The effects of different radiofrequency energy magnitudes on mucociliary clearance in cases of turbinate hypertrophy*

Abdullah Karatas, Mehti Salviz, Burak Dikmen, Turgut Yüce, Gulsah Acar

Ear Nose and Throat Clinic, Haseki Training and Research Hospital, Istanbul, Aksaray, Turkey

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Abstract

Background: Radiofrequency ablation (RFA) application is a commonly used technique for the treatment of inferior turbinate hypertrophies. As the number of RFA applications has increased, some problems have been reported regarding the patient discomfort. The most frequent problems among these are the extended turbinate crusting and nasal obstruction.

Methods: Patients who received RFA were divided into two groups based on the applied energy value during the employment of the technique. Each group was including 30 patients. The patients in the first group received 8 watts and those in the second received 12 watts of energy. Saccharin transport times (STT) were measured four times. First a baseline measurement was performed followed by measurements on the 15th, 30th, and 45th days after the initial procedure. Nasal obstruction was twice assessed by peak nasal inspiratory flow (PNIF) measurements, which were taken both before the procedure and on the 45th day after the procedure. Turbinate surface crustings that were observed for more than 15 days were considered as an extended turbinate crusting.

Results: The STT and PNIF measurements taken before the procedure were not significantly different between the two groups. Postprocedure STT measurements were significantly higher than the preprocedure measurements taken in both groups, and were stable within the physiological range. The STT increase in Group II was significantly greater than in Group I. Postprocedure PNIF values in both groups were significantly higher than the preprocedure values. Group II had showed a significantly higher rate of crusting.

Conclusion: Higher magnitudes of energy elongate the healing process of the turbinate tissue and they affect more extensively the mucociliary clearance. Elongation of the healing process of the turbinate tissue may increase the rate of postprocedural complications such as turbinate surface crusting.

Key words: radiofrequency, mucociliary clearance, turbinate hypertrophy, turbinate crusting, saccharin test

Introduction

Inferior turbinate hypertrophies have significant roles in the aetiology of nasal obstruction. They can either be seen as isolated entities or as concomitant to other nasal pathologies. Allergic rhinitis, frequently repeating or chronic nasal infections, air pollution, and smoking can result in turbinate hypertrophies. As structural turbinate hypertrophies may be encountered, compensatory inferior turbinate hypertrophies may also develop in septum deviations [1]. On the other hand, nasal polyps developing through the inferior turbinate are considered as separate clinical pathologies. There are various treatment options established for inferior turbinate hypertrophies. Topical nasal steroids can provide positive results in the treatment of allergic or inflammatory hypertrophies. Surgical procedures such as turbinate resection, submucosal resection, turbinate lateralization, laser and microdebrider turbinoplasty have been described [2-5]. Total inferior turbinate resection is no longer preferred, since it results in atrophic rhinitis. Partial inferior turbinate resection can be performed in selected cases. Submucosal resection is successfully used to treat bone hypertrophies. On the other hand, turbinate lateralization can provide successful results in selected patients [2].

The turbinate radiofrequency ablation (RFA) method has recently become popular, since this method is easy to implement with its less invasive approach and successful clinical outcomes [3,4,6,8]. However, while the frequency of RFA application increases, some side effects such as extended turbinate oedema, turbinate surface crustings, nose dryness, postnasal discharge and turbinate perforation have been reported [4,6-9]. These complications are attributed to an extension in necrosis due to the occurrence of high temperature during the procedure and/or high level of energy delivered to the tissue [10-12]. How much total energy should be delivered to the turbinates is unclear. The current study is aimed to evaluate the effects of different RFA energy magnitudes on mucociliary clearance and to explore the possible complications.

Materials and methods

Subjects

This study is a randomized clinical trial. Patients who were diagnosed as inferior turbinate hypertrophy between September 2013 and March 2014 were prospectively enrolled in this study. All patients underwent a detailed examination including nasal endoscopy, anterior rhinoscopy and if necessary a CT scan to exclude other sinonasal pathologies. Patients with chronic sinusitis and nasal polyps, as well as the revised cases and those with a history of previous nasal operation were excluded. Patients with a systemic disease or using medications that may impair mucociliary clearance were also excluded. The enrolled patients were randomly assigned into two groups (Group I and II). Each group contained 30 patients. Group I was treated with RFA using a power of 8 Watt (W) and Group II was treated with RFA with a power of 12 W. Group I consisted of 21 males and 9 females with an average age of 29.8 ± 10.4 (ranging from 18 to 51) and Group II consisted of 21 males and 9 females with an average of age was 33.0 ± 12.8 (ranging from 18 to 65). The average of age in the groups were not different from each other ($p = 0.328$). All subjects were volunteers and each of them was fully informed on the design, aim and clinical implication of the study. furthermore, every subject who enrolled in this study signed a letter of permission.

Surgical Procedure

All procedures were performed under local anesthesia. First, a 4% lidocaine soaked pledget was paced into the nasal cavity. Then, 1% lidocaine was injected into the anterior and medial part of the turbinate. The RFA procedure was performed by a RF generator (Curis-Sutter Medizintechnick GmbH-Freiburg-Germany). The device was set in RAVOR mode, which had an auto-stop property blocking the current when impedance increased up to 50 ohm (Ω). The RF generator employed during the procedure did not have a manual timing property in RAVOR mode. The duration of energy supply could be controlled automatically by the RF generator that is sensitive to tissue resistance. Energy supplying time was also measured for each group by an external manual chronometer and was between 6 and 8 seconds. There was no significant time difference between the two groups. The RFA procedure was performed using the device's own bipolar electrodes with a 3 mm insertion width. Bipolar RF ablation was applied primarily into the submucosa and from there to the anterior, middle and posterior parts of each turbinate. No nasal packing was used and no drugs except nasal irrigation were prescribed after the surgical procedure.

Outcome

The main outcome is determined via PNIF that is used to evaluate the success of the procedure. PNIF was applied before the start and on the 45th day after the procedure. PNIF measurements in litre/min (Clement Clarke International, Harlow, UK) were used to evaluate the patency of the nasal airway space. During the measurements, the device was placed on the face covering the mouth and nose, and the patient was asked to take a deep breath while the mouth was closed. The measurement was repeated three times and the mean value of the three measurements was recorded as the test result.

Mucosal side effects of RFA were evaluated by using saccharin transport time (STT) and degree of extensive crusting. STT was performed preoperatively in order to define baseline mucociliary clearance function. STT was also applied on the 15th, 30th and 45th days after the procedure to investigate the effect of RFA upon the mucociliary clearance function. In order to determine the STT, a 25 mg saccharin tablet was placed approximately 1 cm ahead of the turbinates. Patients were asked to declare when they felt a different taste in their mouth. The time interval from the beginning of the test till the sugary taste felt by the patient was measured via a chronometer. These measurements were repeated on the 15th, 30th, and 45th days after the procedure. Before the measurements, nasal crusts were taken from the turbinate surface and the patients were asked to clean their nose with water. The test was initiated 15 minutes later.

The presence of a nasal crusting on the surface of the turbinate was evaluated subjectively using nasal endoscopy and anterior rhinoscopy and it was recorded during the controls. Nasal crusts that lasted more than 15 days after the procedure was noted as "extended crustings".

Statistical analysis

Data were analysed using descriptive statistics including the mean and standard error (SE). Distribution of the variables was tested by the Kolmogorov-Smirnov test. Quantitative data were analyzed by the Mann-Whitney U-test. The Wilcoxon test was also used to analyse the repetitive measurements. Qualitative data were analysed with the chi-square test. The SPSS 21.0 program was used for analyses. Significance level was accepted as $p < 0.05$.

The ethics committee approval for the present study was obtained from the Haseki Training and Research Hospital Ethics Committee on August 25, 2013 (Protocol No: 36).

Results

Preoperative PNIF mesurements were not different between Group I and II, 34.2 ± 13.33 L/min and 33.17 ± 10.0, respectively ($p = 0.934$). In the postoperative period, there was a significant improvement regarding PNIF measurements in both Group I and Group II, 48.3 ± 9.59 and 49.17 ± 8.0 ($p = 0.001$, $p = 0.001$), respectively. However, it was evident that the measurements were not significantly different from one another in each group ($p = 0.518$). Between preoperative and postoperative periods, changes in PNIF measurements did not differ from Group I to Group II. The numerical values for Group I and Group II were as follows: 14.2 ± 10.6 and 16.0 ± 10.0 ($p = 0.441$), respectively. Preoperative and postoperative mean values of PNIF measurments in each group are shown in Figure 1.

Preprocedure STT was 8.3 ± 1.2 min in Group I and 8.3 ± 1.1 min in Group II. There was no difference between Group I and Group II according to preprocedure STT ($p = 0.846$). STT in Group I on the 15th, 30th and 45th days after the procedure were 9.7 ± 1.6, 9.1 ± 1.5 and 8.9 ± 1.4 min, respectively. In Group II, STT measured postoperatively on the 15th, 30th and 45th days were 11.0 ± 1.6, 10.1 ± 1.9 and 9.9 ± 1.8 min, respectively. STT in Group II was significantly higher than in Group I during the postoperative measurements on the15th, 30th and 45th days ($p = 0.006$, $p = 0.034$ and $p = 0.037$). The difference in STT between preoperative and postoperative measurements in Group I and Group II were 0.62 ± 0.94 and 1.55 ± 1.4 min, respectively. In Group II, the difference in STT on the 45th day after the procedure was significantly higher than the Group I ($p = 0.008$). Preoperative and postoperative mean STT values of each group are shown in Figure 2.

When Group I and Group II were compared according to the turbinate surface crustings on day 15, Group II patients showed a significantly higher crusting rate (43.3%) than Group I patients (16.7%) ($p = 0.024$). Crusting ratios for each group are shown in Figure 3.

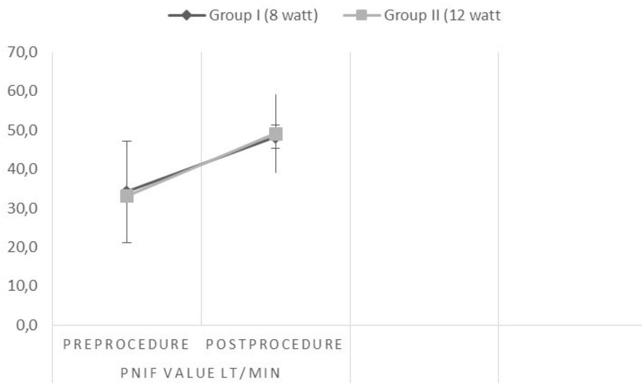

Figure 1. Preoperative and postoperative mean PNIF measurements in Group I and Group II.

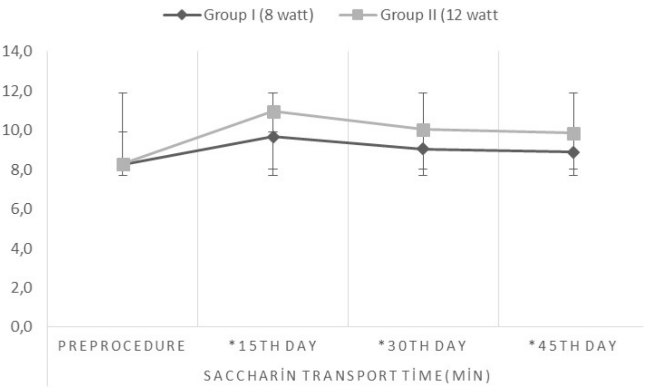

Figure 2. Preoperative and postoperative mean STT measurements in Group I and Group II (*significant diference).

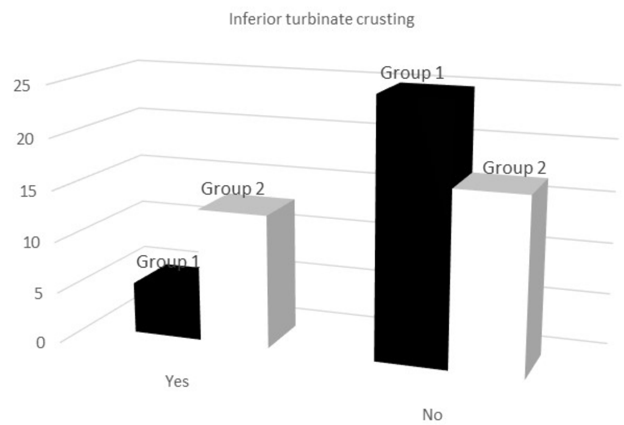

Figure 3. Extended turbinate surface crusting in Group I and Group II.

Discussion

Radiofrequency ablation works on the principal of achieving a limited local temperature increase in the submucosal area and it destructs particularly submucosal glands and large venous sinusoids [13]. Then, loose connective tissue is replaced by extensive fibrosis that causes volumetric reduction of turbinates. Mucosal and submucosal changes after bipolar RFA have been shown in a sheep model in the early period, on the day 0 and 21 [14]. On day 0, a different degree of focal mucosal disruption was found in all specimens. On day 21, it was observed that the mucosa was on the most part preserved except for focal squamous metaplasia. Those mucosal changes after RFA were described in the long-term follow-up in humans. In most cases, the respiratory mucosa was either partially or completely replaced by metaplastic squamous epithelium [13]. Such epithelial damage in the early phases of the postoperative period may cause side effects such as nasal discharge, crusting, pain, hyposmia, oral breathing and snoring [3,4,7].

Turbinate reduction is visible during the first 4 weeks following the RFA procedure and reached its final volume after 12 weeks [15]. In the early period after the procedure, turbinates are oedematous due to an inflammation taking place particularly in the submucosa [6,15]. In several studies, RFA was viewed as an effective way in reducing the turbinate volume by having less complication rates in comparison with the laser technique and electrocoagulation [16,17]. However, revised surgery after RFA has been reported at different rates [18,19]. It can be concluded that RFA is needed to be repeated in some patients but the need for revision remains unclear. To our knowledge, there is no successful study on the magnitude of energy delivered to the turbinate via RFA. On the other hand, high energy levels of RFA could also cause extensive destruction in the turbinate that might result in high rate side-effects [14]. However, sufficient evidence on the relation of mucosal damage with the amount of total energy delivered through an effective RFA is lacking. This study shows that in reducing inferior turbinates, RFA with a power of 8 W has an equal impact with a power of 12 W. In both groups (8W and 12W), it was observed that there was a significant reduction in the volume of the turbinates. The results in this study are a short-term follow-up but the fibrosis process continued in the aftermath of the mentioned period. Therefore, a long-term follow-up is needed to determine the final results and the need for revision procedures.

There are several reports showing that RFA does not impair mucociliary clearance and nasal physiology in the long-term [4,6,8,16]. The mucociliary clearance was evaluated by comparing pre-procedure and post-procedure STTs performed on the 60th day and no apparent differences were found between the pre-procedure and post-procedure values. Literature about mucociliary clearance function in the early period after RFA is controversial. Rhee at al. reported that STT did not change on the week of the 1st, 4th and 6th weeks after the operation. They also noted that temperature controlled radiofrequency ablation was used during the operation and RFA did not impair mucociliary transport [4]. In another study, mucociliary clearance was measured by STT and STT was found in its normal physiological range [15]. However, the authors did not state whether STT was extended according to a baseline measurement or not. In the present study, the final measurements were taken on the 45th day. They are significantly longer than the baseline but all of them were in physiological range. However, using a power of 8 W had a remarkable impact such as less impairment of mucosal clearance. This suggested that a lower power level causes less mucosal damage while being equally effective.

On the other hand, nasal crusting can be considered as another consequence leading to mucosal damage. There are several reports referring that nasal crusting after RFA occurs less frequently than after either electrocoagulation or laser reduction [4,15]. Nevertheless, turbinate surface crustings are seen very commonly and they cause post-procedure nasal obstruction resulting in effects as snoring [4,6-8,16]. Although those crusts can be the result of a secondary heat-trauma, a puncture of a bipolar needle may also cause mucosal damage. Thus, the number of extensions might also influence the severity of crusting. We accept extensive crusting if it appears 15 days after the procedure. In this study, we verified that the crusting rate almost doubled as an effect of 12 W energy level compared to 8 W. The energy level of 12 W is a sign of mucosal damage due to the high power RFA. In the early period of the procedure, extensive crusting can impair nasal patency and can result in both oral breathing and snoring.This can impair the patient’s comfort during the healing period.

To our knowledge, there has been no previously established study in the literature, which analyses the possible changes visible through the application of different energy magnitudes on mucosal function playing a role on postoperative discharge, crustings and oedema. The device which we used had an auto-stop property sensitive to tissue impedence. Moreover, it adjusted its power output to the changes in the tissue resistance. In other words, it limited both the warming effect and heat-related trauma due to an increase in tissue resistance. Yet, this study attempts to show that a higher power level causes more mucosal damage and this is a side effect of the procedure. However, there are different types of RF generator with different setups. Therefore, it is difficult to standardize ideal power or energy level delivery that has optimal success and minimal side effect. In our opinion, more studies are required on this issue. Additionally, to accomplish the long-term success of the different procedures, studies which are employing different magnitudes of energy in the presence of the early side-effects are also needed.

Conclusion

The presented study confirms that increasing the magnitude of RFA energy results in more postprocedural complications that impair mucociliary clearance to a greater extend. These findings suggest that submucosal damage can be pronounced comfortably. Furthermore, the related mucosal response can develop easily in the presence of increased magnitudes of energy, especially in cases of hypertrophies with thick turbinate bone lamella and less soft tissue thickness.

Author contributions

AK: Study design, acquisition of data, analysis and interpretation of data, drafting of the manuscript, final approval of draft. MS: Study design, acquisition of data, analysis and interpretation of data, drafting of the manuscript, final approval of draft. BD: Acquisition of data, analysis and interpretation of data, drafting of the manuscript, final approval of draft. TY: Acquisition of data, analysis and interpretation of data, drafting of the manuscript, final approval of draft. GA: Acquisition of data, analysis and interpretation of data, drafting of the manuscript, final approval of draft.

Conflict of interest

There is no conflict of interest.

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Md. Abdullah Karatas
Ear Nose and Throat Clinic, Haseki
Training and Research Hospital
Istanbul
Aksaray
Turkey

Tel: +90-532-623 0218
Fax: +90-212-529 4400
E-mail: akrts2000@yahoo.ca