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ORIGINAL STUDY

Radiofrequency turbinotomy: basic, practice and statistics

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ABSTRACT

BACKGROUND. Nasal obstruction is one of the most frequent symptoms found in rhinology. One of the major causes of chronic nasal obstruction is represented by the inferior turbinate hypertrophy. Many treatment modalities have been developed for chronic rhinitis. Being a surgery technique which preserves normal function of nasal mucosa and mucociliary clearance, radiofrequency turbinotomy is widely used in the rhinology field.

OBJECTIVE. In this paper, the authors present the basics and principles of radiofrequency turbinotomy and their experience in practising this surgical intervention.

MATERIAL AND METHODS. A representative study was carried out in 150 patients with inferior turbinate hypertrophy, who have undergone radiofrequency turbinotomy and have been controlled rhinomanometrically after a 2 months interval.

RESULTS. The rhinomanometric evaluation performed preoperatively and two months postoperatively compared the results in terms of: nasal air-flow, vertex resistance (VR) and effective resistance (Reff). The nasal air-flow measured at 150 Pa increases statistically significantly 2 months after surgery. At the same time, the inspiratory logarithmic vertex resistance mean value decreases from 1.12 before surgery to 0.83 two months postoperatively. The same good results can be found for the mean value of the logarithmic effective resistance, with a decrease well below half of the initial value.

CONCLUSION. Following the personal experience and after evaluation of the presented data, it can be concluded that radiofrequency turbinotomy, when performed as outlined above, is a safe and highly effective treatment for functional congestions of the inferior turbinates.

KEYWORDS: radiofrequency turbinotomy, 4-phase-rhinomanometry, vertex resistance, effective resistance, turbinate congestion

INTRODUCTION

Nasal obstruction is one of the most frequent symptoms found in rhinology. One of the major causes of chronic nasal obstruction is represented by the inferior turbinate hypertrophy. Many treatment modalities have been developed for chronic rhinitis. In most cases, medical treatment like nasal topic steroids, antihistamines, decongestants, can provide good results. In those cases with no response, surgery is the therapy of choice[1,2].

The surgical treatment of the turbinates is one of the most popular procedures in rhinology. In the last comprehensive review, Hol and Huizing cited 141 authors of at least 13 surgical techniques, among them “Thermal Coagulation – Electrocautery”, and pointed out that this method was suggested as early as 1845 by Heider from Vienna and Crusel from St. Petersburg[3]. Among others, they mentioned Beck (1930) as the first who carried out a submucosal diathermy by a monopolar technique[4], while Hurd (1931) was the first to perform the bipolar intraturbinal diathermy[5].

Woodhead et al.(1989) saw that the effect of submucous diathermy is achieved by coagulation of the venous sinusoids within the turbinates, leading to submucosal fibrosis[6]. Thus, the main difference between cautery or superficial application of laser energy and the contemporary submucosal application of electric energy is the preservation of the mucosal surface including the mucociliary function (Figure 1). The introduction of radio waves replacing HF-energy and the application of bipolar electrodes furthermore reduced remarkably the thermal side effect at the surface because of the short distance of their affectivity.

Radioturbinotomy is defined as “Submucous tissue ablation by targeted low-power radiofrequency energy”. Definitions as “Somnoplasty, RaVor, Rfitt” or similar are incorrect

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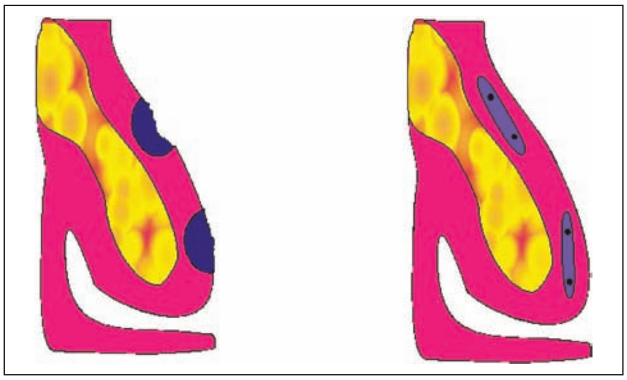


Figure 1 Different effect of cautery (left) and bipolar radiofrequency application (right) on the turbinate mucosa

because they define combinations of electrosurgical generators and electrodes of different companies, by which similar treatment effects can be achieved. Instead, in medical documents or scientific publications, "turbinotomy" should be better used, and the type of electrode and applied energy should be mentioned because of the exchangeability between most of the generators and electrodes.

In this paper, the authors present the basics and principles of radiofrequency turbinotomy and their experience in practising this surgery intervention.

MATERIAL AND METHODS

1. Important technical details

In interstitial applications of radiofrequency, preference should be given to bipolar applications rather than to monopolar electrodes. Monopolar electrodes almost produce circular lesions, are ineffective within the typical "open circuit" as used for superficial lesions in radiofrequency surgery and bad controllable in a closed circuit with a neutral electrode. Bipolar electrodes are available as concentric electrodes mounted behind each other (e.g. Celon) or as parallel needle electrodes of different lengths. The authors use parallel needles of 25 mm working length and a distance of 2 mm. (Ellman, Rhinolab). These electrodes produce a longitudinal lesion with a diameter according to Figure 2.

The best frequencies to be applied are 0.6 to 1.7 MHz. These frequencies are available with many generators of HF- and RF-energy because the difference between "RF" and "HF"-energy is not precisely agreed upon. The applied energy should be around 200 Ws (Joule). Manuals of all

Figure 2 A, B. Bipolar parallel Needle-Electrode for RF-Turbinotomy (Rhinolab/Germany)

generators must have diagrams included, from which the settings on the generator can be read. The same effect in the tissue will appear after an application of 20 W for 10 sec or 10 W for 20 seconds. This amount of energy is sufficient to block the vessels and to produce a scar that reduces the functional volume of the turbinate. A big advantage is the automatic limitation of the delivered energy by measurement of the tissue impedance, available in different contemporary generators.

The electric resistance of every tissue - in particular of tissue with high water or blood content - increases with increasing exsiccation. If the desired degree of exsiccation is reached and the impedance reached a level where a further increase is not possible anymore, the delivery of energy gets stopped. In more voluminous tissue, the delivery of energy between two needle bipolar electrodes is self-limiting because of the insulation effect of dry tissue.

2. Indications

The correct indication for Radioturbinotomy (RF-turbinotomy) is the "Pathological Functional Turbinate Congestion". The frequently used terms "turbinate hyperplasia", "turbinate hypertrophy", "rhinitis vasomotorica" are not in accordance with the definitions as used in general pathology or pathophysiology. This means that skeletal variations of the turbinates, which may cause functional disturbances, should be primarily excluded as indication for RF-turbinotomy, if there are no signs of a congestive mucosal disturbance. The most effective indications are: chronic or chronic-recurrent congestion of the nasal mucosa as manifestation of a perennial allergic rhinopathia, nasal hyperreactivity with congestion without recognizable background ("vasomotor rhinitis") and the drug induced hyperreactivity ("rhinopathia medicamentosa", "Imidazoline-Rhinitis"). If mucosal congestion is a symptom of a chronic rhinosinusitis, the primary treatment of the sinuses is mandatory. A new indication is also the recurrent nasal congestion during the night and normal function during the day (rhinopathia nocturna).

Apart from the state-of-art diagnosis of an allergic rhinopathia, the safest diagnostic method with reproducible quantitative information is the 4-Phase-Rhinomanometry carried out as decongestion test, before and 10 minutes after application of 0.1% spray solution of xylo-metazoline, following the recommendations of the International Standardization Committee for the Objective Assessment of the Upper Airway (ISOANA). The typical pattern of hyperreactivity is the big distance between the 1st and 2nd measurement (Figures 3, 4).

While "classic" rhinomanometry recommended as standard in 1984 the flow at a differential pressure of 150 Pa as the main value for diagnostic decisions, 4-phase-rhinomanometry considers the energy of breathing within the entire breath. Presuming that the general shape of a rhinomanometric curve corresponds to a loop rather than to a simple line, it follows that the differences between the ascending and descending curve parts in inspiration can differ more than 100%. Statistical investigations show in histograms of big cohorts that these values are not normally distributed.

The Effective Resistance and the Vertex Resistance, i.e. the resistance as measured at maximal flow of a normal breath, are strongly correlated with each other, except if "valve phenomena" influence the resistance in phase II of inspiration. The logarithmic transformation of VR and Reff is normally distributed, thus allowing equidistant classes of nasal obstruction as shown in Table 1. LogReff and LogVR could be shown in big statistics as related to the sensing of obstruction or impaired nasal breathing by the patient.

Referring to the numerical evaluation with the new parameters LogReff and LogVR (Table 1), RF-turbinotomy should be performed when the measured resistance is above 1.0 or the mucosal component exceeds 1 degree of obstruction in addition to the skeletal component.

Acoustic rhinometry can also indicate a mucosal swelling, but does not release quantitative information. CT or MRI may be impressive, as shown in Figure 5, but are not acceptable from the economic point of view. CT and MRI do not deliver functional information about the ventilator function of the nose.

It should be mentioned that allergic children with severe nasal obstruction caused by persistent allergy have a great benefit from the RF-turbinotomy. It can be done together with a necessary adenoidectomy and/or tonsillotomy at the beginning of a desensitization treatment, bridging the time before the onset of the immunization effect.

3. Procedure

In adults, RF-turbinotomy can be carried out as outpatient procedure under local anesthesia. Our procedure - proved 13 years ago - starts with a topical anesthesia with vasoconstrictors added. In that way we obtain best insights to the nasal interior, avoiding diagnostic errors. After that, 2-4 ml of 2% articaine or another anesthetic without vasoconstrictors are injected with a thin needle into the inferior turbinate. In this way the turbinate is "blown up" and a good subcutaneous distribution of the applied energy is provided. After that, the first energy application follows, starting with a "test shot" at the head of the turbinate, making sure that the system is properly working and avoiding bleeding after the removal of the bipolar electrode. The electrode is inserted to the full length of 3 cm up to the insulation and then activated with the settings mentioned above. At the

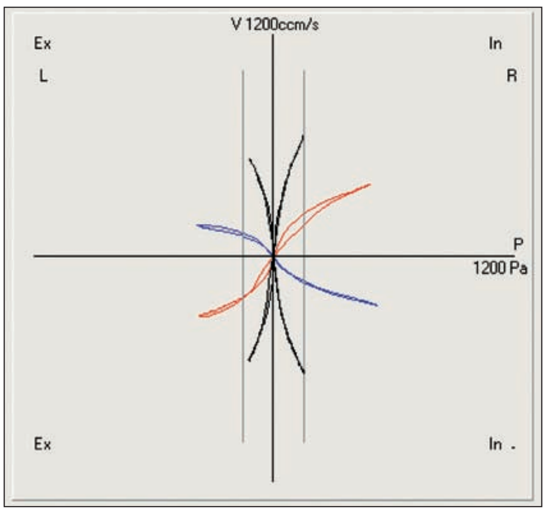


Figure 3 Typical pattern of a rhinomanometric decongestion test in drug- induced hyperreactivity („Rhinopathia medicamentosa"). The distance between the first measurements (red/blue) and the second measurements (black) is showing the high degree of pure mucosal congestion

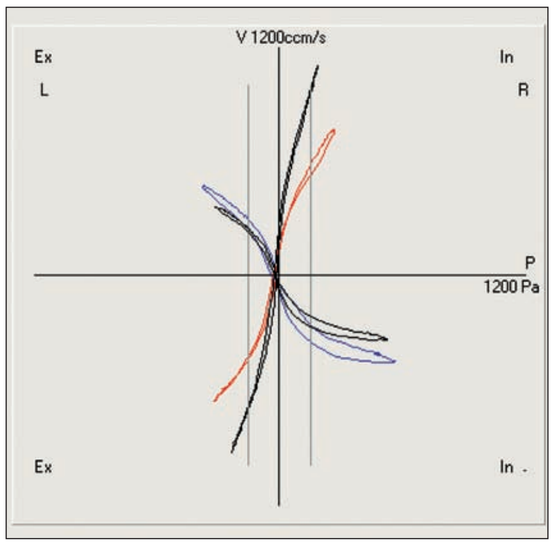


Figure 4 Septal deviation to the left side with additional mucosal congestion. RF-Turbinotomy should be carried out in addition to septoplasty

Table 1
Nasal obstruction classification according to LogReff (effective resistance) and LogVR (vertex resistance) values

	Log10R(VR, REFF)	Obstruction, Resistance	Conductance
1	<= 0.75	very low	very high
2	0.75 - 1.00	low	high
3	1.00 - 1.25	moderate	moderate
4	1.25 - 1.50	high	low
5	> 1.50	very high	very low

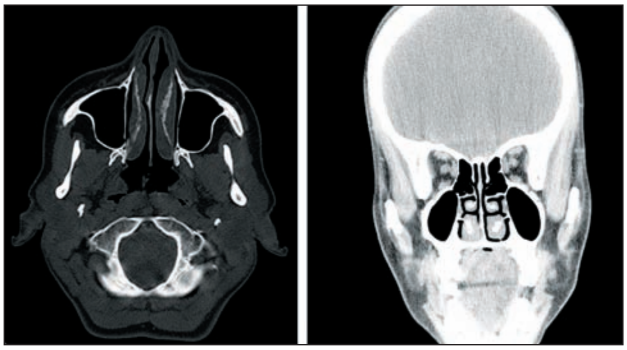


Figure 5 Cranio-facial CT scan - axial and coronal slices - inferior turbinate congestion

end of the activation time, the electrode may be drawn backwards, which leads to a higher energy delivery at the head of the turbinate that is the most reactive zone of the turbinate. While the first application is done at the most bulging part, i.e. medially, the second application should follow at the back of the turbinate, from where the vessels are inserted into the sinusoids.

The insertion of the double-needle has to follow the injection *immediately*, because the resorption in the turbinates is rapid, thus providing an overpressure in the injection. Packing after RF-turbinotomy is generally not necessary.

4. Follow-up

RF-turbinotomy can be followed by instant decongestion of the turbinate with some dryness in the nose within 1-2 weeks; but, mostly, an exudation of fibrin or sticky mucous starts, which should be sucked off on the 1st or 2nd postoperative day. The decongestive effect should be approximately completed after 4 weeks. At this time, the success of the procedure can be confirmed by rhinomanometry (Figure 6). In case of dryness, saline solution or nose drops may be helpful, but are not mandatory.

In our experience, a repeated treatment when using the technique above is not necessary. In cases with recurrent mucosal obstruction, it should be carefully investigated if there are other causes, for example a persistent allergy, polyps, septal deviation or chronic rhinosinusitis. Generally, the effect of the RF-turbinotomy is long lasting through the years.

5. Complications and postoperative results

The personal experience of the authors refers to more than 2000 procedures in 3 centers over 13 years, carried out by the same technique as described above. Three complications occurred among the first 45 cases by bony sequestration, followed by bleeding after 9, 13 and 20 days. These complications were clearly due to high energy, because the correct amount of energy was not sufficiently published at that time (1999-2000).

After having adjusted the energy delivery, no complication has occurred anymore or has been reported to the author (KV).

To control the effectiveness of radioturbinotomy, a representative study was carried out in 150 cases, which have undergone the procedure above and have been controlled rhinomanometrically after a 2 months interval.

RESULTS

The rhinomanometric data obtained preoperatively and 2 months postoperatively compare the results of nasal airflow at 150 Pa (Phase 1 and 2 in 4PR), Logarithmic Vertex Resistance (LogVR) and Logarithmic Effective Resistance (LogReff). The main results are summarized in Table 2. The main results are depicted in Graphs 1 to 3.

The nasal air-flow was measured at 150 Pa pressure on the ascending inspiration curve, allowing a comparison with elder publications using rhinomanometry as diagnostic tool. The first evaluation of our patients before surgery revealed a mean air-flow value of 213 ccm/s before decongestion and of 343 ccm/s after decongestion. As seen in Graphic no. 1, the measurement performed 2 months after surgery showed an important increase in the airstream both

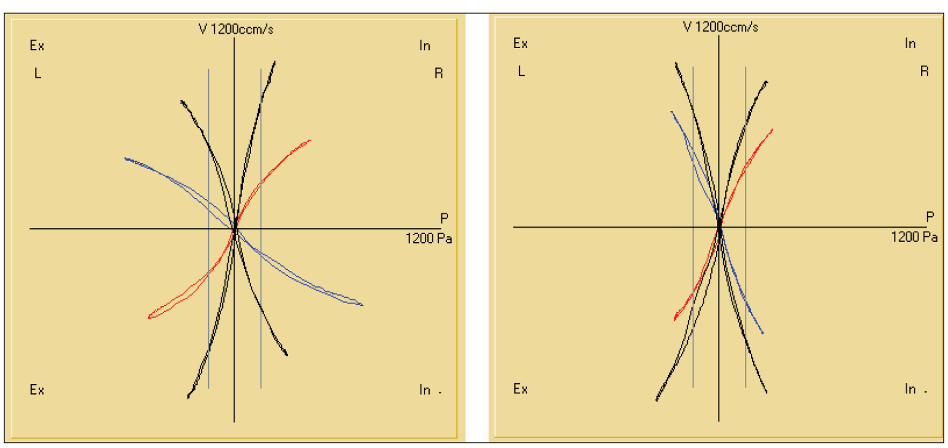


Figure 6 A and B: Typical hyperreactivity before and after RF-turbinotomy. 3 weeks postoperatory rhinomanometry

before (362ccm/s) and after (437ccm/s) decongestion. The average increase of the air flow as induced by RF-turbinotomy is even higher than the effect of the decongestant before surgery.

The positive results of RF-turbinotomy on the increase of nasal air-flow could be seen in all four phases of the rhinomanometric measurement, both during inspiration and expiration (Table 2). The difference between Phase 1 (150 in1) and Phase 2 (150 in2) is significant with P <<0,01.

The results for the Logarithmic Vertex Resistance and Logarithmic Effective are highly correlated and represented in Graphs 2 and 3.

Vertex resistance (VR) is the resistance of the airstream in the maximum flow during inspiration and expiration. The preoperative mean value of the inspiratory logarithmic vertex resistance (logVR) was of 1.12 at 150 Pa before decongestion and of 0.89 after decongestion. Rhinomanometric measurement performed 2 months after surgery revealed a decrease of LogVR to a mean value of 0.83 before and of 0.71 after decongestion ($p<0.05$).

The effective resistance (Reff) introduced in rhinomanometry is used to evaluate the normal breathing and it is in a close relationship with the subjective perception of nasal obstruction (VAS). The rhinomanometric assessment of the Effective Resistance (Vogt and Hoffrichter 7) performed before RF-turbinotomy evaluated a total logarithmic effective resistance (logReff) mean value of 1.087 before decongestion and of 0.828 after decongestion. The postoperatory measurements showed the decrease in logReff as seen in Graphic no. 3.

Referring to the proposed classification of obstruction for Caucasian noses as shown in Table 1, the graphs show, in average, a moderate degree of congestion before surgery, which can be reduced by nose drops. The effect of radioturbinotomy is comparable with the decongestant effect of xylometazoline. After surgery, the nose did not lose its reagibility: after spraying, conductance was higher than before.

DISCUSSIONS

Radiofrequency surgery used for reducing the volume of the soft tissue was first used by Powell et al. in treating patients with sleep-disordered breathing[8]. Later on, the radiofrequency energy was introduced for treating turbinate hypertrophy.

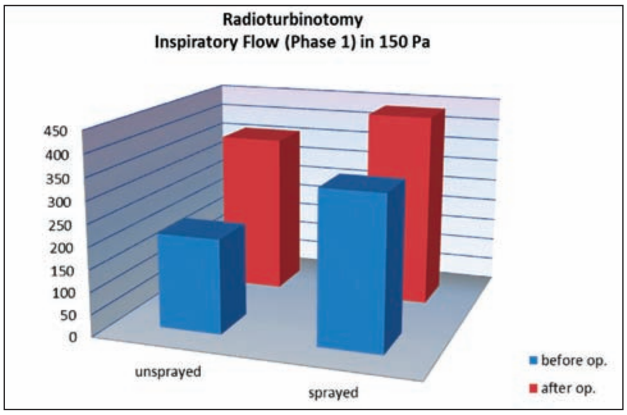
Being a surgery technique which preserves normal function of the nasal mucosa and mucociliary clearance[1,9], RF-turbinotomy is now widely used in rhinology.

There are many studies showing an important improvement in the severity of nasal obstruction in 81 to 100% of the cases[1,10]. In a study published in 2000, Speciale et al. related their experience on 240 patients with inferior turbinate hypertrophy treated with radiofrequency energy. Their results showed that in all patients (100%) nasal obstruction was subjectively improved at 1 and 3 weeks[11].

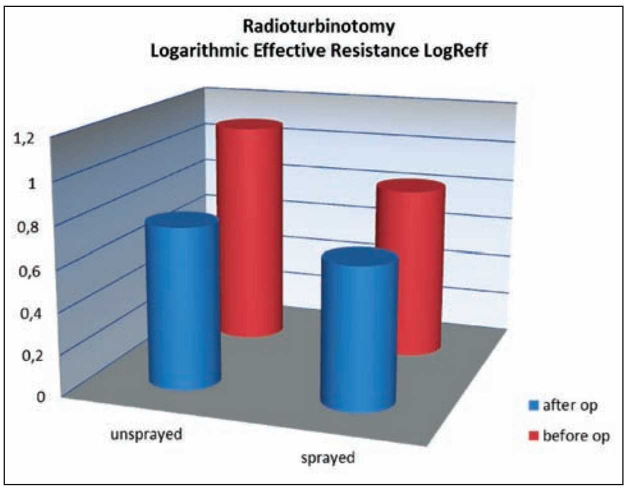
The use of rhinomanometry in evaluating the efficacy of radiofrequency turbinotomy was also proved by Barbieri et al. in a study performed on 1689 non-allergic patients with inferior turbinate hypertrophy. The anterior rhinomanom-

Table 2
Statistical results of 4-phase-rhinomanometry before and after radioturbinotomy. (Nasal airflow in 150 Pa, Log VR and Log Reff)

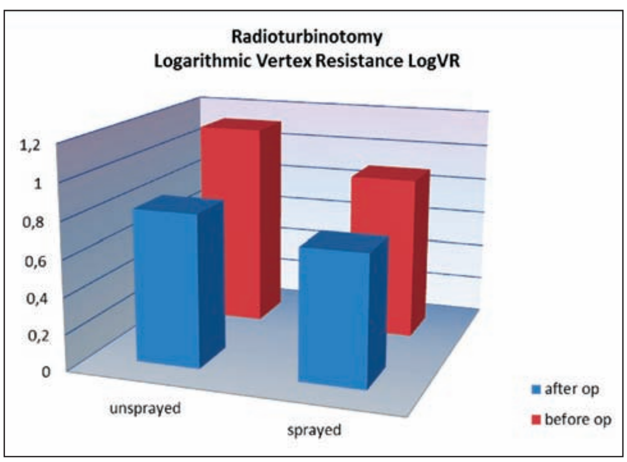
	Before Radioturbinotomy							
	Before Decongestion				After Decongestion			
	150 in1	150 in2	logVRin	logReff	150 in1	150 in2	logVRin	LogReff
Mean	213,4	180,7	1,115	1,087	343,3	320,2	0,892	0,828
Standard error	16,7	17,5	0,047	0,049	22,3	22,1	0,041	0,032
Median	185,0	149,0	1,177	1,111	327,0	282,0	0,853	0,869
Standard deviation	134,5	141,4	0,389	0,397	180,2	179,7	0,337	0,264
Minimum	17	-72	-0,063	-0,086	29	59	0,206	0,188
Maximum	842	822	2,060	2,157	910	897	2,527	1,475
N	65	65	68	67	65	66	68	67
	After Radioturbinotomy							
	Before Decongestion				**After Decongestion**			
	150 in1	**150 in2**	**logVRin**	**logReff**	**150 in1**	**150 in2**	**logVRin**	**logReff**
Mean	361,6	334,1	0,826	0,772	437,2	409,1	0,716	0,675
Standard Error	21,9	24,0	0,036	0,037	23,6	26,2	0,034	0,033
Median	319,0	309,5	0,800	0,751	404,0	388,0	0,694	0,624
Standard Deviation	176,3	192,1	0,300	0,303	188,7	209,6	0,283	0,273
Minimum	71	70	0,002	-0,036	111	-26	0,193	0,121
Maximum	874	889	1,646	1,597	960	921	1,513	1,442
N	65	64	68	67	64	64	68	67



Graphic 1 Variations in nasal air flow at 150 Pa



Graphic 2 Logarithmic Effective Resistance values before and after surgery



Graphic 3 Logarithmic Vertex Resistance values before and after surgery

etry performed at 1 and 12 months after surgery revealed a statistically significant decrease in the mean values of the nasal total resistance ($p<0.05$)[9]. All the literature data can be associated with our study results.

In one of their studies, Smith et al. showed that almost 90% of the reduction occurred in the first 3 weeks, becoming 100% after 8 weeks[12]. Their results are similar with ours, the patients included in our study being evaluated at two months after surgery.

Critical evaluation of the results of surgery by 4-phase-rhinomanometry allows preoperatively the visualization of the effect of nasal mucosa and nasal valve. For medicolegal reasons, it is not only important to use diagnostic methods with a reliable physical and statistical fundament. It is also important that such methods are related to the feeling of obstruction in big cohorts. The classification above allows the relative comparison of pre- and postoperative findings, as well as the critical evaluation of subjective complaints within its ethnical group.

CONCLUSIONS

Following the personal experience and after evaluation of the presented data, it can be concluded that radiofrequency turbinotomy, when performed as outlined above, is a safe and highly effective treatment for functional congestions of the inferior turbinates. 4-Phase-Rhinomanometry can be recommended both for the selection of patients and the control of the outcome in the framework of Evidence-Based Medicine.

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