Comparison of Submucosal Resection and Radiofrequency Turbinate Volume Reduction for Inferior Turbinate Hypertrophy: Evaluation by Magnetic Resonance Imaging

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Abstract Inferior turbinate hypertrophy is a frequent cause of nasal airway obstruction and drastically impairs patients' quality of life. Surgical reduction of the inferior turbinates can be used for patients who did not respond to medical therapy. A number of studies have been performed to identify the most effective technique. The aim of this study was to compare the effectiveness of submucosal resection (SMR) and radiofrequency turbinate volume reduction (RFTVR) in patients with inferior turbinate hypertrophy. A prospective, randomized case–control study was conducted. Sixty patients with inferior turbinate hypertrophy refractory to medical therapy were prospectively and randomly assigned to two groups: SMR and RFTVR. A visual analog scale (VAS) and the nasal inspiratory peak flow (NPIF) were analyzed pre- and postoperatively at the first week and second month. Magnetic resonance imaging was performed pre- and postoperatively at the second month. The surgical outcomes were compared statistically using subjective and objective measures. Significant turbinate volume reduction was achieved in both the SMR and RFTVR groups. However, turbinate volume reduction was significantly greater in the SMR than in the RFTVR group at the second month

postoperatively. NIPF and VAS scores were improved after both procedures at the second month postoperatively. Beside this, surgical outcomes were significantly better after SMR in terms of NIPF and VAS scores. In this study, we demonstrated that both SMR and RFTVR are effective for inferior turbinate hypertrophy. Turbinate volume reduction, improvement of subjective nasal obstruction symptoms, and NIPF after SMR were significantly superior to those after RFTVR.

Keywords Inferior turbinate hypertrophy · Submucosal resection · Radiofrequency · Nasal inspiratory peak flow · Magnetic resonance imaging

Introduction

The inferior turbinates are erectile structures of the lateral nasal wall that play an important role in nasal respiration and the nasal cycle. Inferior turbinate enlargement is mostly reversible. However, this swelling can persist when the autonomic nervous system regulation of the arteriovenous channels within the stroma of the turbinate is disrupted, as in allergic rhinitis, idiopathic rhinitis, or compensatory hypertrophy due to septal deviation [1].

Inferior turbinate hypertrophy drastically impairs patients' quality of life and obligates some patients to the use of topical intranasal decongestants [2]. Medical treatments provide only slight improvement in some cases. Surgical reduction of the inferior turbinates can be proposed in these patients. Many different surgical techniques have been described: “standard” turbinectomy (total or partial), turbinoplasty, submucosal resection (traditional surgical or microdebrider-assisted), outfracture of the turbinates, electrocautery, radiofrequency turbinate volume

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reduction (RFTVR), cryosurgery, argon plasma surgery, and corticosteroid injections [3–6].

Traditional surgical submucous resection procedure and submucous reduction with electrocautery has been evolved to microdebrider assisted turbinoplasty and radiofrequency turbinate volume reduction during past two decades, respectively. Despite increasing of new technologies and technology dependent procedures, traditional standard surgical procedures including outfracture of the turbinates and submucous resection are also used by authors currently [7].

A number of studies have been performed to identify the most effective technique by comparison of techniques using measurement of the nasal flow by acoustic rhinomanometer or acoustic rhinometry [8, 9].

In this study, we sought to compare:

1. Turbinate volume reduction in submucous resection (SMR) and radiofrequency turbinate volume reduction (RFTVR) by using magnetic resonance imaging
2. Clinical efficacy of SMR and RFTVR using visual analog scale (VAS) and nasal inspiratory peak flow (NIPF).

Materials and Methods

Study Design and Patients

This prospective, randomized case–control study was conducted in a tertiary hospital between March 2009 and March 2010. During this time, 60 consecutive patients (mean age 28.9 ± 9.4 years; range 18–50 years; 24 males and 36 females) were enrolled and data were collected. The patients were randomly assigned to two groups: A and B. In Group A, SMR was performed, whereas in Group B, RFTVR was performed. Blocked randomization was performed. Institutional Review Board approval and patient consent were obtained (2009/006332).

Participants comprised all patients complaining of bilateral chronic nasal obstruction with a previous history of failed medical treatment for at least 3 months; failed medical treatment took the form of topical steroids, decongestants, and antihistamines. No distinction was made between patients with allergic or vasomotor rhinitis. Anterior rhinoscopy and diagnostic rigid nasal endoscopic examination were performed preoperatively in all patients. Cottle's test was performed to assess the nasal valve area and nasal valve collapse.

The exclusion criteria were previous nasal surgery, septal perforation, septal deviation, sinusitis, nasal polypsis, benign or malignant tumor of the nasal cavity, adenoid hypertrophy, nasal valve collapse, and middle turbinate hypertrophy including the concha bullosa.

Patients were evaluated preoperatively and at the first week and second month after the surgery.

Surgical Procedure

All surgical interventions were carried out by the same surgeon to prevent differences that exist in techniques, with the patient under sedation and local anesthesia. Conscious sedation with midazolam under anesthetic care was carried out. Initially, the nasal cavity was decongested using cotton pledgets soaked in a solution of 2 % lidocaine and 0.1 % epinephrine. Each inferior turbinate was injected with 3 mL of 1 % lidocaine and 1:100,000 epinephrine. Ten minutes after the injection, the surgical procedure was performed.

In Group A, 30 patients (11 males, 19 females; mean age 28.8 ± 8.2 years; range 18–48 years) underwent SMR. A vertical incision running from the caudal end in an anterior–inferior direction was made in the anterior aspect of the inferior turbinate using a scalpel and turbinate scissors. The medial, inferior, and lateral mucosal layer of the turbinate was elevated from the bony part of the turbinate in an anteroposterior direction using a Freer elevator and scalpel. After elevation of the mucoperiosteal flap, the turbinate bone was fractured medially, and approximately the anterior two-thirds of the turbinate bone and excess cavernous tissue were excised using biting forceps. The posterior end and any mucosal bleeding were cauterized to avoid post-operative bleeding. The mucosal flaps of the turbinate were then repositioned laterally. After the operation, nasal packing was performed for 48 h.

In Group B, 30 patients (13 males, 17 females; mean age 29.0 ± 10.5 years; range 18–50 years) underwent RFTVR. Radiofrequency energy was delivered by a generator (Quantum Molecular Resonance Generator; Telea Electronic Engineering, Italy) using a turbinate handpiece comprising a bipolar long-needle electrode with an active and insulated part. The active portion of the electrode was inserted into the submucosal plane, and the energy was delivered to three different sites of each turbinate (anterior, middle, and posterior thirds of each turbinate). The energy delivered per insertion was 400 J, with a mean duration of 2 min. Nasal packing was not performed in these patients.

Assessment of the Objective Surgical Outcome

Magnetic resonance imaging in the coronal and axial planes was performed in all patients, and turbinate volumes were measured before and 2 months after the operation. MRI volumetric assessment was performed by the same radiologist (NE). The turbinate volume and cross-sectional dimensions of the inferior turbinate were evaluated. The volume was computed using the ellipse formula (mm^3): longitudinal length (mm) $\times$ transverse length (mm) $\times$ anteroposterior

length (mm) $\times$ 0.52. The longitudinal and transverse dimensions of the inferior turbinate were computed at the section that passes through the uncinate process. In the axial plane, the longest value of the turbinate was considered to be the anteroposterior dimension.

NIPF was evaluated in all patients before and at both 1 week and 2 months after the operation. An In-Check Inspiratory Flow Meter portable device (Clement Clarke, Harlow, England) was used for the measurements. The facial mask was duly placed with participants sitting. They were then told to inhale as hard and fast as they could through the mask, keeping the mouth closed and starting from the end of a full expiration. Three measurements were taken, and the highest value (L/min) was used in the analysis.

Assessment of the Subjective Surgical Outcome (Subjective Symptom Improvement)

A standard visual analog scale (VAS) was used to assess the subjective nasal obstruction symptoms before and at both 1 week and 2 months after the operation. The severity of symptoms was measured on a scale ranging from 0 to 10, where 0 = no nasal obstruction and 10 = severe total nasal obstruction.

Statistical Analysis

Statistical analyses were performed using SPSS version 16.0 for Windows (SPSS Inc., Chicago, IL, USA). The significance of the changes between the pre- and postoperative PNIF, cross-sectional turbinate dimensions, and volume of the turbinates were analyzed using the paired *t* test. The comparison of the pre- and postoperative VAS scores was analyzed using the Mann–Whitney *U* test. *p* values of <0.05 were considered to indicate statistical significance.

Results

All patients in both treatment groups completed the first-week and second month follow-up visits. No serious postoperative bleeding was observed. Minor bleeding was observed in four patients while removing the nasal package. Synechia formation was observed in three patients in the SMR group.

Subjective Changes in Symptoms

Preoperatively, the mean nasal obstruction VAS score was 7.7 ± 1.1 in the SMR group and 7.1 ± 1.1 in the RFTVR group. There were slight improvements in VAS scores at 1 week after both procedures. However, statistically significant improvement was observed in both groups at

2 months after the treatment ($p = 0.000$). Furthermore, improvement in the SMR group was significantly better than that in the RFTVR group at 2 months after the treatment ($p = 0.000$) (Table 1).

NIPF

Preoperative and postoperative NIPF values were compared, and values at 1 week were slightly improved after both procedures. Moreover, a statistically significant increment was observed at the second month after the treatment in both the SMR and RFTVR groups. In the SMR group, the median preoperative NIPF was 65.8 L/min and increased to 102.6 L/min at 2 months after the treatment ($p = 0.000$). Similarly, a statistically significant improvement was observed after RFTVR in that the NIPF increased from 67.1 to 91.5 L/min postoperatively ($p = 0.000$). Furthermore, when we compared both procedures in terms of their preoperative and postoperative NIPF values, we observed that the absolute increment in the SMR group was significantly greater than that in the RFTVR group at 2 months after the treatment ($p = 0.007$) (Table 2).

Comparison of Turbinate Volume by MRI

We observed statistically significant reductions in turbinate volume and cross-sectional dimensions in both the SMR and RFTVR groups at 2 months after the treatment. The median preoperative turbinate volume decreased from 5746.5 to 3359.1 mm³ on the right side and from 6,432 to 3,647 mm³ on the left side after SMR ($p = 0.000$). The median preoperative turbinate volume decreased from 5665.8 to 4064.1 mm³ on the right side and from 5897.9 to 4048.2 mm³ on the left side after RFTVR ($p = 0.000$). However, the decrease in volume was significantly greater after SMR compared with RFTVR ($p = 0.000$).

When we compared the preoperative and postoperative cross-sectional dimensions of the inferior turbinate, a significant decrement was observed in all axial, transverse, and longitudinal sections 2 months after the treatment in both the SMR and RFTVR groups (Table 3). However, intergroup comparisons showed that the decrement of the right transverse cross-sectional dimension after SMR was significantly better than that after RFTVR ($p = 0.000$). In contrast, intergroup comparisons of the axial, longitudinal, and left transverse cross-sectional dimensions showed no significant differences postoperatively.

Discussion

The optimal primary treatment for inferior turbinate hypertrophy remains controversial. Some surgeons prefer

Table 1 The mean preoperative, postoperative 1st week, postoperative 2nd month and absolute change in VAS scores after SMR and RFTVR

	SMR					RFTVR				
	Preop	1st week	2nd month	Absolute change	<i>p</i> value	Preop	1st week	2nd month	Absolute change	<i>p</i> value
VAS score	7.7 ± 1.1	7.2 ± 0.9	2.5 ± 0.8	5.2 ± 0.3	0.000	7.1 ± 1.1	6.9 ± 1.2	4.6 ± 1.4	2.5 ± 0.3	0.000 0.000*

Means and standard deviations are illustrated for each subgroup. Statistically significant values are shown in bold

SMR submucosal resection, RFTVR radiofrequency turbinate volume reduction, VAS visual analog scale

* *p* value of intergroup comparison at 2nd month

Table 2 The mean preoperative, postoperative 1st week, postoperative 2nd month and absolute change in NIPF scores after SMR and RFTVR

	SMR					RFTVR				
	Preop	1st week	2nd month	Absolute change	<i>p</i> value	Preop	1st week	2nd month	Absolute change	<i>p</i> value
NIPF	65.8 ± 12.1	77.5 ± 10.5	102.6 ± 10.9	36.8 ± 1.2	0.000	67.1 ± 14.6	75.0 ± 15.5	91.5 ± 18.7	24.2 ± 4.2	0.000 0.007*

Means and standard deviations are illustrated for each subgroup. Statistically significant values are shown in bold

SMR submucosal resection, RFTVR radiofrequency turbinate volume reduction, VAS visual analog scale

* *p* value of intergroup comparison at 2nd month

Table 3 The mean preoperative and postoperative cross-sectional dimensions and volumes of turbinate in MRI after SMR and RFTVR

	SMR			RFTVR		
	Preop	Postop	<i>p</i> value	Preop	Postop	<i>p</i> value
Axial (R) (mm)	52.90 ± 2.55	50.63 ± 2.64	0.000	54.03 ± 3.96	51.57 ± 5.53	0.000
Axial (L) (mm)	53.67 ± 2.70	50.97 ± 2.76	0.000	54.30 ± 4.01	51.70 ± 5.38	0.000
Transvers (R) (mm)	12.10 ± 2.41	8.23 ± 2.54	0.000	11.37 ± 1.93	9.37 ± 1.62	0.000
Transvers (L) (mm)	12.40 ± 1.77	8.57 ± 2.34	0.000	11.80 ± 2.48	9.07 ± 1.83	0.000
Longitudinal (R) (mm)	17.50 ± 2.31	16.07 ± 2.77	0.027	17.47 ± 2.63	15.87 ± 3.18	0.000
Longitudinal (L) (mm)	18.50 ± 2.44	16.50 ± 2.78	0.003	17.60 ± 3.39	16.27 ± 3.71	0.015
Turbinate volume (R) (mm ³)	5746.5 ± 1030.8	3359.1 ± 672.6	0.000	5665.8 ± 1772.2	4064.1 ± 1540.5	0.000
Turbinate volume (L) (mm ³)	6432.0 ± 1377.8	3647.6 ± 792.0	0.000	5897.9 ± 1876.2	4048.2 ± 1679.2	0.000

Means and standard deviations are illustrated for each subgroup. Statistically significant values are shown in bold

SMR submucosal resection, RFTVR radiofrequency turbinate volume reduction, *preop* preoperative, *postop* postoperative, *R* right, *L* left, *mm* millimeter

medical and conservative treatments due to complications such as atrophic rhinitis, postoperative bleeding, and synechia, whereas others perform more radical procedures including SMR, inferior turbinoplasty, and aggressive turbinate resection procedures [10]. Aggressive turbinate resection procedures have evolved to less invasive procedures during the past two decades because of the development of new technologies such as laser cautery [11], radiofrequency ablation [12], and microdebrider systems [13]. In particular, RFTVR has gained popularity since it was approved by the US Food and Drug Administration in 1998. Radiofrequency creates a thermal lesion that induces fibrosis in the erectile submucosa of the inferior turbinate

without damaging the overlying mucosa. Thus, preservation of the inferior turbinate mucosa leads to less crusting and postoperative bleeding. Many studies have demonstrated the efficacy of RFVTR [8, 12, 14].

In the present study, two popular mucosa-sparing techniques, SMR and RFVTR, were compared in terms of turbinate volume reduction and short-term efficacy. Both techniques have been proven effective for inferior turbinate hypertrophy. Various studies comparing techniques in terms of objective changes in nasal functions have been performed. Objective measurements including acoustic rhinomanometry, acoustic rhinometry, and mucociliary function testing are usually applied to compare outcomes

[3, 8, 9]. To our knowledge, three radiologically designed studies that used MRI or computed tomography for evaluating outcomes after turbinate surgery have been performed [14–16]. However, they evaluated only the efficacy of radiofrequency. The current study compared the volumetric change after treatment and nasal flow in both techniques using MRI and NIPF, respectively. Sapci et al. [14] used MRI to evaluate the efficacy of RFTVR on inferior turbinate volume and reported an 8.7 % postoperative volume reduction. The most significant change was observed in the anteroposterior length on the axial plane in their study. However, Demir et al. [15] reported a 25.0 % postoperative volume reduction on CT after RFTVR. In their study, the mean changes in the cross-sectional areas at the anterior and middle thirds of the turbinate were significantly reduced, whereas that reduction was not significant at the tail of the turbinate. They attributed this to the difficulty in application of radiofrequency probe to the posterior part of the turbinate. In the present study, we found an average postoperative total turbinate volume reduction of 29.8 % on MRI after RFTVR. We also identified significant decrements in all axial, transverse, and longitudinal sections 2 months after RFTVR. Moreover, we analyzed the volume reduction and cross-sectional dimensions of the turbinates after SMR. Significant decrements were observed in all axial, transverse, and longitudinal sections postoperatively, and we found that the total turbinate volume reduction was significantly greater after SMR (42.4 %) than after RFTVR (29.8 %). This result confirms that reduction of turbinate bone creates more space and provides more volume reduction. In addition, cauterization of submucosal tissue to prevent postoperative bleeding induces fibrosis and minimizes congestion of the inferior turbinates.

Nasal airway patency and nasal flow are most commonly evaluated by acoustic rhinometry and acoustic rhinomanometry. In contrast, we used NIPF to evaluate the nasal air flow due to the easy application of this measurement. NIPF measurements, which have been shown to correlate with the results of rhinomanometry, allow for appropriate measurement of the nasal airway during therapeutic approaches [17]. Measurement of the maximal inspiratory air flow rate can be a convenient method of objective evaluation of the therapeutic response in patients with inferior turbinate hypertrophy [18]. Moreover, nasal inspiration is most strongly correlated with the subjective feeling of nasal obstruction, and NIPF provides a physiological measurement of the air flow through the nose [19]. In the present study, NIPF and nasal obstruction VAS scores were significantly improved in both groups after the treatment. Furthermore, subjective symptom improvement and the NIPF increment in the SMR group were significantly greater than those in the RFTVR after the treatment.

Recently, Cingi et al. [20] compared the effectiveness of SMR using a microdebrider *versus* RFTVR, and reported that both treatment modalities are effective for relieving nasal obstruction. However, SMR can effectively widen the nasal airway. They used acoustic rhinomanometry to compare outcomes and reported that the measurements of patients who underwent SMR were lower than those in the RFTVR group, and patient satisfaction in the SMR group was higher than that in the RFTVR group. Therefore, they suggested the use of microdebrider SMR in consideration of the advantages, including cost-effectiveness and better surgical outcomes. In contrast, a few authors compared SMR and RFTVR using acoustic rhinometry or acoustic rhinomanometry [21, 22]. They found both treatments to be effective, but did not report any significant differences between the two treatment modalities. However, they suggested the use of radiofrequency because of its advantages, including the lack of a need for nasal packing, a short operation time, preservation of the nasal epithelium, and absence of complications such as synechia formation.

This controversy can be explained by differences in follow-up periods, differences in measurement methods for nasal flow, and probable nuances of the practiced surgical methods. However, in this study, postoperative MRI measurements also supported the effectiveness of SMR in terms of the turbinate volume reduction. To our knowledge, no comparisons of SMR and RFTVR by MRI have been performed. Our data suggest that SMR results in a greater reduction in turbinate volume than does RFTVR. Therefore, if greater volume reduction is the goal, particularly in patients with bony hypertrophy of the turbinate, SMR should be preferred over RFTVR.

Conclusion

In this study, we demonstrated that SMR and RFTVR are both effective for inferior turbinate hypertrophy. However, SMR results in a greater reduction in turbinate volume than does RFTVR. Improvements in subjective nasal obstruction symptoms and NIPF after SMR were significantly better than that after RFTVR. Although risks of postoperative crusting and synechia exist, SMR is associated with better surgical outcomes compared with RFTVR.

Conflict of interest There are no financial disclosures and conflict of interest in this study.

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