

Radiofrequency Is a Safe and Effective Treatment of Turbinate Hypertrophy

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Objective: To evaluate the safety and efficacy of radiofrequency for reduction of inferior turbinate volume. **Study Design:** Prospective before-and-after trial. **Methods:** Fourteen patients complaining of chronic nasal obstruction and failing to respond to medical treatment were prospectively enrolled. All patients presented with inferior turbinate hypertrophy and no septal deformity. Radiofrequency inferior turbinate tissue reduction with three punctures in each turbinate (mean energy/puncture: 342 ± 36 J, mean duration: 69 ± 17 s, plateau tissue temperature: $75 \pm 6.4^\circ\text{C}$). Patients were evaluated before and on days 3, 7, and 60 after intervention. **Results:** No postoperative pain or complications were reported. Evaluation of nasal obstruction, quantified by visual analogue scale, showed a significant decrease of day time and nighttime obstruction after surgery. Acoustic rhinometry measurements showed that turbinate hypertrophy was significantly reduced in the sitting and supine positions on day 60 after surgery. Saccharin transit times decreased significantly on day 60 compared with preoperative measurements. Ciliary beat frequency, measured in vitro in nasal epithelial cells sampled from the inferior turbinate by brushing, was not significantly different before surgery and on day 60 after surgery. In the same samples, ciliated cells were the most abundant epithelial cell type before and after surgery, although in five cases, moderate numbers of squamous cells were detected on either day 7 or day 60 after surgery. **Conclusion:** Radiofrequency is a safe surgical procedure capable of reducing turbinate volume without altering the nasal mucosa, and causing minimal discomfort for the patient.

Key Words: Rhinitis, radiofrequency, turbinate hypertrophy, nasal epithelium, ciliary beating.

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INTRODUCTION

Chronic nasal obstruction is a frequent symptom that can result either from nasal and septal deformities or from mucosal disease associated with turbinate hypertrophy. Turbinate hypertrophy is observed during various types of rhinitis including allergic perennial rhinitis and vasomotor dysregulation. Although medical treatments (i.e., local corticosteroids, antihistamines, decongestants) are frequently effective to restore comfortable nasal breathing, nasal obstruction is sometimes only slightly improved, leading some patients to increase their consumption of local decongestants with a high risk of iatrogenic effects. In these cases, surgical reduction of inferior turbinates can be proposed. Various techniques are currently performed to reduce the volume of the mucosal (and sometimes bony) tissues of the inferior turbinates: total or partial turbinectomy; turbinoplasty, laser-assisted turbinoplasty; and chemical, electrical, or diathermy coagulation or even cryotherapy.¹ Although most of these techniques provide satisfactory results for a more or less long period, adverse events are frequently observed after such treatments: postoperative bleeding; crusting, sometimes associated with a foul odor; pain; hyposmia; and synechia.^{1–4} Most of these postoperative problems result from local wound healing because each of these techniques is responsible for major mucosal lesions, especially of the surface epithelium. Postoperative nasal packing and serum lavages, although unpleasant, are often useful to prevent these adverse events.

Radiofrequency tissue reduction, which has been successfully used in neurosurgery, urology, and cardiology for many years, has been demonstrated recently to be safe and effective for tissue reduction of the soft palate in snorers.⁵ This technique is based on the local submucosal delivery of low-frequency energy by means of a specifically adapted electrode. This energy induces ion agitation within the tissue, which increases the local temperature and causes a thermal lesion that should occur in the deep mucosa without damaging the surface. The healing process secondarily induces fibrosis with wound contraction

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leading to tissue volume reduction. Therefore, radiofrequency could be useful for turbinate volume reduction because, theoretically, it should help to treat nasal obstruction without the disadvantages of the other techniques. The aim of the present pilot study was to evaluate the safety, efficacy, and functional tolerance of radiofrequency reduction of inferior turbinate volume to treat chronic nasal obstruction.

PATIENTS AND METHODS

Fourteen patients reporting chronic nasal obstruction and failing to respond to medical treatment were prospectively enrolled in this study. All patients gave their written informed consent before being included in this study, which was approved by the Henri Mondor Ethics Committee. All patients presented with inferior turbinate hypertrophy and little or no septal deformity on endoscopic examination. Patients with previous turbinate surgery or nasal radiotherapy, nasal polyps or tumor, or recurrent sinusitis were excluded. Additional exclusion criteria included blood coagulation disorder, oral steroid use, heart failure, or poorly controlled hypertension.

Surgical Procedure

All surgical procedures were performed by the same surgeon in an outpatient facility. Radiofrequency energy was delivered by an S215 power generator (Somnus Medical Technology, Inc., Sunnyvale, CA) at a frequency of 465 kHz, using a handled 20-mm needle electrode consisting of an insulated proximal part, a 10-mm active part, and two thermocouples (one at the tip and one at the junction between the active and insulated parts of the electrode). Temperature, energy, time and tissue impedance were monitored throughout each procedure; the maximum values of temperature, power, local energy, and duration of the procedure were set preoperatively to 85°C, 8 W, 350 J, and 2.5 minutes, respectively. All procedures were performed with the patient under local anesthesia using 5% lidocaine (5 puffs per nostril) and 3 mL 1% lidocaine (injected into each turbinate). The radiofrequency electrode was inserted under endoscopic guidance, and the energy was delivered successively to three different sites of each turbinate (to the upper and lower area of the anterior portion and to the middle portion). After treatment, patients returned to work or home with no medication apart from paracetamol in the case of pain. Patients were not allowed to take any corticosteroids, antihistamines, or decongestants during the follow-up period.

Symptom Evaluation

Each patient used a 10-cm visual analogue scale (VAS) to grade daytime and night-time nasal obstruction preoperatively (day 0) and on days 3, 7, and 60 after surgery. On the same days, the patients also evaluated other nasal symptoms (rhinorrhea, postnasal drip, nasal pruritus, sneezing, rhinolalia, hyposmia), and turbinate edema, abundance of secretions, and crusts were graded by the surgeon using a four-point scale (0, absent; 1, mild; 2, moderate; 3, severe). Postoperative pain was evaluated using a visual analogue scale, and patients were asked to report the use of analgesic medications.

Acoustic Rhinometry

The equipment used for acoustic rhinometry measurements has been described previously.⁶ In brief, a wave tube with an inner diameter of 1.6 cm was prepared to accommodate two flush-mounted pressure transducers (8510 B piezoresistive pressure transducers (Endevco, Le Pré-St-Gervais, France) placed 7 cm apart. The acoustic impulse was generated by a small horn

driver (motor 25 W, Bouyer, Montauban, France) connected to the wave tube by a side port located approximately 6 cm from the first microphone. A nosepiece was attached to the extremity of the wave tube so that the distance between the second microphone and the nose was 7 cm. The other end of the wave tube was open to the atmosphere.

Acoustic measurements were performed during a breathing pause with the patients in the sitting position. The free end of the nosepiece was inserted a few millimeters into the nostril. The angle of the incident acoustic impulse was 45° with respect to a line joining the base of the piriform aperture of the nose to the tragus. The cross-sectional area obtained was the mean of three runs, each consisting of 10 repeated impulses.

Cross-sectional areas of the nasal cavity were inferred from the impulse response as a function of the longitudinal axis. The incremental step between two measurements was 0.4 cm, as previously described.⁶ The first centimeters of the curve reflected the dimensions of the nosepiece. This technique was able to detect three successive local minima on the acoustic area-distance curve in the region considered to be representative of the nasal cavity (i.e., 7 to 8 cm beyond the nosepiece). The cross-sectional area of the nasal cavity at the level of the head of the turbinate (corresponding to the first notch on the area-distance curve) and the nasal fossa volumes (total volume calculated between the end of the nosepiece notch and the choanal notch; "turbinate" volume calculated between the turbinate head notch and the choanal notch) were measured by acoustic rhinometry.⁷

Measurements were performed preoperatively and 60 days postoperatively with the patient in the sitting and then the supine position, and after local administration of decongestants.

Nasal Epithelial Function

Nasal epithelial function was evaluated preoperatively and on days 7 and 60 after surgery in vivo by the saccharin test and in vitro by ciliary beat frequency measurements. Saccharin transit time was measured after depositing 15 mg of 2% sodium saccharin including 1% indigotin on the floor of the nasal fossa at the level of the head of the inferior turbinate. The patient was asked to swallow every 30 seconds until he or she tasted the saccharin, at which time the test was stopped and the transit was confirmed by direct viewing of the blue color of indigotin on the pharyngeal wall. Superficial nasal mucosal cells were collected by brushing from the middle portion of the inferior turbinate under local anesthesia (5% lidocaine with naphazoline, Roger Bellon, France). Cells were immediately suspended in 5 mL tissue culture medium IP 199 (Eurobio, France), and ciliary beat frequency was measured using a stroboscopic light microscope at room temperature on at least three separate areas and expressed in hertz as the mean of the various measurements. Cytological analysis was also performed after cytocentrifugation (Cytospin Shandon II, 500 rpm for 10 min) and May-Grünwald-Giemsa staining to evaluate nasal epithelial morphological appearance according to the abundance of the various epithelial cell types (ciliated, secretory, basal, and squamous cells) and to determine the relative percentages of the various inflammatory cell types (lymphocytes, neutrophils, eosinophils, macrophages, and mast cells).⁸

Statistics

Results were expressed as mean $\pm$ SD. Comparisons of scores of nasal obstruction obtained by visual analogue scales at night and during the day, before and after surgery (days 3, 7, and 60) were made using a two-way ANOVA for repeated measures. Because it was found that there were significant changes in VAS with time and between day and night, a one-way ANOVA with repeated measures was then performed to compare the different scores at night and day with time. ANOVA for repeated measures

was used to test the relationship between saccharin transit time, ciliary beat frequency, and treatment. When significant differences were found, individual means were compared using the Scheffé test. Differences were considered to be significant when the *P* value was less than .05.

Concerning acoustic rhinometry measurements, statistical comparisons were performed using the nonparametric Wilcoxon test. The χ^2 test was used to compare symptom scores established by patients and surgeon, with Yates correction when necessary.

RESULTS

Fourteen patients (11 men and 3 women; mean age, 49.4 ± 12.4 y) were enrolled in this study. Three patients had perennial allergic rhinitis; the other patients had a diagnosis of vasomotor dysfunction. One patient was a smoker, and six patients were obese with a body mass index greater than 27 kg/m^2 (body mass index of study population [mean $\pm$ SD], $25.3 \pm 4.2 \text{ kg/m}^2$).

Radiofrequency Procedure and Tolerance

The mean energy delivered for each puncture was $342 \pm 36 \text{ J}$ with a mean duration of 69 ± 17 seconds and a plateau tissue temperature of $75^\circ\text{C} \pm 6.4^\circ\text{C}$. Three patients had pain during the turbinate procedure. An additional lidocaine infiltration allowed completion of the procedure in one patient; in the other two patients the procedure was stopped before the total energy had been delivered. Postoperative pain was minimal (mean pain scores were 0.9 ± 1.2 on day 3 and 1 ± 1.1 on day 7), and none of the patients took any analgesic medication. A small area of necrosis on the surface of the head of one turbinate was observed in one patient on day 7, but on day 60 the mucosal surface had recovered a normal appear-

ance. No local problems were observed in any of the other patients. Bleeding and crusting were not reported by the patients or observed by the surgeon. The abundance of secretions increased significantly on day 3 after surgery (79% of nasal fossa with moderate or severe secretions, $P < .05$) and then decreased significantly on day 60 (4% of nasal fossa with moderate or severe secretions, $P < .01$) compared with preoperative data (50% of nasal fossa with moderate or severe secretions). Turbinate edema decreased significantly on days 7 (18% of turbinates with a moderate or severe edema, $P < .05$) and 60 after surgery (4% of turbinates with a moderate or severe edema, $P < .001$) compared with preoperative data (79% of turbinates with a moderate or severe edema).

Nasal Obstruction and Associated Symptoms

Concerning nasal obstruction, a considerable improvement was observed at night. Significant changes in analogue visual scale evaluations with time from day 0 to day 60 ($P < .00001$) and significant differences between night and day ($P < .0001$) were found. A significant interaction was noted between the two variables (i.e., period [day or night] and days [$P < .0001$]). Significant changes in the day score ($P < .0005$) and night score were noted ($P < .00001$). Individual means were compared using the Scheffé test. During the day, a significant decrease was noted in nasal obstruction on day 60 as compared with day 3. At night, a significant decrease in nasal obstruction was observed at day 60 as compared with days 0, 3, and 7. When comparing daytime nasal obstruction to nasal obstruction during the night, we found significant higher scores at night on day 0 ($P < .0001$) and on day 3 ($P < .007$). There was no more difference between day score and night score on day 7 and day 60 (Fig. 1).

Among the nasal symptoms associated with nasal obstruction, rhinorrhea, nasal pruritus, sneezing, and rhinolalia were significantly reduced after surgery ($P < .05$).

Acoustic Rhinometry

Acoustic rhinometry measurements demonstrated a significant reduction of turbinate hypertrophy in the sitting and supine positions after surgery (Table I). Measurements performed after topical decongestants were not significantly different before and after treatment.

Epithelial Function and Morphology

Saccharin transit times were obtained in 13 patients before surgery ($22.5 \pm 11 \text{ min}$) and on days 7 ($18 \pm 9.3 \text{ min}$) and 60 ($14.6 \pm 4.4 \text{ min}$) after surgery. Significant changes in saccharin transit time were observed (ANOVA, $P < .03$) with a significant decrease on day 60 as compared with the baseline value ($P < .03$) (Fig. 2).

Ciliary beat frequency measurements were obtained in nine patients before surgery ($11.6 \pm 0.8 \text{ Hz}$) and on days 7 ($10.7 \pm 1.1 \text{ Hz}$) and 60 ($11.7 \pm 1.2 \text{ Hz}$) after surgery. Ciliary beat frequency could not be measured at any investigation time in one patient because of the absence of ciliated cells, and measurements were obtained only at two of the three investigation times in four patients, for the same reason. Significant changes in ciliary beat frequency were observed (ANOVA, $P < .04$), with a signifi-

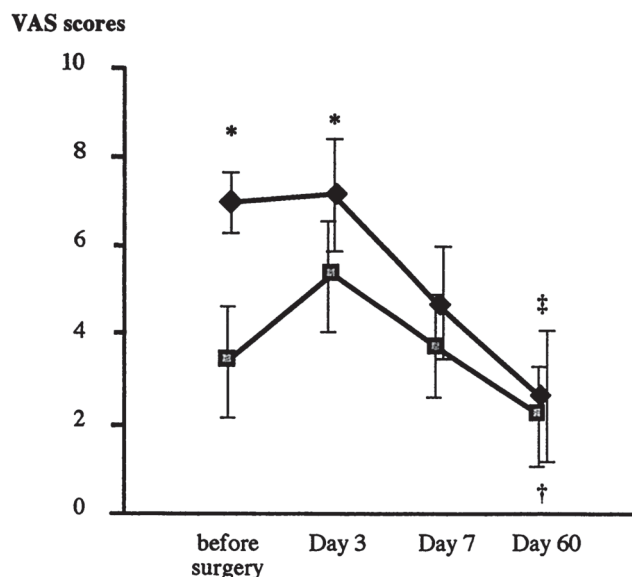


Fig. 1. Nasal obstruction scores (from 0 to 10) assessed by the patients at night (black diamonds) and during the day (gray squares) by means of visual analogue scale (VAS) before surgery and on days 3, 7, and 60 after surgery. * = Nighttime scores were significantly higher than daytime scores before surgery ($P < .0001$) and on day 3 ($P < .007$); † = daytime scores were significantly lower on day 60 than before surgery ($P < .05$); ‡ = nighttime scores were significantly lower on day 60 than on day 7, on day 3, and before surgery ($P < .05$).

TABLE I.
Acoustic Rhinometry Measurements (mean $\pm$ SD) Before and 60 Days After Radiofrequency Turbinate Tissue Reduction.

	Before Treatment	Day 60	P
Nasal volume (cm ³)			
Sitting	7.67 $\pm$ 2.67	9.28 $\pm$ 2.67	<.01
Supine	3.69 $\pm$ 2.35	7.94 $\pm$ 2.83	<.01
Decongestants	13.16 $\pm$ 3.61	14.28 $\pm$ 3.25	NS
Turbinate volume (cm ³)			
Sitting	3.90 $\pm$ 1.79	5.04 $\pm$ 1.89	<.01
Supine	3.19 $\pm$ 2.27	4.23 $\pm$ 1.81	<.03
Decongestants	6.31 $\pm$ 1.99	7.89 $\pm$ 2.56	NS
Cross-sectional area (cm ²)			
Sitting	1.25 $\pm$ 0.46	1.54 $\pm$ 0.48	<.02
Supine	1.04 $\pm$ 0.59	1.32 $\pm$ 0.48	<.02
Decongestants	2.03 $\pm$ 0.69	2.21 $\pm$ 0.54	NS

Turbinate volume: calculated volume between the first and second notches on the cross-section curve; cross-section: nasal fossa cross-section at the level of the head of the turbinate; NS = not significant.

cant lower value of ciliary beat frequency on day 7 as compared with day 60 ($P < .05$) (Fig. 3). Ciliary beat frequency on day 60 was not significantly different from baseline value.

Ciliated cells were the most abundant epithelial cell type before surgery in all cases, except in one case initially exhibiting no ciliated cells, but only squamous cells, which were still present on days 7 and 60 after surgery. Ciliated cells remained the most numerous epithelial cell type after surgery, but in five cases, moderate numbers of squamous cells were detected on either day 7 or day 60 after surgery. The percentages of inflammatory cells were initially moderate with marked variability from one patient to another ($16.8\% \pm 58.6\%$). They increased significantly on day 7 after surgery ($35.6\% \pm 2.8\%$, $P < .05$) and then returned to baseline values on day 60 ($17.2\% \pm 14.8\%$).

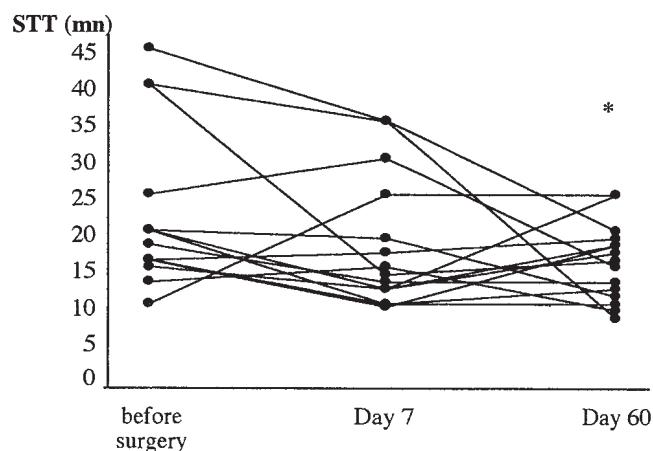


Fig. 2. Saccharin transit times (STTs) before surgery and on days 7 and 60 after surgery. * = STT was significantly lower on day 60 than before surgery ($P < .03$).

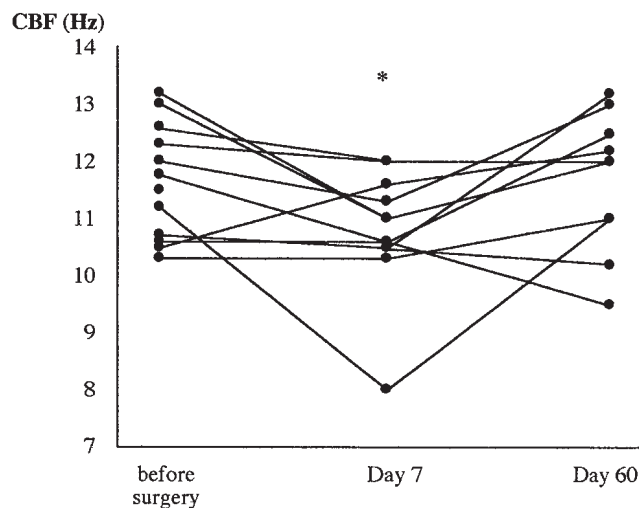


Fig. 3. Ciliary beat frequency (CBF) in vitro measurements on nasal brushing of epithelial ciliated cells harvested from the inferior turbinate of patients before surgery and on days 7 and 60 after surgery. * = CBF was significantly lower on day 7 than on day 60 ($P < .05$).

DISCUSSION

The present study was designed to assess the efficacy of radiofrequency to reduce nasal obstruction and to verify that this treatment does not damage epithelial structure and function. The data obtained show that radiofrequency tissue reduction is a safe and effective technique for the treatment of nasal obstruction associated with turbinate hypertrophy.

The radiofrequency technique achieves a reduction of turbinate volume by inducing a thermal lesion, the size of which depends on the energy delivered locally. Interestingly, this energy generates frictional heating in the tissue and the system used allows continuous monitoring of the tissue temperature. In this study, the temperature was maintained at approximately 75°C (i.e., less than 90°C, when charring is observed around the electrode). Therefore, low-level energy (8 W) delivered slowly with control of tissue impedance and temperature presents major advantages and allows the creation of a focal lesion with no damage to adjacent structures (e.g., turbinate bone and mucosal surface). In this pilot study, three different turbinate sites were treated, delivering approximately 340 J to each site. In another study,⁹ only one puncture delivering 380 J was performed in each turbinate, and in another,¹⁰ three punctures (450 J each) were performed. The results in terms of the subjective feeling of nasal obstruction were fairly similar to those of the present study, but no objective measurements were performed. Further studies are needed to determine the ideal number of punctures per turbinate and the optimal energy level per treatment site, to optimize the results of the technique while maintaining satisfactory tolerance. The value of repeated treatment sessions to achieve maximal improvement of nasal obstruction must also be assessed.

Subjective and objective assessments of nasal obstruction were both significantly improved after surgery. Most patients were considered to present vasomotor dysfunction. We observed lower nasal cross-sectional areas

and volumes on acoustic rhinometry in the supine position than in the sitting position, as expected from previous studies of nasal resistance in this disease.¹¹ These findings could help to explain a more severe feeling of nasal obstruction at night. Therefore, it was not surprising to observe a significant improvement of subjective nasal obstruction at night, whereas only a moderate, although significant, improvement was reported for daytime nasal obstruction. A significant improvement in the subjective feeling of nasal obstruction has also been reported in recent studies. In the present study, acoustic rhinometry measurements demonstrated a significant objective improvement in nasal cross-sectional area and volumes in both the supine and sitting positions. Logically, measurements performed after topical decongestants were not modified after treatment because topical decongestants induce a maximum reduction of mucosal thickness, both before and after surgery. Objective measurements of nasal obstruction were performed in only one other study of radiofrequency turbinate reduction¹² and showed a significant improvement in minimum cross-sectional area. However, in the study of Elwany et al.,¹² radiofrequency energy was delivered with a different power system, using a bipolar electrode without control of energy and tissue temperature. It must be stressed that the present study, like other studies,^{9,10,13} reports only medium-term results. Elwany et al.¹² reported good 1-year postoperative results, but according to a different procedure. Therefore, long-term maintenance of our good results cannot be confirmed at present.

In contrast to conventional instrumental or laser turbinate surgery, which generates more or less disabling symptoms,¹⁻⁴ the present study and other studies clearly indicate that radiofrequency turbinate reduction is safe and well tolerated with no postoperative pain, bleeding, or crusting. Turbinectomy, although effective, is also a more aggressive procedure that usually requires general anesthesia and nasal packing.^{2,4} Radiofrequency turbinate reduction is a rapid procedure that can be performed with the patient under local anesthesia, allowing the patient to return to work or home immediately after treatment. Local congestion with nasal blockage and rhinorrhea were reported and observed during the days after the procedure, and nasal cytology showed a moderate and temporary inflammatory cell infiltrate on day 7 after surgery in some patients. This inflammatory reaction, occurring after the procedure, reflects the first stage of the healing process. Obviously, patients must be informed about the possibility of this minor temporary inflammation before deciding on this surgical procedure.

Postoperative preservation of nasal epithelial function must be emphasized. Radiofrequency turbinate reduction according to the parameters tested in the present study did not induce any detectable epithelial damages. In a previous study, transmission electron microscopy performed 1 year postoperatively showed that the epithelium was intact with ciliated and goblet cells.¹² Our study showed for the first time that, even 1 week after the procedure, ciliated cells were still present in the surface epithelium, exhibited a normal ciliary beat frequency, and were able to ensure effective mucociliary clearance as

evaluated by the saccharin transit time results. Other turbinate surgery techniques, possibly with the exception of submucosal turbinate resection, are unable to preserve the nasal epithelium and its function to this degree.⁴ As in any nasal surgical procedure, it is always important to preserve the major epithelial function, that is, mucociliary clearance, which is the first line of defense of the airways.

CONCLUSION

Radiofrequency is a useful alternative to reduce turbinate volume while preserving integrity and function of the surface epithelium. This new technique effectively improves both subjective and objective nasal obstruction. Radiofrequency appears to be safer and better tolerated than any other form of turbinate surgery because it does not modify epithelial structure and function. More studies are required to define the optimal treatment parameters and to assess the long-term results. In every case, the surgical procedure must be performed with the objective of lowering the patient's postoperative discomfort and maintaining nasal physiology.

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