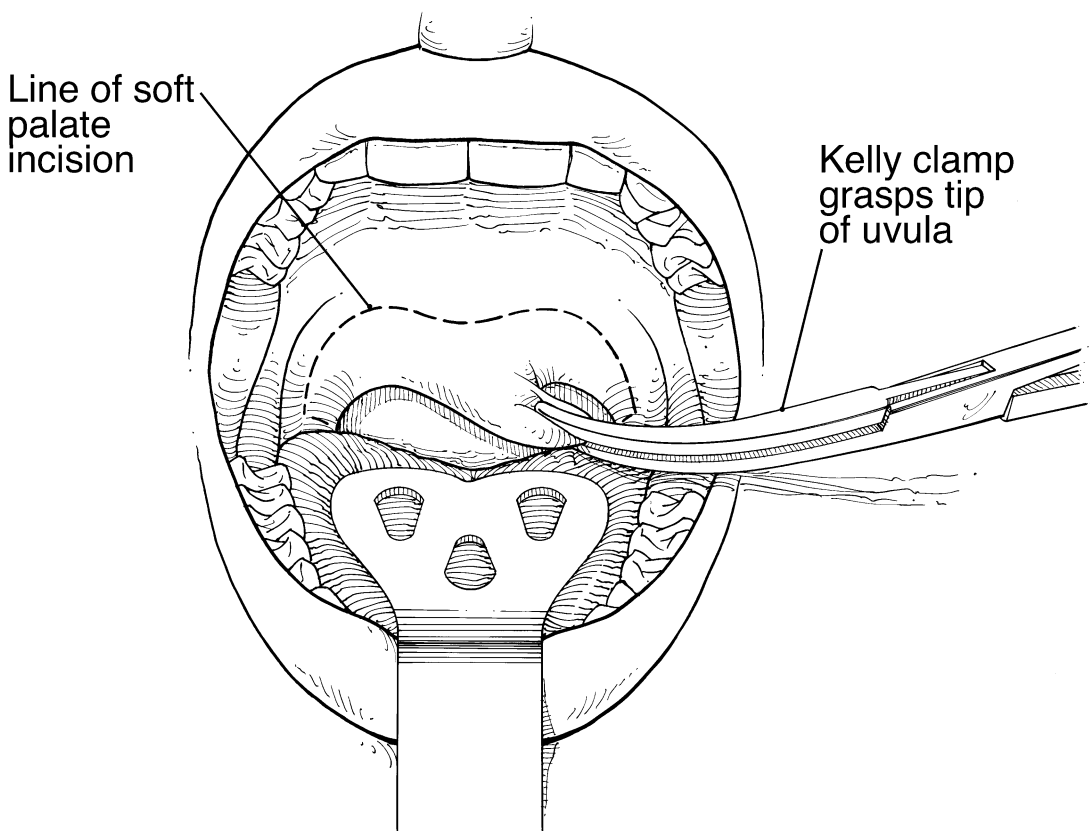


Fig. 14. The uvula is pulled to one side with a long curved hemostat. The ablation is initiated on the opposite side in the anterior and posterior pillar area.

annoying for the patients. On the other hand, the Somnoplasty<sup>®</sup> probe size is smaller and causes less bleeding, and the hand piece is easier to work. The outcome of this procedure seems to be more promising than palatal radio-ablation. Eighty five percent of patients reported improved nasal breathing, less allergies, reduced postnasal drip, and improved sense of smell. There were no cases of infection, only 5% of patients developed nasal bleeding, and only 2 patients needed electrocautery to stop the bleeding. Bleeding may occur up to 5 weeks postoperatively, particularly if there is scab formation and the nasal cavity is dry, and the patient forcefully blows through the nose. It must be stressed to patients that they remove the nasal packing 48 hours after placement, and it must be completely wet. Holding two pieces of ice cubes on either side will prevent bleeding as well.

#### **Laser-assisted uvulopalatopharyngoplasty (LA-UPPP) vs. ultrasound-assisted uvulopalatopharyngoplasty (UA-UPPP)**

One of the latest techniques investigated by the author is use of an ultrasonically activated scalpel to perform UPPP. The device we used was the Harmonic Scalpel<sup>®</sup> (Ethicon, Endo-surgery, Cincinnati, OH), which cuts and coagulates tissues with ultrasonic vibrations at 55.5 kHz. This device is used in laparoscopic and open abdominal surgeries as well as tonsillectomies. The advantages of this system are that it is smoke-free, causes minimal tissue damage without charring, and is an excellent tool to control bleeding without major thermal damage. It is safe for patients and surgeons. Unlike monopolar electro-surgery, there is no flow of electrical current to or

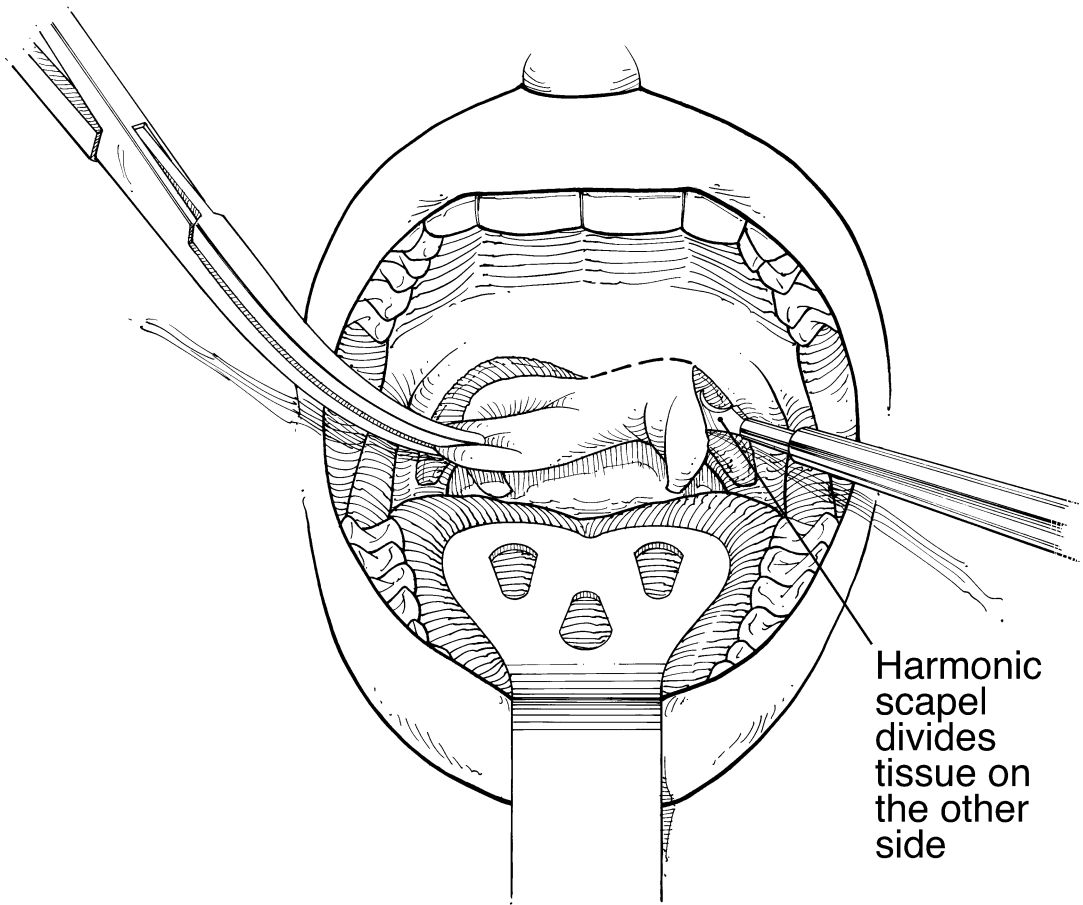


Fig. 15. The ablation is carried up to an area around 5–mm above the lower end of the posterior pillar, and the posterior pillar is then released. The ablation is then carried forward to approximately the base of the uvula.

through the patient. The system is readily available in most operating rooms and can be used as an alternative to electrosurgery or steel blade. The Harmonic Scalpel<sup>®</sup> operates in two power modes, variable and full. The blade vibrates longitudinally, like a reciprocating saw blade. The ultrasonic vibration at the blade enhances its cutting ability, whereas the vibrating blade edge coagulates bleeders as tissues are excised. Hemostasis occurs when tissue couples with the blade. The coupling causes collagen molecules within the tissue to vibrate and become denatured, forming a coagulum.

The basic technique of performing UPPP with the Harmonic Scalpel<sup>®</sup> is very similar to that of laser-assisted UPPP surgery. The technique that we use is as follows. First, the oral and nasal cavities are inspected carefully. An excessively elongated and thick uvula, a floppy soft palate, and enlarged tongue as well as swollen tonsils and nasal turbinate hyper-

plasia are the most common findings in a snoring individual. Lateral pharyngeal walls are also examined for thickness. Seventy-five percent of patients are given mild IV sedation using a combination of Versed<sup>®</sup> (midazolam HCL, Roche Laboratories, Inc. Nutley, NJ), 3 mg; fentanyl, 50 micrograms (1 ml); and Propofol, 30–40 mg, in a running IV. The patient is placed in the supine position in a dental or ENT chair. Routine monitors are applied, and the patient is prepped and draped in the usual manner. Four mg of IV Decadron<sup>®</sup> (Dexamethasone sodium phosphate, Merck & Co. Inc., West Point, PA) is also given. A plastic double-cheek retractor is placed on the inside of the cheek to give the best visualization and also protect the commissures of the lip. The attachment of the levator veli palatini is visualized and marked with a blue marker (Dr. Thompson's) applicator (Fig. 12). This is done for precision and accuracy of the final excision to avoid excessive

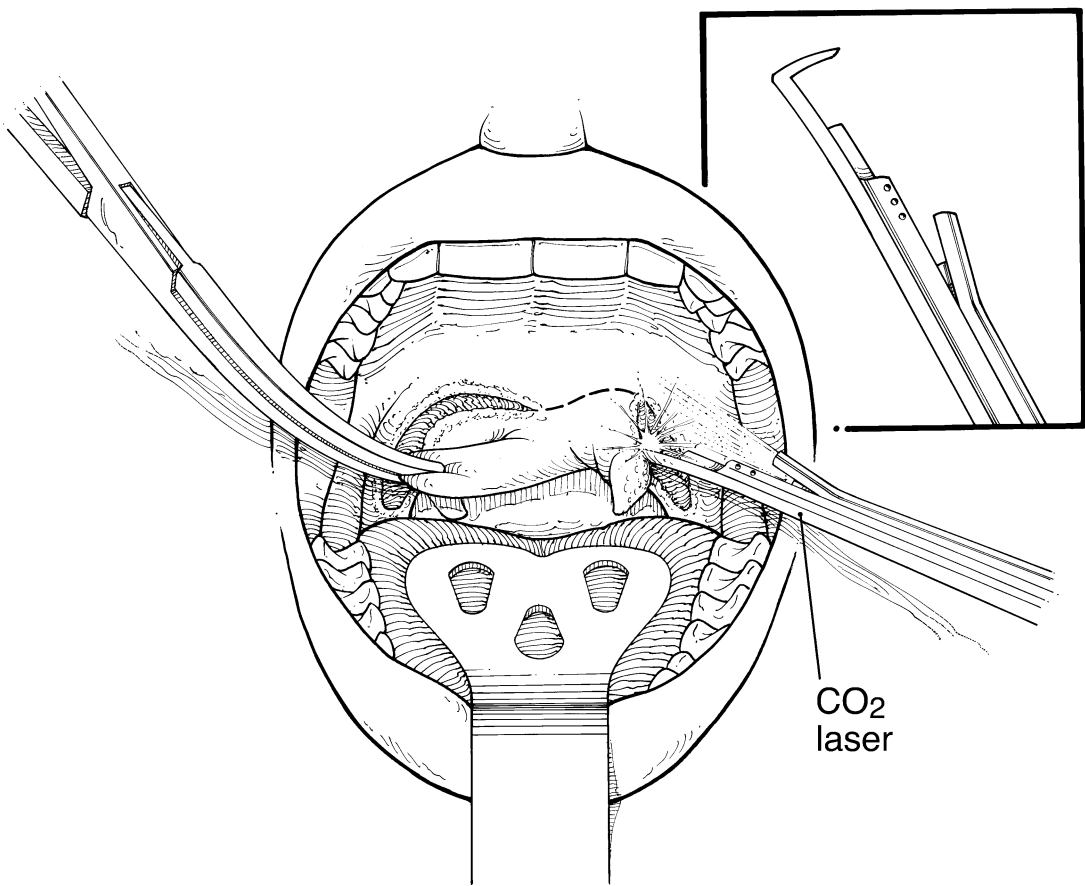


Fig. 16. Laser hand piece has a protective metal shield, preventing the laser from damage collateral tissues. The Harmonic Ultrasound does not have this feature. The surgical technique, however, is the same.

reduction of the tissues. Marcaine 0.5% with 1:200,000 epinephrine is injected in a semicircular fashion following the arch of the soft palate. The total amount of injection should be limited to 1.8–2.5 cc (Fig. 13). Using a #12 Frazier suction tip, the oral cavity is suctioned and the tip of the uvula is identified, lifted with the suction tip, and grabbed with a long-curved hemostat. As the uvula is pulled to one side, the ablation is initiated on the opposite side in the anterior and posterior pillar area (Fig. 14).

The power setting of the unit is put on number 3 in a continuous mode. A gentle touch is sufficient for tissue cutting; a fast side-to-side motion should be avoided because this will cause less effective cutting and more bleeding. As the uvula is held with a curved hemostat, the hand piece is used to start releasing the posterior pillars from the soft palate. The ablation is carried up to an area around 5-mm above the lower end of the posterior pillar, and the posterior pillar is then released. The ablation is then carried forward to

approximately the base of the uvula (Fig. 15). Hence, the hanging part of the uvular is removed, but without total excision of the uvular muscle. Special attention is directed to the anterior and posterior pillars and the soft palate to make sure adequate yet not excessive soft tissue is removed in the fashion similar to the standard laser-assisted UPPP procedure (Fig. 16). If any bleeding is encountered, the flat side of the blade is used to stop the bleeding (Fig. 17). Caution should be taken for the water vapor created by this device. Once the uvula and the desired portion of soft palate are removed, lateral sutures can be placed to expand and secure the soft palate laterally (Fig. 18). There is certainly a learning curve in using this system because, unlike many of the surgical devices used, the extremely fast reciprocating movement of the blade (55,000 rpm) is invisible to the surgeon's eyes, and contacting the tongue or posterior wall of the pharynx could cause complications. In 50% of patients, sutures are not needed, but by placing lateral

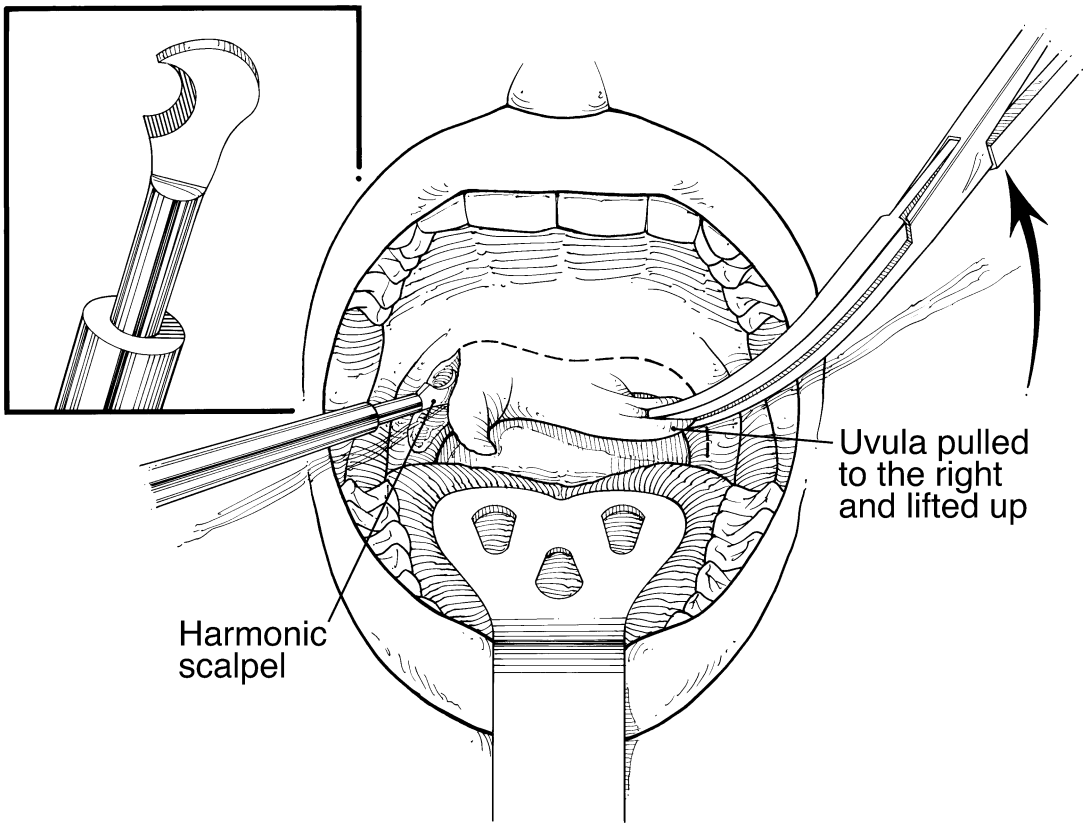


Fig. 17. One of the great features of Harmonic Ultrasound is that, if any bleeding is encountered, the flat side of the blade is used to stop the bleeding.

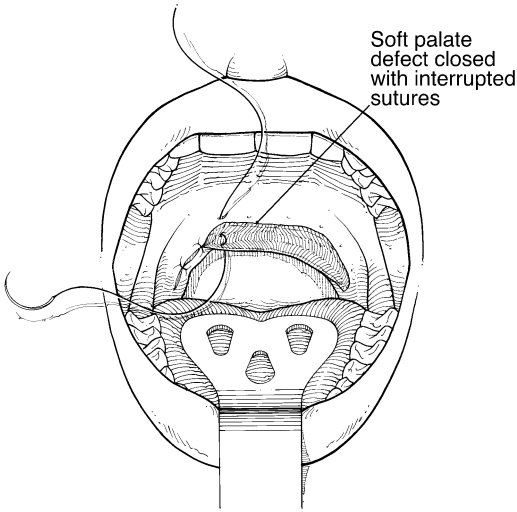


Fig. 18. Once the uvula and the desired portion of soft palate are removed, lateral sutures can be placed to expand and secure the soft palate laterally.

sutures and pulling the unprotected edge of the soft palate to the area just above and lateral to the anterior pillar, the airway is expanded even further (Fig. 19). In our experience, this maneuver has increased the

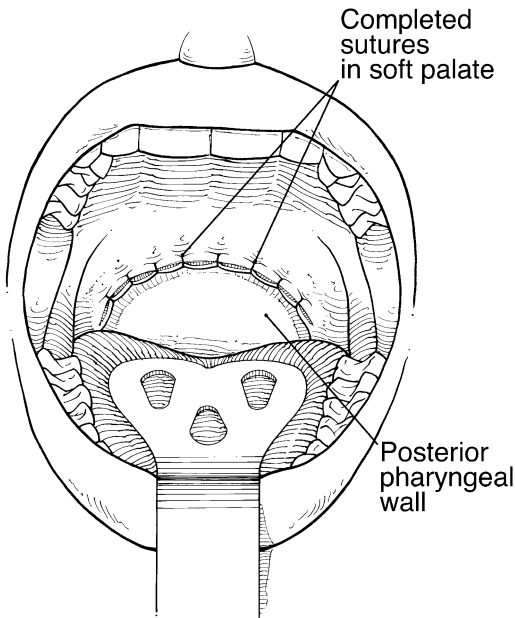


Fig. 19. By placing lateral sutures and pulling the unprotected edge of the soft palate to the area just above and lateral to the anterior pillar, the airway is expanded even further.

success of the operation drastically (Fig. 20). The specimen, including the uvula in its entirety, is sent for histological evaluation. Sleep study is generally recommended prior to and following the completion of the procedure. (In over 5000 of our treated cases, 35% of patients preferred to have a sleep study after the surgery.) The reason for postop study is to make sure there is no residual apnea or to adjust the pressure setting of the CPAP. The patients are advised to follow the instructions of the sleep disorder center for management of any apnea problem. This procedure does not cure the sleep disorder; it helps in reducing snoring by 70% and results in an average reduction of mild sleep apnea by up to 50%. It must be stressed that weight reduction should take place if more effective opening of the airway and increased longevity are desired.

### Ultrasound-assisted UPPP results

Forty-five patients, with age ranging 39–54 years, were treated in an office setting with the Harmonic Scalpel<sup>®</sup> for snoring and mild obstructive sleep apnea. The procedure was fast and easy, with excellent visualization of the surgical field without smoke or char. If any bleeding were encountered, it was simply coagulated with the side of the harmonic blade. The subjective results were similar to laser-assisted UPPP; the snoring sound reduction, on aver-

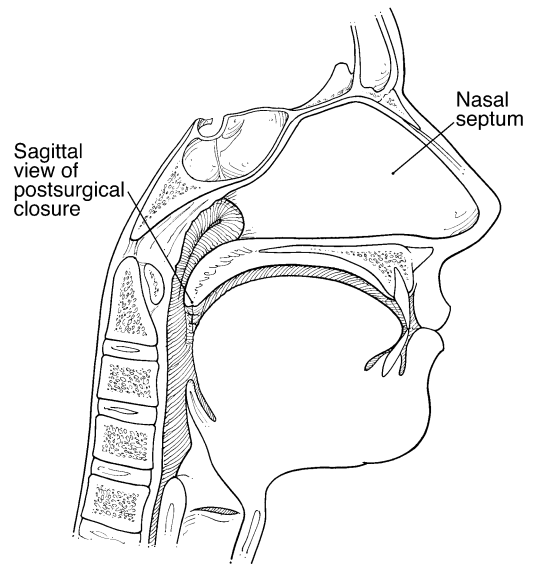


Fig. 20. Suturing of is of particular value when tonsils are surgically removed with the Harmonic Ultrasound.

age, was 75%. Patients reported improved breathing and sleeping, remembering vivid dreams, and experiencing less fatigue during the day and restful sleep without gasping for air. One major difference noted when using this device as compared with CO<sub>2</sub> laser was that Harmonic Ultrasound UPPP patients had less pain postoperatively as compared with those treated with CO<sub>2</sub> laser. The other important issue was the absence of delayed bleeding in ultrasound-treated patients. Overall, ultrasonic UPPP seems to be an effective alternative to expensive laser systems and can deliver the same or even better results when used properly.

## Discussion

Every surgeon should customize treatment of snoring and obstructive sleep apnea in accordance with the patient's anatomy, social and financial concerns, and with his or her own practice parameters. The author's current clinical practice uses several surgical techniques to varying degrees. Each procedure can have a place in the clinical practice of today's practitioners.

Palatal flutter, obstructive tonsils, and, in some cases, nasal obstructions are the major sources of noise production in individuals who suffer from habitual snoring. Many surgical procedures have been advocated. They include traditional UPPP performed in the hospital under general anesthesia. It has about a 5–10% chance of major side effects, such as voice change, bleeding, and nasal reflux. In addition to all its limitations, UPPP is expensive. Costs vary widely among institutions, but the procedure, the anesthesia, and one night of postoperative monitoring in an intensive care unit can cost in excess of \$10,600. Laser-assisted uvulopalatoplasty (LAUP) is the staged laser treatment of snoring. There were major drawbacks with LAUP including lack of effectiveness for addressing obstructive sleep apnea [63–65]. Patients did not favor this multiple stage technique. Our observation was that because LAUP did not remove the soft palatal tissues on either sides of the uvula, creating a narrow lumen effect and thus making the task of breathing even harder. The modification presented in this article eliminates the hospital visit and is done in an office setting. The author has treated over 5,000 patients by laser-assisted uvulopalatopharyngoplasty (LA-UPPP) without any major complications [66]. This technique is easy, safe, and effective in treating snoring and mild sleep apnea. It has far fewer complications or side effects when compared with traditional UPPP. In our patients

treated by LA-UPPP or UA-UPPP none have developed voice change or food or fluid reflux problems, and overall complications were very rare. The major drawback of these procedures is 2 weeks of intense pain, which are well controlled by pain medications. We routinely have covered our patients with antibiotics, and no one has developed postoperative infections directly related to the surgical site. The use of ultrasound in treating snoring and obstructive sleep apnea is promising; however, further studies are necessary.

In search of a painless procedure to treat snoring and mild obstructive sleep apnea, radio-ablation procedures were introduced to this field. The concept is that using the mild heat of radio-ablation devices reduces tissue volume, stiffens the soft palate, and, at the same time, reduces morbidity and mortality. Palatal radio-ablation procedures are safe and easy to perform, but they are only effective in patients with a small uvula and very thick soft palate. Repeated procedures may be needed. Nasal and tonsillar radio-ablations are far easier and less invasive than traditional surgeries. Tongue-based radio-ablation has potential risks for developing abscess and relapse.

We have not mentioned every procedure that is used to treat snoring and obstructive sleep apnea. Uvulectomy has been attempted, but its short-term results were poorer than those of other procedures [67]. In addition, other procedures are under investigation, including ones that induce palatal stiffening by injecting sclerosing agents into palatal tissue [68,69]. This procedure and its long-term benefits are highly questionable. Each of these procedures has its own advantages and limitations; and which procedure is the best treatment for excessive snoring and obstructive sleep apnea is a controversial issue. We present our experience with each of these procedures, along with a thorough review of the literature, to help practitioners determine which one is best for their individual patients.

## References

- [1] Scharf MB. Sleep disorders. In: Paparella MM, Shumrick DA, Gluckman JL, Meyerhoff WL, editors. *Otolaryngology*, ed 3. Philadelphia: Harcourt Brace Jovanovich, Inc; 1991. p. 865–877.
- [2] Sher AE. Obstructive sleep apnea syndrome: a complex disorder of the upper airway. *Otolaryngol Clin N Am* 1990;23:593–608.
- [3] Thawley SE. Sleep apnea disorders. In: Cummings CE, editor. *Otolaryngology—head and neck surgery*, ed 2. St. Louis: Mosby Year Book, Inc; 1993:1392–1413.
- [4] Westbrook PR. Sleep disorders and upper airway ob-



- struction in adults. *Otolaryngol Clin N Am* 1990;23:727–43.
- [5] Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. *N Engl J Med* 1993;328:1230–5.
- [6] Poole MD. Obstructive sleep apnea. In: Bailey BJ, editor. *Head & neck surgery—otolaryngology*. Philadelphia: JB Lippincott Co; 1993:598–611.
- [7] Koopman CF, Moran WB. Sleep apnea—an historical perspective. *Otolaryngol Clin North Am* 1990;23:571–75.
- [8] Koopman CF, Moran WB. Surgical management of obstructive sleep apnea. *Otolaryngol Clin N Am* 1990;23:787–808.
- [9] Kuna ST, Sant’Ambrogio G. Pathophysiology of upper airway closure during sleep. *JAMA* 1991;266:1384–9.
- [10] Lojander J, Maasilta P, Partinen M, Brander P, Salmi T, Lehtonen H. Nasal-CPAP, surgery, and conservative management for treatment of obstructive sleep apnea syndrome. *Chest* 1996;110:114–9.
- [11] Fairbanks DN. Snoring: surgical vs. nonsurgical management. *Laryngoscope* 1984;94:1188–92.
- [12] Hudgel DW, Hendricks C. Palate and hypopharynx—sites of inspiratory narrowing of the upper airway during sleep. *Am Rev Resp.Dis* 1988;138:1542–7.
- [13] Borowiecki B, Pollack CP, Weitzman ED, Rakoff S, Imperato J. Fibro-optic study of pharyngeal airway during sleep in patients with hypersomnia obstructive sleep-apnea syndrome. *Laryngoscope* 1978;88:1310–3.
- [14] Isono S, Remmers JE, Tanaka A, Sho Y, Sato J, Nishino T. Anatomy of pharynx in patients with obstructive sleep apnea and in normal subjects. *J Appl Physiol* 1997;82(4):1319–26.
- [15] Smithson AJ, White JE, Griffiths CJ, et al. Comparison of methods for assessing snoring. *Clin Otolaryngol* 1995;20:443–7.
- [16] Hoffstein V, Mateika S, Anderson D. Snoring: is it in the ear of the beholder? *Sleep* 1994;17:522–6.
- [17] Strelzow VV, Blanks RHI, Basile A, Strelzow AE. Cephalometric airway analysis in obstructive sleep apnea syndrome. *Laryngoscope* 1988;98:1149–58.
- [18] Mathru M, Esch O, Lang J, Herbert ME, Chaljub G, Goodacre B, et al. Magnetic resonance imaging of the upper airway. *Anesthesiology* 1996;84:273–9.
- [19] Riley RW, Powell NB. Maxillofacial surgery and obstructive sleep apnea syndrome. *Otolaryngol Clin N Am* 1990;23:809–26.
- [20] Riley RW, Powell NB, Guilleminault C. Inferior sagittal osteotomy of the mandible with hyoid myotomy-suspension: a new procedure for obstructive sleep apnea. *Otolaryngol Head Neck Surg* 1986;94:589–93.
- [21] Riley RW, Powell NB, Guilleminault C. Obstructive sleep apnea syndrome: a review of 306 consecutively treated surgical patients. *Otolaryngol Head Neck Surg* 1993;108:117–25.
- [22] D’Arsonval A. Action physiologique des courants alternatifs. *Comput.Read. Biol. Paris* 1891;43:283.
- [23] Riviere AJ. Action des courants de haute fréquence et des effluents du résonateur osseux sur tumeurs malignes. *J de Med Interne* 1900;4:776.
- [24] McLean AJ. The Bovie electro surgical current generator: some underlying principles and results. *Arch Surg* 1929;18:1863.
- [25] Fox J. Experimental relationship of RF electrical current and lesion size for application to percutaneous cardotomy. *J Neurosurg* 1970;33:415.
- [26] Organ LW. Electro physiology. Principle of RF lesion making. *Appl Neurophysiology* 1976;39:69.
- [27] Dickson JA. Calderwood sic.: temperature range and selective sensitivity of tumors to hyperthermia: a critical review. *Ann N Y Acad Sci* 1980;335:180.
- [28] Pawl PP. Percutaneous RF electro coagulation in the control of chronic pain. *Surg Clin North Am* 1975;55:167.
- [29] Collings CW. Transurethral electro surgery for relief of prostate. *Obstruction J. Urol.* 1932;28:529.
- [30] Huang SKS et al. Closed chest catheter desiccation of the atrioventricular junction using RF energy. *J Am Coll Cardiol.* 1987;9:349–58.
- [31] Honig NM. The mechanism of cutting in electro-surgery. *IEEE Trans Biomed Eng* 1975;22:58–62.
- [32] Sherk HH, et al. The effects of lasers and electrosurgical devices on human meniscal tissue. *Clinical Orthopedics and Related Research* 1995;310:14–20.
- [33] Mankin HJ, Mow VC, Buckwalter JA, et al. Form and function of articular cartilage. IN: Simon ST, editor. *Rosemont, IL: Orthopedic Basic Science. American Academy of Orthopedic Surgery*; 1994. p 1–44.
- [34] Kim HK, Moran ME, Salter RB. The potential for regeneration of articular cartilage in defects created by chondral shaving and subchondral abrasion. An experimental investigation in rabbits. *J Bone Joint Surg.* 1991;73:1301–15.
- [35] Altman RD, Kates J, Chun LE, et al. Preliminary observations of chondral abrasion in a canine model. *Ann Rheum Dis* 1992;51:1056–62.
- [36] Ellis P, Frowcs-Williams J, Shneersan J. Surgical relief of snoring due to palatal flutter: a preliminary report. *Annals of the Royal College of Surgeons of England.* 1993;75:286–290.
- [37] Whinney DJ, Williamson PA, Bicknel PG. Punctate diathermy of the soft palate: a new approach in the surgical management of snoring. *Journal of Laryngology and Otology* 1995;109:849–52.
- [38] Powell NB. Radio frequency volumetric reduction of the tongue. a porcine pilot study for the treatment of obstructive sleep apnea syndrome. *Chest* 1997;134:1355.
- [39] Madani M. Radiofrequency: a new treatment for nasal congestion and snoring. *Otolaryngology- Head and Neck Surgery* 2000;123(2):192.
- [40] Madani M. Nasal turbinate somnoplasty utilization of radiofrequency to treat chronic nasal obstruction and congestion. *British Journal of Oral and Maxillofacial Surgery* 1999;37(5):414–15.
- [41] Madani M. Tonsillar ablation, using radiofrequency for

- reduction of tonsils. *Otolaryngology–Head and Neck Surgery* 2000;123(2):163.
- [42] Pizzuto MP, Brodsky L, Duffy L, Gendler J, Nauenberg E. A comparison of microbipolar cautery dissection to hot knife and cold knife cautery tonsillectomy. *Int J Pediatr Otorhinolaryngol* 2000; 52(3):239–46.
- [43] Sandooja D, Sachedeva OP, Gulati SP, Kakkar V, Sachdeva A. Effect of adeno-tonsillectomy on hearing threshold and middle ear pressure. *Indian J Pediatr* 1995; 62(5):583–85.
- [44] Faulconbridge RV, Fowler S, Horrocks J, Topham JH. Comparative audit of tonsillectomy. *Clin Otolaryngol*. 2000; 25(2):110–7.
- [45] Nowlin JH. Coagulation studies prior to tonsillectomy: an unsettled and unsettling issue. *Arch Otolaryngol Head Neck Surg* 2000;126(5):687.
- [46] Hartnick CJ, Ruben RJ. Preoperative coagulation studies prior to tonsillectomy. *Arch Otolaryngol Head Neck Surg* 2000;126(5):684–6.
- [47] Limb R, Walkley I. Adult day case tonsillectomy. *Anaesth Intensive Care*. 2000;28(2):229–30.
- [48] Goldstein NA, Post JC, Rosenfeld RM, Campbell TF. Impact of tonsillectomy and adenoidectomy on child behavior. *Arch Otolaryngol Head Neck Surg* 2000;126(4):494–98.
- [49] Marshall T. How many tonsillectomies are based on evidence from randomized controlled trials? *Br J Gen Pract* 1999;49:487–8.
- [50] Panarese A, Clarke RW, Yardley MP. Early post-operative morbidity following tonsillectomy in children: implications for day surgery. *J Laryngol Otol* 1999; 113(12):1089–91.
- [51] Raut VV, Yung MW. Peritonsillar abscess: the rationale for interval tonsillectomy. *Ear Nose Throat J* 2000; 79(3):206–9.
- [52] Motamed M, Djazaeri B, Marks R. Acute pulmonary edema complicating adenotonsillectomy for obstructive sleep apnea. *Int J Clin Pract* 1999;53(3):230–1.
- [53] Hultcrantz E, Linder A, Markstrom A. Tonsillectomy - tonsillotomy?—A randomized study comparing post-operative pain and long-term effects. *Int J Pediatr Otorhinolaryngol* 1999;51:171–6.
- [54] Colreavy MP, Nanan D, Benamer M, Donnelly M, Blaney AW, O'Dwyer TP, et al. Antibiotic prophylaxis post-tonsillotomy: is it of benefit? *Int J Pediatr Otorhinolaryngol* 1999;50:15–22.
- [55] Boelen-van der Loo WJ, Scheffer E, de Haan RJ, de Groot CJ. Clinimetric evaluation of the pain observation scale for young children in children aged between 1 and 4 years after ear, nose, and throat surgery. *J Dev Behav Pediatr* 1999;20(4):222–7.
- [56] Anand VT, Phillips JJ, Allen D, Joynson DH, Fielder HM. A study of postoperative fever following pediatric tonsillectomy. *Clin Otolaryngol* 1999;24(4):360–4.
- [57] England RJ, Lau M, Ell SR. Angular cheilitis after tonsillectomy. *Clin Otolaryngol* 1999;24(4):277–9.
- [58] Drake-Lee A, Harris S. Day case tonsillectomy: what is the risk and where is the economic benefit? *Clin Otolaryngol* 1999;24(4):247–51.
- [59] Homer JJ, Williams BT, Semple P, Swanepoel A, Knight LC. Tonsillectomy by guillotine is less painful than dissection. *Int J Pediatr Otorhinolaryngol* 2000;52(1):25–9.
- [60] Linder A, Markstrom A, Hultcrantz E. Using the carbon dioxide laser for tonsillotomy in children. *Int J Pediatr Otorhinolaryngol* 1999;Oct:31–6.
- [61] Sood S, Strachan DR. Surgical workshop: bipolar scissor tonsillectomy. *Clin Otolaryngol* 1999;24:465.
- [62] Saito T, Honda N, Saito H. Advantage and disadvantage of KTP-532 laser tonsillectomy compared with conventional method. *Auris Nasus Larynx* 1999;26(4):447–452.
- [63] Lauretano AM, Khosla RK, Richardson G, et al. Efficacy of laser-assisted uvulopalatoplasty. *Lasers Surg Med* 1997;21:109–16.
- [64] Standards of Practice Committee of the American Sleep Disorders Association. Practice parameter for the use of laser-assisted uvulopalatoplasty. *Sleep* 1994;17:744–8.
- [65] Finkelstein Y, Shapiro-Feinberg M, Stein G, Ophir D. Uvulopalatopharyngoplasty vs. laser-assisted uvulopalatoplasty: anatomical considerations. *Arch Otolaryngol Head Neck Surg* 1997;123:265–76.
- [66] Madani M. Effectiveness of UPPP assisted with laser for treatment of snoring and mild to moderate sleep apnea. *Sleep* 1998;21:322.
- [67] Ariyasu L, Young G, Spinelli F. Uvulectomy in the office setting. *Ear Nose Throat J* 1995;74:721–2.
- [68] Mair EA, Day RH. Cautery-assisted palatal stiffening operation. *Otolaryngology - Head and Neck Surgery* 2000;122:547–56.
- [69] Madani M. Radiofrequency somnoplasty: a new treatment for snoring and sleep apnea. *Int J Oral and Maxillofac Surg* 1999;28(1): 108–109.