Correlation Between Subjective and Objective Results in Nasal Surgery

George L. Murrell, MD, FACS

Abstract

Background: There is a lack of medical literature demonstrating a positive correlation between subjective and objective results in functional nasal surgery.

Objective: The author presents his experience measuring nasal function subjectively and objectively before and after functional nasal surgery.

Methods: Between March 2011 and June 2012, a total of 119 consecutive patients with nasal obstruction underwent rhinoplasty with a variety of septorhinoplasty techniques. Results were evaluated with a scientifically validated patient questionnaire as well as pre- and postoperative rhinomanometry measurement comparisons. Preoperative and postoperative rhinomanometry measurements were standard protocol, and the rhinomanometry measurements were designed as a prospective study.

Results: Ninety of the 119 patients had postoperative rhinomanometry measurements that could be compared with preoperative values, and these patients were included in the study. Statistically significant subjective and objective functional improvements were reported in 98.9% and 95.6% of patients, respectively, while 94.4% of patients had both subjective and objective statistically significant functional improvement. A statistically significant correlation between the subjective and objective improvements was noted.

Conclusions: The findings provide statistically significant evidence to support surgical treatment of nasal obstruction.

Level of Evidence: 3

Keywords

nasal obstruction, airway, rhinoplasty, septorhinoplasty, functional nasal surgery, NOSE scale, rhinomanometry

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Evidenced-based medicine, the realm in which modern health care operates, dictates integration of the provider’s clinical/surgical expertise, the individual patient’s needs and preferences, and the application of the best, most current medical knowledge found in the literature. The adage that one cannot manage what one does not measure has value. Assessment of nasal airway function can be performed with both subjective and objective techniques. The medical literature is replete with reports of both techniques but is sparse when assessing correlation between subjective and objective techniques. This article reports the author’s experience using both subjective and objective nasal function measurements, including correlation between the 2 types of measurements. A literature review and presentation of a representative case are included.

METHODS

This project was approved by the corresponding Institutional Review Board from the US Navy.

Dr Murrell is a facial plastic surgeon at the Uniformed Services University of the Health Sciences in Bethesda, Maryland; he is also Clinical Assistant Professor of Surgery at The School of Medicine and Health Sciences, George Washington University, Washington, DC.

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Corresponding Author:
Dr George L. Murrell, 1200 First Colonial Rd, Virginia Beach, VA 23454, USA.
Email: glmurrellmd@gmail.com
Over a 15-month period (March 2011 through June 2012), 119 consecutive patients with nasal obstruction were treated by the author with functional nasal surgery, including septoplasty, turbinate reduction, and various rhinoplasty techniques. Patient nasal function was evaluated preoperatively and postoperatively with both subjective and objective measurements. Surgical treatments were dictated by preoperative findings.

Subjective nasal function was measured by the Nasal Obstruction Symptom Evaluation (NOSE) scale from the American Academy of Otolaryngology–Head and Neck Surgery Foundation (AAO-HNSF). Two symptoms were given a score from 0 to 4; the total was multiplied by 5 to yield a 0 to 100 scale, with 0 being asymptomatic (Table 1).

Objective nasal function was measured with rhinomanometry (GM Instruments; Kilwinning, Scotland). Rhinomanometry is the only quantifiable objective measure of nasal function currently available. Posterior rhinomanometry tests, in which patients hold a mask to their face and place a small tube in their mouth, were administered. The rhinomanometer measures air pressure and rate of airflow to calculate resistance. By rhinomanometric convention, 4 nasal breath cycles were recorded with resistance calculated at 75 Pascals during inspiration.

Patients were given the NOSE questionnaire and underwent rhinomanometry preoperatively and at 1, 3, 6, and 12 months after surgery. Preoperatively, rhinomanometry was performed both before and 10 minutes after decongesting nasal spray (oxymetazoline) was given. As measured by rhinomanometry, a 30% reduction in nasal resistance is considered indicative of a good response to decongesting spray. This, in turn, indicates a good candidate for submucosal tissue reduction with powered instruments, which has been shown effective in numerous long-term Level of Evidence (LOE) category 1 studies.

### RESULTS

Over a 15-month period, 119 patients were surgically treated for nasal obstruction with a variety of techniques, including 85 septoplasties, 88 inferior turbinate reductions, 71 internal nasal valve spreader grafts, 18 external nasal valve grafts, and 2 middle turbinate reductions.

Postoperative nasal function measurements of at least 1 month were obtained in 90 of 119 patients (76%); those 90 patients were included in the final data presented here. The average follow-up was 2.96 months. The patient series included 60 men and 30 women who ranged in age from 20 to 72 years (mean, 32.3 years). Subjective improvement was measured by having each patient complete the AAO-HNSF NOSE questionnaire at 1, 3, 6, 9, and 12 months after surgery. The postoperative NOSE questionnaire score was then compared with the patient’s preoperative NOSE score. The patient’s longest-term follow-up score was used in final calculations.

Subjective improvement—a decrease in the NOSE score—was achieved in 98.9% (n = 89) of patients. Objective improvement—a decrease in nasal resistance—was achieved in 95.6% (n = 86) of patients. Improvement in both subjective and objective nasal function was achieved in 94.4% (n = 85) of patients. The 5 patients who did not exhibit improvement shared the characteristic of normal preoperative nasal resistance, so any improvement would be subtle at best. The average decrease in the postoperative NOSE score was 75%.

Comparing postoperative scores only, the average change in the postoperative NOSE score over time was 3.7 (on a 0-100 scale). Only 6 patients reported an increase in the NOSE score with longer follow-up; 16 patients reported a decrease in the NOSE score with longer follow-up, 12 patients reported no change in the NOSE score, and the remainder had a single postoperative reading. The average decrease in nasal resistance was 52%, which translated to an average increase in nasal airflow of 329%.

Regarding sequential postoperative readings, only 1 patient experienced an increase in the rhinomanometric nasal resistance value that rose above what is considered normal resistance (ie, < 0.31 Pa/mL/s). In this patient, calculated airflow still improved 355%. All other postoperative variances in nasal resistance occurred with readings falling within the normal resistance range of < 0.31 Pa/mL/sec.

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**Table 1. Patient Questionnaire From the American Academy of Otolaryngology–Head and Neck Surgery**

<table>
<thead>
<tr>
<th>Nasal Obstruction and Septoplasty Effectiveness Scale</th>
<th>Not a Problem</th>
<th>Very Mild Problem</th>
<th>Moderate Problem</th>
<th>Fairly bad Problem</th>
<th>Severe Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal congestion or stuffiness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Nasal blockage or obstruction</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Trouble breathing through my nose</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Trouble sleeping</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Unable to get enough air through my nose during exercise or exertion</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
Table 2. Decreases in the Subjective Nasal Obstruction Symptom Evaluation (NOSE) Score

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Wilcoxon P Value</th>
<th>Signed Rank P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOSE score preoperatively and 1 month</td>
<td>.0000</td>
<td>.00</td>
</tr>
<tr>
<td>NOSE score preoperatively and 3 months</td>
<td>.0000</td>
<td>.00</td>
</tr>
<tr>
<td>NOSE score preoperatively and 6 months</td>
<td>.0002</td>
<td>.00</td>
</tr>
<tr>
<td>NOSE score preoperatively and 9 months</td>
<td>.0434</td>
<td>.2190</td>
</tr>
<tr>
<td>NOSE score preoperatively and 12 months</td>
<td>.0422</td>
<td>.0830</td>
</tr>
</tbody>
</table>

Statistically significant decreases are italicized.

Table 3. Decreases in Objective Nasal Resistance

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Wilcoxon P Value</th>
<th>Signed Rank P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance preoperatively and 1 month</td>
<td>.0000</td>
<td>.00</td>
</tr>
<tr>
<td>Resistance preoperatively and 3 months</td>
<td>.0000</td>
<td>.00</td>
</tr>
<tr>
<td>Resistance preoperatively and 6 months</td>
<td>.0016</td>
<td>.0080</td>
</tr>
<tr>
<td>Resistance preoperatively and 9 months</td>
<td>.2932</td>
<td>.6870</td>
</tr>
<tr>
<td>Resistance preoperatively and 12 months</td>
<td>.1380</td>
<td>.3750</td>
</tr>
</tbody>
</table>

Statistically significant decreases are italicized.

Table 4. Correlations Between Subjective and Objective Nasal Function Measurements

<table>
<thead>
<tr>
<th>Analysis</th>
<th>No. of Patients</th>
<th>Spearman Correlation Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to NOSE score 1 month</td>
<td>72</td>
<td>0.29</td>
</tr>
<tr>
<td>Resistance to NOSE score 3 months</td>
<td>44</td>
<td>0.33</td>
</tr>
<tr>
<td>Resistance to NOSE score 6 months</td>
<td>18</td>
<td>0.32</td>
</tr>
<tr>
<td>Resistance to NOSE score 9 months</td>
<td>6</td>
<td>0.26</td>
</tr>
<tr>
<td>Resistance to NOSE score 12 months</td>
<td>5</td>
<td>0.87</td>
</tr>
</tbody>
</table>

Positive correlations are italicized. NOSE, Nasal Obstruction Symptom Evaluation.

Discussion

Nasal obstruction is a common clinical complaint. One study found that 33% of randomly sampled adults complained of nasal obstruction. It is essential for nasal surgeons to have a working knowledge of nasal anatomy, causes of nasal obstruction, components of an appropriate nasal examination, and various treatment options. An excellent and more comprehensive review of these issues than is appropriate for this article was recently published by Becker et al. The nose is the largest contributor to overall airway resistance. The most common causes of nasal obstruction include a deviated nasal septum, hypertrophied nasal turbinates, and nasal valve dysfunction (internal and/or external). The external nasal valve is formed by the cartilaginous and soft tissue components of the mobile alar wall. The internal nasal valve—the largest contributor to nasal resistance (about 50%)—is formed by the upper lateral cartilage, the nasal septum, the anterior head of the inferior turbinate, and the nasal sill. The internal nasal valve is small, with an area of less than 3/4 cm², and formed by the junction of the upper lateral cartilage with the septum. Since nasal airflow is governed by Poiseuille’s law, the flow is proportional to the cross-sectional area squared; accordingly, a small change in the cross-sectional area results in a proportionally larger change in airflow. For example, a 10% change in cross-sectional area results in a 21% airflow change.

A targeted patient history and appropriate physical examination will enable an accurate diagnosis of the nasal obstruction’s cause. In a recent article, the author surveyed attendees of the 2011 Rhinoplasty Society 16th Annual Meeting and used a literature review to propose which components should be included in the nasal examination. These components include visual inspection of the external and internal nose during quiet and forced inspiration, anterior rhinoscopy, nasal endoscopy, a patient symptom questionnaire, specific observation of the nasal valves during quiet and forced inspiration, rhinomanometry, and—if turbinate hypertrophy is suspected—response to decongesting spray.

Anterior rhinoscopy, with either a headlight or head mirror, is considered an essential, universal part of nasal examinations. Anterior rhinoscopy allows direct examination of any mid-to-anterior nasal structures or abnormalities (eg, most septal deviations, turbinates, nasal mass recognition, tissue response during quiet and forced inspiration). Nasal
Figure 1. (A) Preoperative frontal view of a 20-year-old man, 6 years following septrhinoplasty in South America, showing a crooked nose, left greater than right middle vault collapse, and alar retraction. (C) Preoperative lateral view. (E) Preoperative submental view, showing alar notching. (G) Intraoperative view, showing 1 spreader graft on the right, 2 spreader grafts on the left, and a left alar graft, placed via an endonasal approach. The patient also had a septoplasty performed. (H) Intraoperative view, showing harvested right cymba concha composite graft, with full-thickness skin graft reconstruction from the postauricular area. The composite cymba concha graft was split lengthwise and used for bilateral alar rim grafts. (I) Intraoperative view, showing composite alar rim grafts used to relieve the alar retraction. (B) One-year postoperative frontal view, showing a straighter nose with greater internal/external nasal valve support. (D) One-year postoperative lateral view. (F) One-year postoperative submental view, showing improved alar support. (J) One-year postoperative image of the donor ear. (K) Rhinomanometry graph, preoperatively and 1 year postoperatively. The nasal resistance decreased from 1.897 to 0.289 Pa/mL/s, which translates to improvement in nasal airflow of more than 500%.
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endoscopy is well established as a treatment for patients presenting with the primary complaint of nasal obstruction, particularly in ruling out posterior causes of nasal obstruction not visible by anterior rhinoscopy. Medical literature supports endoscopic applications even when function may be a secondary complaint. Lanfranchi et al\textsuperscript{13} found that endoscopy revealed additional pathology in 29.2\% (n = 28 of 96) of patients who presented for rhinoplasty and complained of nasal obstruction.

A patient questionnaire provides an extremely valuable tool to subjectively measure nasal function. This study’s author uses the questionnaire from the AAO-HNSF (Table 1), which has been validated in clinical application.\textsuperscript{2} The questionnaire is given preoperatively and at each postoperative visit from 1 month forward.

Rhinomanometry is the only currently available, quantifiable, objective measure of nasal function.\textsuperscript{3} Pioneering work done by Eugene Kern\textsuperscript{14} showed that rhinomanometry could serve as an effective tool to measure objective nasal resistance and nasal airflow. This study’s author prefers posterior rhinomanometry over anterior rhinomanometry since the test is fast, accurate, and comfortable. Anterior rhinomanometry requires a sealed probe in 1 nostril while the other side of the nose is tested, and—a drawback to this method—nasal support can be changed with the probe used during the test. In addition, with the anterior test, each side of the nose must be tested independently. With posterior rhinomanometry, the patient breathes simultaneously through both sides of the nose to generate the results; this simulates normal nasal breathing more than anterior tests.

The cost of the GM Instruments rhinomanometer is approximately $6000.00 There is a Current Procedural Terminology code (92512), a relative value unit of 0.55, and a range of current reimbursement from $29 to $65 for rhinomanometry. Rhinomanometry is analogous to an Epworth sleep score questionnaire and a sleep study score in patients with sleep apnea. Both of these tests are required by third-party payers prior to approval for sleep apnea surgery. That similar documentation (ie, subjective questionnaire and objective measure of function) may be required by third-party payers prior to functional nasal surgery is unsurprising.

Rhinomanometry is the best way to measure response to decongesting spray. Knowing a patient’s response to decongesting spray is critical when turbinate hypertrophy—recognized as one of the most common causes of nasal obstruction—is suspected. Berger et al\textsuperscript{15} have shown that hypertrophied inferior turbinates have a wider lamina propria or submucosa compared with normal turbinates; submucosal tissue responds to decongesting spray. A 30\% reduction in nasal resistance as measured by rhinomanometry is generally considered indicative of a positive response to decongesting spray and would indicate that the patient is a good candidate for submucosal tissue reduction with powered instruments. (As mentioned previously, submucosal tissue reduction has been shown effective via subjective and objective measurements in numerous long-term LOE category 1 studies.\textsuperscript{16–18})

Many authors, including Mark Constantian,\textsuperscript{16–18} have shown that a significant percentage of both primary and secondary rhinoplasty patients either have or are at risk for having compromised internal or external nasal valves. Constantian,\textsuperscript{18} through objective rhinomanometry measurements, found that nasal valve dysfunction was present in 78\% of his primary nasal cases and 91\% of his secondary nasal cases. Correction of valve dysfunction led to an increase in geometric mean nasal airflow of between 2 and 4 or more times over preoperative values. In fact, in Constantian’s patient cohort, nasal valve dysfunction was more common than septal deviation; this finding highlights the importance of recognizing nasal valve dysfunction.\textsuperscript{19} Correction of valve dysfunction can include but is not limited to spreader grafts, dorsal grafts, and alar batten grafts. One valuable adjunct to the physical examination in suspected nasal valve dysfunction can include the use of Breathe Right nasal strips (GlaxoSmithKline; Philadelphia, Pennsylvania). Gruber et al\textsuperscript{19} have shown that Breathe Right strips, but not the Cottle test, can be used to diagnose accurately the presence of internal or external nasal valve weakness.

A PubMed review of pertinent literature showed numerous studies that assessed nasal surgery patients using subjective and objective measurements. In a review article, Moore and Eccles\textsuperscript{20} summarized 7 prospective objective studies that supported septoplasty as an effective treatment of nasal obstruction. Mengi et al\textsuperscript{21} looked at the response to septoplasty in 44 patients using the NOSE score and acoustic rhinometry, as well as rhinomanometry. While there was significant improvement in both subjective and objective measurements, no significant correlation was found between the 2 measurements. Persichetti et al\textsuperscript{22} looked at the response to extracorporeal septoplasty using the NOSE score and rhinomanometry in 153 patients. Although both subjective and objective measurements significantly improved, possible correlation between the 2 measurements was not reported. Similarly, Vural et al\textsuperscript{23} looked at response to septoplasty using the NOSE score and rhinomanometry in 39 patients; while both subjective and objective measurements improved significantly—like the Persichetti et al study—no correlation was found between the 2 measurements. Oeken and Kiefer\textsuperscript{24} assessed 52 septorhinoplasty patients using a questionnaire and rhinomanometry. In the questionnaire, 65\% of patients (n = 34) reported an improvement in nasal function; however, no significant improvement in rhinomanometry was found. Thus, no correlation between subjective and objective results can be made.
The data reported in the cited studies are not presented in enough detail for an in-depth statistical review to provide hypotheses regarding the reported findings (ie, lack of correlation between subjective and objective results). In addition, no judgment can be made on diagnostic accuracy, appropriateness of performed surgical techniques, or surgical acumen of the cited authors.

Constanitines et al\textsuperscript{25} reported no correlation between subjective and objective results in a group of 200 septorhinoplasty patients. However, only 13.5\% (n = 27 of 200) of patients had usable objective data, and 77.8\% (n = 21) of that patient subset had functional subjective data. Regarding objective results as measured with rhinomanometry, 63\% (n = 17 of 27) of patients achieved normal airway resistance after surgery, and 17.6\% (n = 3) of that patient subset reported subjective improvement in nasal function. Constatinides et al provided no specifics regarding subjective scores or the subjective questionnaire, or whether the latter had been validated previously. This particular study represents such a small sampling of a consecutive series that drawing any firm conclusions seems difficult.

Constatindies and Zoumalan\textsuperscript{26} reported their experience with a separate retrospective cohort of 31 patients who underwent septorhinoplasty. Subjective nasal function was measured via a 1 to 10 scale, but no specifics regarding the scale or prior validation of the measuring system are given. Objective nasal function was measured with acoustic rhinometry rather than rhinomanometry. While the authors discuss a “calculated” nasal resistance using acoustic rhinometry, the reader should recall that acoustic rhinometry is an anatomic assessment rather than a functional one. Any reference to nasal resistance, therefore, does not come from direct measurement of the 2 variables that determine nasal resistance (ie, pressure differential and airflow). Regardless, Constatinides and Zoumalan reported a statistically significant improvement of 38\% in average subjective nasal function value. Improvement in objective nasal function as measured with acoustic rhinometry did not reach statistical significance. Therefore, once again, no correlation between subjective and objective results can be made.

To this author’s knowledge, the findings in the current report are the first to show a positive correlation between subjective and objective measurements in nasal surgery patients. This study undoubtedly has both strengths and weaknesses. On the positive side, relative to other similar studies, this study contains a good-sized cohort of patients (n = 90) with usable data. Also, this study employed rhinomanometry, the only accepted method for measuring objective nasal airway function. In addition, a scientifically validated questionnaire measured subjective nasal function. Last, the postoperative readings for subjective and objective nasal function were consistent. (As mentioned previously, only 1 patient showed an unfavorable change in postoperative nasal resistance with longer follow-up. This patient still showed an improvement of a 355\% increase in airflow compared with the preoperative reading.) On the negative side, the average patient follow-up was relatively short—about 2.69 months. Furthermore, an even larger patient population would allow a statistical analysis of individual surgical techniques, which was not possible with the current cohort.

**CONCLUSIONS**

By documenting both preoperatively and postoperatively the patient’s subjective nasal function with a questionnaire and objective nasal function with rhinomanometry, a patient’s condition and surgical result can be measured quantifiably. In this study of 90 patients, statistically significant subjective and objective functional improvements were reported in 98.9\% and 95.6\% of patients, respectively, while 94.4\% of patients had both subjective and objective statistically significant functional improvement. A statistically significant correlation between the subjective and objective improvements was noted. The findings provide statistically significant evidence to support surgical treatment of nasal obstruction.

**Disclosures**

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**REFERENCES**