Prognostic Value of Anterior Rhinomanometry in Diode Laser Turbinoplasty

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Objective: To identify objective criteria predicting the success of diode laser-assisted turbinoplasty.

Design: Prospective before-and-after trial with follow-up of 8 weeks.

Setting: Outpatient department of a tertiary referral center.

Patients: Forty-one patients with nasal obstruction caused by hyperplastic inferior nasal turbinates.

Intervention: Active anterior rhinomanometry with and without decongestion was used to assess the patients both before and after diode laser-assisted turbinate surgery. Surgery was performed under local anesthesia in “contact mode” using a continuous diode laser. In addition, a questionnaire assessed the subjective postoperative benefit.

Main Outcome Measures: Presurgical effect of topical decongestion was correlated with postoperative improvement of nasal airflow and patients' subjective satisfaction.

Results: Turbinoplasty significantly improved the mean (SD) nasal airflow by 37.1% (52.4%) (95% confidence interval [CI], 20.6%-53.7%), from 509.8 (189.2) cm³/s (95% CI, 450.1-569.5) to 660.9 (285.4) cm³/s (95% CI, 570.8-751.0) (P < .001). There was no significant correlation between patients' subjective satisfaction and improvement of nasal airflow postoperatively (r = −0.01; P = .93). There was a strong correlation between the presurgical effect of topical decongestion and the improvement of nasal airflow by surgery (r = 0.42; P = .01). The correlation was even stronger when the absolute values were adjusted by the preoperative nasal airflow baseline (r = 0.55; P = .01).

Conclusions: Rhinomanometry with topical decongestion has a high predictive value for the objective outcome of diode laser–assisted turbinoplasty. Thus, performing a rhinomanometry with topical decongestion and calculating the relative spread of decongestion can help to estimate the patients' benefit from diode laser–assisted turbinoplasty.


Diode laser-assisted turbinate surgery is a well-known technique for improving nasal airflow. It is indicated in cases of hypertrophic thickening of the mucosa of the inferior turbinates due to conditions such as allergic rhinitis and vasomotor rhinitis.

The nasal lining is composed of 3 layers: an outer layer of respiratory mucosa, a middle submucosal layer, and an inner perichondrial or periostal layer. The submucosal layer is largely made up of venous sinusoids, which are capable of engorging with blood, causing swelling of the nasal mucosa. The degree of distension of these venous sinusoids is controlled mainly by the sympathetic nervous system and alters in response to various physiologic and pathologic factors. Thus, assessing the degree of hypertrophy of the submucosal layer in vivo is always influenced by physiologic factors like the nasal cycle and the ambient temperature. Laser-assisted turbinate surgery achieves its effect by causing submucosal scarring and obliteration of the venous sinusoids. Thus, engorgement is largely abolished, and the nasal mucosa is rendered relatively thin.

This pathomechanism supports the clinical impression that the effectiveness of turbinate surgery in improving nasal airflow depends on the hypertrophy of the submucosal layer. However, to our knowledge, this impression has not yet been confirmed by objective measurements in a clinical trial. The hypertrophy of the submucosal layer can be estimated by comparing the nasal flow by active rhinomanometry with and without nasal
decongestion using xylometazoline hydrochloride–containing nose spray.

We used the results of presurgical rhinomanometry, with and without nasal decongestion, to predict the post-surgical outcome of diode laser turbinoplasty. Correlations between subjective postoperative ratings and objective outcome were also analyzed.

**METHODS**

Forty-one patients were evaluated, 10 women and 31 men aged 13 to 71 years, with a mean (SD) age of 42.4 (15.1) years. The patients were diagnosed as having a nasal obstruction syndrome, vasomotor rhinitis. After taking the medical history and performing an examination, any patients with nasal or sinus infection, polyps, severe deviation of the nasal septum, previous nasal surgery, or allergies reported in the medical history were excluded. Patients were requested to stop the use of topical nasal treatment during the week before the intervention and before the postoperative assessment. Each patient received an active anterior rhinomanometry directly before the operation and 8 weeks later. In this method, the airflow through 1 nasal cavity and the pressure gradient across this nasal cavity are measured simultaneously at each breath as recommended by the committee report on the standardization of rhinomanometry.4

For each nasal cavity, the mean of 6 measurements was calculated. Herein, all presented airflow values are the sum of inspiratory airflow of the right and left sides of the nose at 150 pascals (Pa). The rhinomanometry was performed using a Rhino 4000M (Homoth Medizinelektronik GmbH & Co KG, Hamburg, Germany).

For topical decongestion, a nasal spray containing xylometazoline hydrochloride, 0.1%, was used twice with an interval of 5 minutes to decrease the volume of the submucosal layer. The difference between the values of the baseline rhinomanometry and the rhinomanometry after decongestion of the nasal mucosa represented the spread of decongestion, indicating the degree of present mucosal swelling. The greater this difference, the stronger was the increase in nasal airflow by decongestion.

The operation was performed in our outpatient department under local anesthesia by 1 medically qualified physician. The output power of the diode laser (Ceralas D15 Evolve; CeramOptec GmbH, Bonn, Germany) (wavelength, λ=980 nm) was set to 8 W in a continuous-wave mode. In “contact mode,” 3 to 4 laser light applications were performed by drawing the fiber from the posterior to the anterior part of the inferior turbinate. A total energy of 100 J was applied per inferior turbinate. Postoperatively, the nasal cavity was filled with antibiotic ointment, and the patients were prescribed nasal irrigation with saline and nasal ointments for 4 weeks.

All patients received a second rhinomanometry after 8 weeks and were also asked for subjective ratings on this occasion. The questionnaire contained questions about complications (postoperative pain, bleeding, and infections) and changes in nasal obstruction. When asked about postoperative complications, patients could provide open-format answers, but pain and bleeding were offered as examples. To assess the changes in nasal obstruction, patients had to choose between the following closed-format answers: deterioration, no change, temporary improvement, or constant improvement. For quantitative analysis and correlations, the responses were weighted as follows: deterioration, –1; no change, 0; temporary improvement, 1; and constant improvement, 2.

Statistical evaluation of the results was performed using SPSS statistical software (version 15.0; SPSS Inc, Chicago, Illinois); Wilcoxon signed rank tests identified significant changes of nasal resistance before and after surgery, and Spearman rank correlation coefficient (r,) was used to correlate the results of the rhinomanometry with the outcome of the endonasal diode laser–assisted turbinate surgery. The 2-sided significance level was set to P=.005. The 95% confidence intervals (CIs) were reported and rated as clinically meaningful difference.

**RESULTS**

No nasal packing was necessary, and no immediate or delayed complications (eg, major bleeding) were observed or reported by the patients. In the questionnaire completed 8 weeks after turbinoplasty, 18 of 41 patients (43.9%) reported a constant improvement, 12 (29.3%) experienced a temporary improvement of nasal obstruction, and 5 (12.2%) experienced deterioration.

In the objective measurement by active anterior rhinomanometry, 32 of 41 patients (78%) showed a higher nasal airflow 8 weeks after the operation. This difference in mean nasal airflow is statistically significant (mean [SD] preoperative measurement, 509.8 [189.2] cm3/s; 95% CI, 450.1-569.5); postoperative measurement: 660.9 [285.4] cm3/s; 95% CI, 570.8-751.0; difference: 151.1 [242.3] cm3/s; 95% CI, 74.3-227.9) (z=−3.80; P < .001).

**Figure 1** plots the preoperative nasal airflow against the postoperative values. It also includes patients’ subjective evaluations of postoperative nasal airflow using different symbols for the different satisfaction scores. There was no significant correlation between patients’ subjective satisfaction and their objective improvement of postoperative nasal airflow (r = −0.01; P = .93).

The difference between the nasal airflow before and after decongestion is called the absolute spread of decongestion. It is dependent on the thickness of the submucosal layer and the effect of the decongestion on it. Before decongestion, the mean (SD) preoperative airflow measured at 150 Pa was 509.8 (189.2) cm3/s (95%
Diode laser turbinoplasty led to a mean (SD) significant improvement of nasal airflow of 37.1% (52.4%) (95% CI, 20.6%-53.7%) 8 weeks after surgery. A total of 73.2% of patients reported a temporary or lasting improvement of nasal obstruction, and only 12.2% experienced a deterioration. Severe complications did not appear in our study. These results are consistent with preliminary data.1

The easy and short duration of the procedure, the good adverse event profile, and the subjective and objective improvement of nasal airflow indicate that laser turbinoplasty is a safe and effective treatment for patients with hyperplastic inferior nasal turbinates, once the cause of turbinate hyperplasia has been determined and nonsurgical treatment of turbinate dysfunction (ie, decongestants, antihistamines, intranasal corticosteroids, allergen avoidance) has failed.3

The lack of correlation between patients’ subjective postoperative satisfaction and the objective measurements by rhinomanometry is a well-known phenomenon and has already been described in other publications.4-9 Other aspects, such as laminar or turbulent flow of the air in the nose or the sensibility of the mucosa, seem to have a stronger influence on subjective evaluations than the objective nasal airflow measured in this study. A randomized control study with sham operations, for example, performed with very low or even no energy on the laser, would be helpful to elucidate the proportion of a placebo effect.

The correlations found in this study between the spread of decongestion preoperatively and the postoperative improvement by diode laser–assisted turbinoplasty offer possibilities of interpretation and could be useful in clinical practice.

From the pathophysiologic point of view, the correlation—and with it the prognostic value of the spread of nasal decongestion measured by rhinomanometry—is obvious: endonasal diode laser–assisted turbinate surgery improves the nasal airflow by causing submucosal scarring and obliteration of the venous sinusoids. Consequently, if there is a thick submucosal layer, the laser can substantially improve the nasal airflow. In contrast, if the nasal resistance is caused by cartilage obstacles or narrow nostrils, the spread of nasal decongestion should be small, and little improvement can be expected by endonasal diode laser–assisted turbinate surgery.11

The significant correlation \( r_s = 0.42; P = .01 \) between the preoperative absolute spread of decongestion and the postoperative absolute improvement is illustrated in Figure 2.

To view the absolute airflow values in relation to the anatomy of the nose, the absolute spread of decongestion is divided by the absolute preoperative airflow before decongestion. The resulting relative spread of decongestion has a mean (SD) rate of 85.0% (91.1%) (95% CI, 56.2-113.8). Similarly, the absolute improvement is also divided by the absolute preoperative airflow before decongestion. The resulting relative improvement by laser turbinoplasty has a mean rate of 37.1% (52.4%) (95% CI, 20.6%-53.7%). The correlation between relative spread of decongestion and relative improvement is \( r_s = 0.55 \) \( (P = .01) \) (Figure 3), and thus is stronger than when calculated with absolute values. Again, there is no significant correlation between patients’ subjective satisfaction and relative improvement of nasal airflow postoperatively \( r_s = 0.18; P = .26 \). The goodness of fit for the linear functions of preoperative spread of decongestion and postoperative improvement also increases from \( R^2 = 0.13 \) to \( R^2 = 0.26 \) when switching from absolute data to relative data.

**Figure 2.** Significant correlation \( r_s = 0.42; P = .01 \) between the preoperative absolute spread of decongestion and the postoperative absolute improvement. The fitting of linear function to the absolute data is shown as a dashed line \( (R^2=0.13) \).

**Figure 3.** Improved significant correlation \( r_s = 0.55; P = .01 \) between the preoperative relative spread of decongestion and the postoperative relative improvement. Also, improved fitting of linear function to the relative data is shown as a dashed line \( (R^2=0.26) \). There is no significant correlation between patients’ subjective satisfaction, indicated by different symbols, and relative improvement of nasal airflow postoperatively \( r_s = 0.18; P = .26 \). Thresholds for treating patients are illustrated as dashed vertical lines at relative spread of decongestion of 50% and 100%.

[Graphs and figures are not transcribed but are referenced and described in the text.]
Decongestion with a sympathomimetic topical medication is an easy and effective way to determine the potential causes of a high nasal resistance. A strong improvement in nasal airflow after decongestion is the direct objective correlate of a reduced submucosal layer with constricted venous sinusoids. To our knowledge, the results of the present study for the first time provide evidence for this well-known clinical impression.

The correlation between the preoperative spread of decongestion and the outcome of endonasal diode laser–assisted turbinate surgery can be interpreted as statistical evidence for the previously described physiologic effect and demonstrates the high predictive value of measuring changes between nasal air flow before and after nasal decongestion with xylometazoline. Using relative values (adjusted by the preoperative nasal airflow baseline) further improves this correlation and the predictive value. Therefore, the probability that the patient will benefit from diode laser–assisted turbinate surgery can be estimated by performing a rhinomanometry with topical decongestion and calculating the relative spread of decongestion preoperatively. The preoperative and postoperative measurements of the nasal airflow by active anterior rhinomanometry are influenced by physiologic and pathologic changes like the nasal cycle or infections. This might explain a relatively weak correlation between the spread of decongestion and postoperative benefit in our study. Measurement of the nasal airflow at different daytimes or successive days could possibly reduce this drawback and promises to improve the statistical correlation might be fortified; however, this would hardly be practicable in clinical routine.

Our results suggest that diode laser–assisted turbinate surgery is a safe and effective way of improving nasal airflow. Furthermore, the rhinomanometrically measured spread of decongestion is a well known but, until now, not evidence-based predictive marker for the outcome of turbino-plasty. We provide significant data showing the predictive value of rhinomanometry with decongestion for postoperative improvement of nasal flow. We recommend performing anterior active rhinomanometry without and then with decongestion in any candidate for laser-assisted turbino-plasty. Before deciding on the operation, the patient should be informed not only about the adverse event profile but also of the probability of a postoperatively improved airflow, based on his or her personal spread of decongestion.13 However, the discrepancy between subjective and objective improvement of nasal airflow should also be mentioned. In our study, if we had treated only patients with a relative spread of decongestion greater than 100%, all patients would have objectively benefited from the treatment, although only 8 of the 10 patients (72%) reported a subjective benefit (Table). Similarly, if we had treated only patients with a relative spread of decongestion greater than 50%, 17 of 21 patients (81%) would have objectively benefited from the treatment, but a nearly unchanged percentage of 71% (15 of 21) would have reported a subjective improvement. Based on the limited sample size of our study, we do not recommend a fixed threshold for all patients but instead recommend using the relative spread of decongestion as one indicator for the usefulness of laser-assisted turbino-plasty. Based on our results, additional studies with a longer follow-up period and a control group should follow to verify the validity of the described correlation and the effectiveness of the treatment even in the long term.

Submitted for Publication: December 1, 2009; final revision received March 21, 2010; accepted May 18, 2010. Correspondence: Gerd Fabian Volk, MD, Department of Otorhinolaryngology, Friedrich-Schiller-Universitat, Lessingstraße 2, D-07743 Jena, Germany (fabian.volk@med.uni-jena.de).

Author Contributions: All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Volk, Pantel, and Wittekindt. Acquisition of data: Volk and Pantel. Analysis and interpretation of data: Volk and Guntinas-Lichius. Drafting of the manuscript: Volk, Pantel, and Wittekindt. Critical revision of the manuscript for important intellectual content: Volk, Pantel, and Guntinas-Lichius. Statistical analysis: Volk. Obtained funding: Volk and Guntinas-Lichius. Administrative, technical, and material support: Volk and Pantel. Study supervision: Guntinas-Lichius and Wittekindt. Financial Disclosure: None reported.

Funding/Support: This study was financially supported by the Interdisciplinary Center for Clinical Research (IZKF) of the University Hospital Jena.
REFERENCES