



Reviews

Treatment of Patients With Simple Snoring

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ABSTRACT

Management of snoring is part of the treatment offered to patients with obstructive sleep apnea syndrome. In patients who do not have this syndrome, however, snoring should be treated according to the severity of the condition. General or specific therapeutic measures should be applied to snorers that have concomitant cardiovascular disease or unrefreshing sleep and in cases in which an individual's snoring disturbs his/her partner's sleep. The present review examines the treatments currently available for snorers and the current state of knowledge regarding each option. It will also focus on the possible indications of these treatments and evaluate their effectiveness.

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Tratamiento del paciente con ronquidos simples

RESUMEN

En los pacientes afectados de síndrome de apneas obstructivas durante el sueño, el tratamiento del ronquido forma parte de las medidas terapéuticas que se han de aplicar para tratar el síndrome. Sin embargo, en los sujetos que roncan y no presentan dicho síndrome el tratamiento del ronquido debería ir en relación con su intensidad. Se recomienda iniciar las medidas terapéuticas generales y específicas en los pacientes roncadores cuyo sueño no sea reparador, impida el descanso de la pareja o bien se acompañe de otras enfermedades cardiovasculares. En la presente revisión se hace una relación de las diferentes opciones terapéuticas y del estado actual del conocimiento de cada una de ellas, incidiendo en sus posibles indicaciones y en el control de la eficacia de las mismas.

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General Considerations

Although there is no set definition of snoring, it is generally accepted that the term refers to a breathing sound that occurs during nighttime or daytime sleep and can be inspiratory, expiratory, or both.¹ The American Academy of Sleep Medicine (AASM), formerly known as the American Sleep Disorders Association, defines snoring as a sound originating from the upper airway that does not occur with apnea or hypoventilation, and that is caused by vibrations of

different tissues in the pharynx.² Snoring can be classified as mild, moderate, or severe in accordance with factors such as frequency, body position, and degree of social disruption. According to the AASM, simple snoring does not interfere with the patient's sleep or cause excessive daytime sleepiness. A person that snores for more than 10% to 20% of a monitored night or more than 3 or 4 nights a week should be classified a habitual snorer.³ Lee et al⁴ proposed a limit of 15 snores an hour measured using acoustic methods.

An association between snoring and obstructive sleep apnea syndrome (OSAS) was first observed in 1975, by Lugaresi et al,⁵ who were also the first to develop a sleep continuity model to monitor developments in OSAS. Based on data from epidemiologic studies performed between 1980 and 2007, the mean prevalence of snoring in the general population is approximately 32% in men and 21% in

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women. In Spain, according to Zamarron,⁶ 49.2% of middle-aged men and 42% of middle-aged women snore; the corresponding figures for men and women under 45 years of age are 34.1% and 27.15%, respectively. For individuals aged between 30 and 70 years, Duran et al⁷ calculated a prevalence of 46% and 25% for men and women, respectively, and Marin et al⁸ reported figures of 63.7% and 36.3%. The prevalence of habitual snoring in children ranges from 3% to 15%.^{9,10}

There is an important likely relationship between snoring and arterial hypertension. Marin et al,¹¹ for example, observed arterial hypertension in 17.7% of snorers compared to 14.8% of nonsnorers and 30% of patients with OSAS. Nieto et al,¹² in turn, on studying a large population of adults, found that, following adjustment for body mass index (BMI) and anthropometric body fat variables, patients with simple snoring had an odds ratio of 1.11 for hypertension. In a study of 2266 individuals, Duran et al⁷ found a corresponding odds ratio of 2.47 for individuals with an apnea-hypopnea index (AHI) of less than 5 following adjustment for BMI, neck circumference, and alcohol and tobacco use. Finally, Peppard et al¹³ reported an odds ratio of 1.66 for the development of arterial hypertension within 4 years in snorers with an AHI of less than 5.

Interestingly, no association was found between cardiovascular mortality and snoring in a 10-year follow-up study,¹⁴ and Marin et al¹¹ failed to find evidence of increased risk of cardiovascular death in snorers with an AHI of less than 5.

Weight gain has the greatest influence on the development of snoring in the long term,^{15,16} indicating that weight control is important in snorers.

In conclusion, simple snoring is very common in the general population, affecting both children and adults. It can occur in association with other disorders such as OSAS, hypertension, and cardiovascular disease. It can even have medicolegal consequences in which physicians may be required to provide an expert opinion. For all these reasons, we believe that the study and treatment of snoring should form part of specific health care programs implemented within a specialized medical-surgical unit.

An initial approach to the management of simple snoring should target the patients' bedpartners, as it is they who most often complain. The interview should aim to collect information on snoring frequency (how often does the patient snore during the night?), sensitivity to position (in what position does he/she snore most: supine, side, or prone?), the existence of apnea episodes, time since onset (how long has he/she been snoring?), and effect on sleep (number of nights a week they sleep separately or the partner cannot sleep). Snorers' most common complaints are related to disruption of their partner's sleep, poor sleep quality, and sore throat.¹⁷

The objective measurement of snoring is based on analysis of snoring sounds, which are recorded directly using specific acoustic systems or indirectly using conventional or respiratory polygraphy. Unfortunately, these measurement techniques are not standardized and therefore the boundaries for action on the basis of test results are not clear.

Finally, all snorers with nonrestorative sleep, hypertension, cardiovascular disease, and socially disruptive sleep should be studied, and depending on the severity of the snoring, treated.

There are 3 major treatment categories¹⁸:

1. Patient-administered interventions such as weight loss, adjustment of sleeping position, reduction of medication that can interfere with sleep, use of nasal dilators or lubricants, and reduced consumption of alcohol and tobacco.
2. Nonsurgical interventions such as use of tongue-retaining devices, mandibular advancement devices, and continuous positive airway pressure (CPAP).
3. Surgical interventions such as nasal surgery, palatal surgery, and bariatric surgery.

General Measures

Certain general factors such as the consumption of alcohol, tobacco, or medication, can predispose certain individuals to the development of snoring.

Drinking alcohol can cause snoring in people who do not usually snore¹⁹ and exacerbate it in those who do.^{20,21} Alcohol causes oropharyngeal muscle hypotonia,²² increased upper airway resistance,²¹ and blunted arousal response. Wu et al²³ recently found that the injection of 70% ethanol into the pharyngeal mucosa caused local tissue contraction, suggesting its indication for the treatment of conditions such as uvuloptosis (elongated uvula) and hypertrophy of the palate mucosa. Alcohol has not been seen to cause changes in snoring intensity in tests performed using audio recordings.²⁴ The effect of alcohol on snoring is generally related to dose and individual susceptibility. Its effects can occur after the first intake, are more pronounced in the early hours, and, depending on the amount consumed, can last for hours. Susceptible individuals should be advised to limit their alcohol intake in the evenings.

Smoking is another risk factor for the development of habitual snoring in adults, even after adjustment for family and genetic factors.²⁵⁻²⁸ Proposed mechanisms include inflammation, edema, and increased upper airway resistance. A recent study by Virkkula et al²⁸ of 44 patients that underwent nasal surgery indicated that smokers had higher nasal resistance and louder snoring than nonsmokers. Baik et al²⁹ reported an association between the development of snoring and chronic bronchitis symptoms in 5015 middle-aged men and women studied over 4 years. Their findings corroborate those of Bloom et al³⁰ and Kauffman et al,³¹ who, in the 1980s, found an association between the number of cigarettes smoked and snoring intensity. In conclusion, both alcohol and tobacco use should be avoided, not only because they influence snoring but also, and more importantly, because they can cause serious health problems. Sedatives and muscle relaxants can also increase snoring severity, which is why snorers are generally advised to avoid these drugs.

It has been demonstrated that obese individuals have a 5-fold increased risk of snoring compared to nonobese individuals^{15,16,30,32,33} and that obesity is an independent risk factor for the development of snoring.³¹ Furthermore, weight loss alone has been seen to reduce or eliminate snoring in individuals with sleep apnea and simple snoring,³⁴ and small weight changes have been linked to increases and decreases in sleep-disordered breathing and snoring index.^{35,36} The amount of weight a patient needs to lose to stop snoring cannot be predicted but according to a study by Braver and Block,³⁷ an average weight loss of 3 kg may be sufficient to reduce the number of snores per hour by half. Patients that lose around 7.5 kg tend to stop snoring. Despite the effectiveness of this measure, most obese patients find it difficult to follow a diet, and only half of them manage to lose weight.³⁵ This is why other, controllable, weight-loss treatments are applied. In a study of 123 patients who underwent bariatric surgery, the percentage of habitual snorers decreased from 82% to 14% a year after surgery, with the mean BMI decreasing from 46 to 35 kg/m².³⁸ In a more recent study of 1728 patients who underwent bariatric surgery, Grunstein et al³⁹ observed a reduction in the persistence of snoring, the presence of sleep apnea, and the sensation of sleepiness in those who underwent surgery at 2-year follow-up compared to those who did not undergo the intervention. The prevalence of snoring after bariatric surgery is similar to that observed in members of the general population in the normal weight range.⁴⁰ Dietary measures should be widely applied in view of the serious consequences associated with obesity, namely an increased risk of cardiovascular death.^{11,41}

Studies conducted in adults have shown that the exercise and weight loss have concomitant benefits.^{42,43} Nonetheless, a recent study by Davis et al,⁴⁴ performed in 100 children aged 7 to 11 years,

found that snoring but not BMI decreased in patients that did varying degrees of exercise (20 to 40 minutes a day) over 10 to 15 weeks.

The development of snoring depends on sleeping position. Most bedpartners report that the intensity and even the number of snores increases in the supine position. Indeed, changing from sleeping on one's side to the supine position can increase snoring loudness by 8 dB.^{45,46} Pasterkamp et al⁴⁷ demonstrated that sleeping in the supine position increased tracheal sound intensity in patients with OSAS. Snoring duration has also been found to change in the lateral position in some but not all studies.^{37,46,48} Although sleeping on one's side has no effect on snoring frequency, that fact that it reduces the intensity of the snores explains why this position is perceived positively by patients' bedpartners.^{48,49} Methods that discourage patients from sleeping in the supine position, such as the tennis ball technique, have been successful in reducing snoring intensity.⁵⁰ Because, however, the majority of patients who try this method complain about discomfort, an alternative method consisting of a linen vest with a cylindrical piece of hard foam on the rear was recently introduced.^{51,52} This new method reduced snoring duration by an average of approximately 60 minutes in 26 snorers studied.

Nasal Dilators

Increased nasal airflow resistance is a common problem in patients with nasal mucosal congestion due to disorders such as allergic rhinitis. Nasal obstruction has been associated with an increase in the number of snores per night⁵³ and epidemiologic studies have confirmed that patients with chronic rhinitis snore more often.^{54,55}

Nasal dilators work by reducing nasal resistance and increasing airflow during wakefulness and sleep.⁵⁶⁻⁵⁸ The nostril is the narrowest point of the respiratory system and is responsible for over 50% of total nasal respiratory resistance.^{59,60} According to Poiseuille's law governing laminar flow, a small increase in the diameter of the nasal cavity will reduce the pressure gradient in equal flow conditions.⁶¹

Nasal dilators can be either internal (Nozovent)⁶¹⁻⁶³ or external (Breathe Right).⁶⁴⁻⁶⁶ Nozovent, which was invented by Petruson, is a silicone strip that dilates the front part of the nose. It can be used for a period of 3 months, after which it should be replaced. Results for Nozovent are varied. Petruson,⁶³ for example, found that Nozovent improved snoring tolerance levels in patients' bedpartners after a week. Hoffstein et al,⁶² in turn, did not observe changes in snoring characteristics in patients without nasal obstruction but they did find a reduction in snoring during deep sleep. Metes et al⁶⁷ failed to observe changes in snoring intensity, duration, or frequency in 72 snorers treated with Nozovent. More recent studies have reported benefits for Nozovent, including a perceived reduction in snoring for 50% of partners, less morning and daytime tiredness in 40% of snorers,⁶⁸ and improved mouth dryness.⁶⁹ Löth and Petruson⁶¹ also found that snorers treated with Nozovent for 6 months complained less of morning tiredness.

The single-use external dilator Breathe Right (CNS, Minneapolis, Minnesota, USA), invented by Bruce Johnson, is an adhesive elastic band which, when applied to the front part of the nose, dilates the nostrils by pulling out on the bridge of the nose. This system was widely used by athletes after the Atlanta Olympic Games. Nepemuceno et al⁷⁰ found that Breathe Right reduced total inspiratory resistance in just 4 of 7 subjects, although more recently, Wong and Johnson⁷¹ observed an average reduction in nasal resistance of approximately 0.5 cmH₂O/L/s during inhalation and exhalation. Acoustic rhinomanometry has also shown Breathe Right to improve nasal volume.^{57,72} The results of studies using audio recordings are contradictory. Liistro et al⁶⁴ and Djupesland et al⁷³ found no changes in snoring index or intensity, while other authors have found Breathe Right to reduce snoring intensity⁷⁴ and

frequency.^{65,74,75} Subjective sleepiness measured using tools such as the Epworth Sleepiness Scale and the Stanford Sleepiness Scale has also been seen to improve after 2 weeks' treatment.^{75,76} Disadvantages of nasal dilators include skin irritation and loss of strips during sleep. While Breathe Right is more expensive than Nozovent and can only be used once, it has been more widely accepted, and this is particularly true for the transparent version.

Nasal Lubricants

Oil-based sprays, which lubricate and strengthen oropharyngeal soft tissue, have been used in both animals⁷⁷ and humans.⁷⁸ Hoffstein et al⁷⁹ found that the inhalation of phosphocholinamin reduced snoring in a group of 6 snorers. Nasal lubricants such as Good Night or Snoreless, in contrast, have not been found to lead to significant outcomes in randomized controlled trials.^{80,81} One of these studies, which analyzed 20 snorers using acoustic methods and a specific questionnaire, presented varying results, with a 30% improvement in snoring index and benefits reported by bedpartners in 37% of cases.⁸⁰ The second study, which involved 36 snorers, found a subjective improvement in snoring in just 8 cases.⁸¹ In other words, some of the bedpartners of patients using nasal lubricants noticed an improvement in snoring. It is possible that this treatment reduces the frequency of snoring in patients in whom it has been effective. It is likely that the lubricant works by reducing the surface tension of the upper airway mucosa, facilitating the opening of this airway and reducing the frequency of snoring.

Combined Use of Nasal Decongestants, Dilators, and Other Treatments

Braver et al⁴⁸ found that the combined use of oxymetazoline and positional therapy did not change snoring frequency measured with a substernal microphone. When combined with weight loss, however, the treatment led to a reduction in the number of snores per hour.³⁷

A new treatment involving the injection of 20 U of botulinum toxin type A into the levator veli palatini muscle was recently found to reduce snoring frequency from 119.9 snores per hour to 11.4 in a study of 8 patients.⁸² No variations in snoring intensity were observed. The unilateral paralysis effect on the palate caused by botulinum toxin might reduce snoring frequency by preventing the palate from moving with the force of the air that causes the vibration responsible for snoring. Although the results are just preliminary, the effects of botulinum toxin are believed to last for 3 to 6 months.⁸³

Oral Devices

Oral devices have been used to manage snoring since the end of the 19th century. The technology has improved greatly since then, however, and oral devices are currently among the treatments of choice for patients with simple snoring.⁸⁴

Oral devices are classified into 3 categories: a) soft palate elevation devices, which are no longer used; b) tongue-retaining devices, which are only used in certain dental applications; and c) mandibular advancement systems, which are the most common devices. Mandibular advancement systems work by moving the jaw forward, minimizing or preventing upper airway collapse.

Several studies have shown that mandibular advancement increases the cross-sectional area of the airway and reduces pharyngeal collapsibility.^{85,86} Other effects include tongue base elevation; increased palatoglossus muscle tension; forward displacement of the soft palate; decompression of the tissue around the pharynx, permitting greater pharyngeal expansion; greater stability of lateral pharyngeal wall through tension applied to the pterygomandibular raphe, which is attached to the pharyngeal

constrictors; and separation of the tonsillar pillars formed by the palatoglossus and palatopharyngeal muscles, providing even greater stability to the lateral pharyngeal wall.⁸⁷ In the majority of randomized controlled studies involving a placebo, mandibular advancement has been seen to greatly reduce snoring^{88,89} assessed using acoustic analysis and subjective measurements.⁸⁴ The system has also been seen to reduce snoring intensity by up to 69%.⁹⁰

Mandibular advancement devices, which can be made of different materials such as acrylic, cover the top and bottom part of the teeth. They are connected using plates and screws or plastic bands of varying lengths. Most systems allow the mouth to open and the jaw to make lateral movements. At the beginning, they are adjusted to 75% of the maximum possible protrusion, after which the jaw is progressively advanced, in steps of 1 mm, until the symptoms are resolved.⁹¹

Several adverse effects have been reported for mandibular advancement devices, including chewing difficulty, excessive salivation, dry mouth, occlusion, tooth, tongue, and jaw discomfort, headache, and masseter muscle pain. Oral devices should be inserted by experienced odontologists.

The prolonged use of mandibular advancement systems may lead to dental changes that are well tolerated, including a reduction in overjet (vertical overlap) from 3.8 mm to 2.4 mm and in overbite (horizontal overlap) from 4.0 mm to 2.7 mm.^{84,92,93} Furthermore, acceptance rates range from 30% to 64%, and 82% of bedpartners have noted benefits.⁹⁴⁻⁹⁶ Discomfort and lack of perceived benefits are the 2 main reasons why users discontinue treatment; between 56% and 68% of patients have been found to be still using oral devices after 3 years.⁸⁴ A recent randomized controlled trial found mandibular advancement devices to be more effective than CPAP in snorers.⁹⁷

Tongue-retaining devices are similar but incorporate an anterior plastic bulb that applies suction pressure to hold the tongue in a forward position, thus conferring stability to the jaw and the hyoid bone and preventing the tongue from collapsing.⁹⁸ They help to reduce snoring by reducing oropharyngeal and hypopharyngeal obstruction.^{99,100}

CPAP Treatment

CPAP eliminates snoring, as Berry and Block¹⁰¹ observed in 5 patients with simple snoring. It also improves sleep quality by reducing arousals, sleep fragmentation,¹⁰²⁻¹⁰⁴ and daytime sleepiness.¹⁰⁵ Unfortunately, despite its effectiveness, many patients stop using it for use it for fewer than 3 hours a night,¹⁰⁵ leading to the reversal of improvements in snoring intensity and frequency within just a few days.¹⁰⁶ The lack of acceptance of CPAP among snorers is attributed more to a lack of noticeable benefits by patients than to its adverse effects.³⁴ Its use is possibly greatest in patients with excessive daytime tiredness.¹⁰⁷ Pressure levels used to eliminate apnea and snoring are very similar, with snoring disappearing when the pressure used to treat apnea is increased by 2 cmH₂O.¹⁰⁸ This would explain why, on occasions, although CPAP succeeds in eliminating the apnea, the patient's snoring continues to disturb their partner.¹⁰⁷

Surgical Treatment

Surgical treatment of snoring consists of operating on the nose, mouth, and jaw using techniques involving scalpels, laser, and microwaves. The general recommendation is that snoring should not be surgically treated in patients with a BMI of over 28 kg/m².¹⁰⁹ General results indicate that surgery succeeds in eliminating snoring in 75% to 100% of the cases in the short term.³⁴

Surgery for snoring is performed via nasal and pharyngeal interventions.

Nasal Surgery

Snorers tend to complain of nasal obstruction. Nasal airway obstruction increases negative intrathoracic pressures, which, in turn, cause an increase in upper airway turbulence, which would cause the airway walls to vibrate and produce snoring. A study of 6000 patients with chronic rhinitis conducted by the University of Wisconsin in the United States of America found that those with nighttime symptoms of nasal obstruction were more likely to snore.⁵⁴ It is currently impossible to predict response to nasal surgery. None of the techniques used, including radiography and rhinomanometry, are sufficiently reliable predictors. Nasal surgery is, thus, reserved for snorers with anatomic nasal obstruction due to conditions such as nasal septum deviation and nasal polyps.

Pharyngeal Surgery

This is the most common surgical method used to treat snoring.

Conventional Uvulopalatopharyngoplasty. This technique was first described by Ikematus,¹¹⁰ who partially removed the uvula, the soft palate, and the mucosa of the posterior faucial pillars. Later, in 1981, Fujita et al¹¹¹ applied a modified version of the procedure to treat patients with OSAS. Preliminary studies showed that the technique was effective in 75% to 100% of patients.¹¹²⁻¹¹⁵ According to Hoffstein,¹⁰⁷ UPPP was effective in 84% of 3730 snorers between 1981 and 1999 but there was enormous variability in outcomes, with success rates ranging from 18% to 100%, and only 20% of patients reporting that their snoring had disappeared completely. Subjective improvement in snoring in the 6 months after UPPP is reported in 18% to 65% of cases, with numbers increasing after 6 months but decreasing (to 50%) in the long term.^{114,116} There is, thus, no guarantee of the long-term effectiveness of UPPP for treating snoring.

There are no clear preoperative criteria for predicting the success of UPPP. None of the procedures used during either wakefulness (cephalometry, computed tomography fat measurement, magnetic resonance imaging, snoring simulation via the Müller maneuver) or sleep (nasendoscopy, upper airway pressure measurements, image processing) are recommended for systematic preoperative assessment.¹⁰⁷ Using the automated SNAP system (Snap Laboratories, Glenview, Illinois, USA)^{117,118} to analyze snoring in a group of 18 patients, Weingarten and Ravi¹¹⁸ found a reduction in mean snoring intensity, a reduction in snoring from the veli palatini muscle in 30% of patients, and a mean increase in frequency of 90 Hz (104.3-198.6 Hz). The snoring index (292-307 snores/h) did not vary. The researchers also reported a subjective improvement in symptoms. Jones et al¹¹⁹ observed frequency band changes of between 0 Hz and 250 Hz, although these were short lived and the 35 patients studied continued to snore. We can conclude from the results of the above 2 studies that UPPP reduces the soft palate vibration responsible for lower-frequency snoring and that palatal surgery reduces the energy content within this lower frequency band. Indeed, it has been seen that soft palatal flapping tremor generates complex periodic waves between 64 Hz and 135 Hz.¹²⁰ According to a recent study by Brietzke and Mair,¹²¹ patients with palatal flutter of greater than 68% experienced subjective improvement with palatal stiffening. Unfortunately, UPPP does not reduce the total number of snores, but it does reduce snoring intensity, at least in a study by Weingarten et al.¹¹⁸ In a study performed using ambient audio testing, the 1 percentile sound level (L₁) was the parameter that most closely related acoustic intensity with improvement in symptoms after UPPP.¹²²

The most common adverse effects after surgery are pain, mucus hypersecretion, throat irritation, nasal regurgitation, nasal voice,¹²³ bleeding, and dysphagia. Most of these problems resolve within several weeks. Longer-term complications such as velopharyngeal incompetence and qualitative voice changes are less common but

have been found in 10% to 57% of patients, as has long-term nasal regurgitation (24% of patients).¹²⁴

Laser-assisted uvulopalatopharyngoplasty. Laser-assisted uvulopalatopharyngoplasty (LAUP), which was introduced by Kaman¹²⁵ in 1990, consists of removing part of the soft palate and uvula, just as in conventional UPPP but with the aid of a laser. Two vertical incisions are made at the base of the soft palate, on either side of the uvula, and the tip of the uvula is vaporized. The treated area heals, stiffening the tissue and conferring greater rigidity to the palate and reducing its ability to vibrate. Subjective improvement in snoring is attributed to the deposition of type I collagen in the scar that forms with healing.¹²⁶ The procedure is performed under local anesthesia during several visits separated by intervals of 2 to 3 weeks. Assessment of effectiveness is subjective. The main advantage of LAUP over conventional UPPP is that it does not require admission to hospital as general anesthesia is not necessary. The main adverse effect is pain, which is intense but lasts for only a few weeks¹²⁷; complications are less common than with UPPP. LAUP is also associated with a lower frequency of nasal regurgitation and postoperative bleeding and does not affect taste or smell.^{128,129} As with UPPP, positive outcomes become less evident with time, with success rates for reduced snoring of 82% after the operation, 68% after 6 months, and 55% after 18 to 24 months.¹³⁰⁻¹³² This reduction in effectiveness has partly been attributed to weight gain.¹³³ The Standards of Practice Committee of the AASM concluded in 2000 that the results for LAUP were not convincing.¹³⁴ They stated that there was excessive variability between studies (with reported snoring improvement rates ranging from 43% to 90%) due to different measurement systems, follow-up periods, and sample sizes. Reda et al^{135,136} confirmed the poor correlation between reduced snoring intensity and subjective improvement, although they observed that a 4-dB reduction in snoring intensity was maintained after 5 years. Larrosa et al,¹³⁷ for their part, were unable to detect objective changes after 3 months in 25 patients with simple snoring. Namyslowski and Scierski,¹³⁸ in contrast, using the PolyMESAM measurement system (Medizine-Technologie, Martinsried, Germany), found that LAUP eliminated or reduced snoring in 18 habitual snorers. In another study by MacDonald et al,¹³⁹ cephalometry, rhinometry, snoring sound, and BMI parameters did not predict LAUP success rates.

Recent attempts have been made to determine whether snoring is mostly caused by vibration of the soft palate as it is palatal snoring that responds best to surgery of the palate (UPPP or LAUP). Al-Jassim and Lesser¹⁴⁰ used injection snoreplasty to differentiate snoring due to palatal flutter from other types of snoring, and found that 40 of the 60 patients treated showed improvement in snoring. Eleven of these underwent UPPP or LAUP and they all improved.

Radiofrequency Pharyngeal Surgery. Radiofrequency was introduced by Powell et al^{141,142} as a surgical technique for snoring in 1997. The technique consists of delivering thermal energy by radiofrequency to the soft parts of the pharynx, the adenoids, the uvula, and the base of the tongue. The procedure yielded promising results at the beginning, by reducing the volume and increasing the stiffness of the pharynx, reducing wall vibration, and increasing resistance to collapse. The results showed a subjective reduction in snoring of 30% to 55% in 2 to 3 months after the operation. Fourteen months later, however, 40% to 55% of the patients had started snoring again,¹⁴³⁻¹⁴⁵ and in some cases, a second session was required. According to Mandani,¹⁴⁵ laser treatment is the best option for patients with a large, swollen uvula, and hypertrophy of the soft palate. Patients with a short uvula and a flexible soft palate respond better to radiofrequency ablation. Radiofrequency seems to be most effective in women, probably due to anatomic differences between men and women.¹⁴⁵

Palatal Implants. Palatal implants were introduced in 2002 as a treatment for snoring.¹⁴⁶ The standard procedure consists of

placing 3 polyethylene terephthalate palatal implants measuring 18 × 1.8 mm (Pillar, Restore Medical Incorporated, St. Paul, Minnesota, USA) on the soft palate under local anesthesia in a single session. A distance of 2 mm between each implant is recommended and at least 25 mm should be left between the soft palate and the base of the uvula. Additional implants (up to 4 or 5 if necessary) are placed on different days.¹⁴⁷ According to subjective measures, snoring intensity decreases but relapse occurs in 50% of cases.¹⁴⁵ Other recent studies have noted improved snoring in patients who received implants after failed UPPP.¹⁴⁷⁻¹⁴⁹ Nordgard et al¹⁵⁰ and Maurer et al¹⁵¹ observed reduced snoring intensity in palatal implant patients after 1-year follow-up, although some of these patients had partial extrusions.¹⁵² Finally, using the SNAP system, Ho et al¹⁴⁶ observed a reduction in snoring intensity (measured in dB) in 3 of 5 patients that had received palatal implants.

Snoreplasty. This technique consists of injecting the patient with a sclerotherapy agent, sodium tetradecyl sulphate (Soltradelcol, Elkins-Sinn, Inc. Cherry Hill, New Jersey, USA), under local anesthesia. The solution is injected into the middle of the soft palate and an additional 2 injections are performed on either side of the midline. Scarring forms with a few weeks, stiffening the palate and reducing vibration.^{154,155} Sodium tetradecyl sulphate is typically administered intravenously to harden the veins of the legs. Its local use can have secondary effects such as tissue necrosis in the injection area and allergic reactions. Four deaths have been reported with the use of sodium tetradecyl sulphate. Other products that have been used in the past are ethanol and doxycycline.¹⁵⁶ The effects are temporary and the technique has been used to select patients likely to benefit from UPPP or LAUP.^{140,145}

A more recent development is sling snoreplasty, which consists of suturing 3 portions of soft palate in a triangular, tetragonal, or pentagonal shape.¹⁵⁷ The aim is to push the soft palate upwards and outwards, thereby widening the oral cavity and nasopharyngeal space. The suture includes muscle, enhancing the stiffness of the structure even further.¹⁵⁷

Other Surgical Procedures

Adenoidectomy is reserved for cases when there is upper airway obstruction, chronic infection that does not respond to medical treatment or drainage, a need for total resection for diagnostic purposes, the presence of 3 or more infections a year, or persistent foul breath due to chronic adenoiditis despite antibiotic treatment. It has been shown that removal of the adenoids does not reduce the likelihood of developing snoring¹⁵⁸ but that it is a 100% effective measure in patients with airway obstruction, with a relapse rate of 0%.¹⁴⁵

In summary, simple snoring can be treated with general measures including weight control and loss, avoidance of detrimental habits and toxic substances that interfere with sleep, modification of sleeping position, and physical exercise. The use of nasal dilators and lubricants can be effective in some cases. Oral devices are effective, but patients may often stop using them due to a perceived lack of benefits. Surgical techniques are effective in the short term but in many cases the benefits are not maintained. Finally, novel procedures such as palatal implants, snoreplasty, and botulinum toxin therapy offer promising results, but their effectiveness must be confirmed in larger population samples. The availability of new snoring detection, analysis, and quantification equipment will allow an objective evaluation of different treatment options in patients with simple snoring.¹⁵⁹⁻¹⁶¹

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