The Effect of Rhytidectomy on the Nasal Valve

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Objectives: To determine the effect of deep-plane rhytidectomy on the cross-sectional area of the nasal cavity in the vicinity of the nasal valves and to compare this quantitative measure with patients' subjective assessment of their postoperative nasal airway.

Design: An inception cohort of 17 patients undergoing rhytidectomy (either cheek-lift or face-lift) for facial rejuvenation was evaluated with acoustic rhinometry. Initial measurements were taken approximately 1 week prior to surgery, followed by postoperative measurements at 1 week and again at 1 month (a total of 18 measurements per patient). Patients undergoing simultaneous nasal procedures were excluded. Control subjects consisted of patients undergoing facial plastic procedures other than rhytidectomy or septorhinoplasty (n=3). The main outcome measure was cross-sectional area of both the internal and external valve regions as determined by acoustic rhinometry. The setting was an ambulatory surgery center at a large academic institution.

Results: Seventy percent of patients (12 of 17) reported subjective improvement of their nasal airway patency following rhytidectomy, whereas no control subjects (0%) reported any such change. Eighty-eight percent of patients (15 of 17) had a substantial increase in the dimension of their internal nasal valve area as measured with acoustic rhinometry at 1 week, with 70% of patients demonstrating increase at 1 month. Fifty-three percent of patients (9 of 17) demonstrated an increase in their external valve area at 1 week, and 59% had a persistent increase as measured at 1 month. No control subjects demonstrated any significant nasal valve area increases at either time. There was no correlation between age or body mass index and the measurement outcomes among participants.

Conclusions: While there is a statistically significant increase in both the internal and external nasal valve cross-sectional areas at 1 month after rhytidectomy, the permanency of this effect is unknown. In support of these findings, a sizable proportion of patients undergoing rhytidectomy subjectively report an increase in their ability to breathe through their noses, lending credence to a postrhytidectomy melonasal effect.

Arch Facial Plast Surg. 2005;7:45-50

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Asperbauer and Kern1 define the nasal valve region as the functional unit that includes the caudal margin of the upper lateral cartilage, the anterior face of the inferior turbinate, and the caudal septum. Anatomically, this location corresponds to the minimal cross-sectional area (MCA) of the nasal cavity and hence the primary site of nasal airway obstruction (Figure 1). Poiseuille’s law, with its exquisite sensitivity to changes in radius (−r⁴), governs airflow through the nostril and nasal valve region, which in turn is influenced by Bernoulli’s principle. These considerations define the nasal valve region as the primary flow-limiting segment in the nasal airway.

A secondary site of nasal obstruction is located anterior to the nasal valve and has been referred to as the external nasal valve, I-notch, or ostium internum.2 This region is comprised of the ala, the skin of the vestibule, the nasal sill, and the contour of the medial crus of the lower lateral cartilage. This site is frequently the location of the second MCA of the nasal cavity. When considered together, these 2 sites of cross-sectional narrowing act as 2 resistors in series: the external and internal nasal valves. Grymer et al3 reported the approximate location of these valve regions to lie at 1.46 cm and 2.23 cm, respectively, into the nasal airway, and Roithmann et al4 reported similar locations at 1.18 cm and 2.86 cm.
Acoustic rhinometry (AR) is a noninvasive method of measuring nasal airway patency and has become a useful tool for evaluation in rhinology and rhinosurgery (Figure 2). Its use has been well documented in patients with allergic rhinitis, nasal septal deflection, inferior turbinate hypertrophy, and nasal deformity. Panigello5 used AR to show the benefit of nasal valve suspension sutures in patients with nasal valve collapse. In this article, we expand the use of AR to include nasal airway assessment after facial rejuvenation.

Rhytidectomy results in rejuvenation of the visage by opposing the force of gravity on the soft tissues of the face. Deep-plane rhytidectomy achieves this with dissection deep to the superficial musculoaponeurotic system in the region of the melolabial folds, with a vector of pull directed in a superolateral direction. Intraoperatively, it has been noted that these forces mimic the Cottle maneuver, visibly opening the external nasal valves of rhytidectomy patients. It was surmised that this “surgical” Cottle maneuver might also produce a concomitant change in the internal nasal valve. To quantitate these findings, preoperative and postoperative AR was performed on patients undergoing deep-plane rhytidectomy to measure the static dimensions of the nasal cavity, specifically in those regions of the external and internal nasal valves.

METHODS

Twenty women (ages 28–69 years; 18 white, 1 African American, 1 Asian American) scheduled to undergo facial cosmetic surgery were enrolled in the study. Among them, 17 had undergone either a cheek-lift (n = 3) or deep-plane face-lift (n = 14) in combination with other facial plastic surgery procedures. Other procedures included brow-lift, blepharoplasty, autologous fat augmentation of the midface, genioplasty, forehead shortening, supraorbital rim contouring, placement of lateral mandibular implants, or alloplastic lip augmentation. Three patients had facial cosmetic procedures without rhytidectomy, and these patients served as controls. Their procedures included endoscopic brow-lift, blepharoplasty, neck-lift, autologous fat augmentation of the midface, or mole removal. No patients undergoing nasal surgery were included. All patients were operated on by 1 surgeon (J.M.S.) and 1 assistant (R.B.C.). The surgeon was blind to the inclusion status of the patients. Six patients (30%) reported a history of allergic rhinitis, although no patients reported taking medications for this during the time of the study. All patients were queried with regard to their medical health and surgical history. Three patients (15%) had previously undergone prior septorhinoplasty. Body mass index was calculated from preoperative heights and weights.

After informed consent was obtained, each patient underwent acoustic rhinometric examination approximately 1 week prior to surgery (9.4 days for patients; 5 days for controls) in a private examination room with central temperature control and low level of ambient noise. An acoustic rhinometer (SRE2100; Rhinometrics A/S, Lyng, Denmark) was used for all measurements (Figure 3). One person performed all measurements (R.B.C.) to eliminate the possibility of tester variability. Subjects sat comfortably upright in an examination chair, with quiet respirations. Medium disposable nose adapters (Rhinometrics A/S) were used for all patients except for one who had large nostrils. Large adapters were used for this patient. Petroleum jelly (Vaseline Lip Therapy; Chesebrough-Ponds USA, Greenwich, Conn) was sparingly applied to the rim of the adapters as a sealant. During each measurement, care was taken not to deform the nostril while making a seal. Subjects were instructed to momentarily stop breathing during the measurements. Each test consisted of at least 3 consecutive measurements of each side of the nasal cavity. Any measurement with fluctuation greater than 3% was discarded. The average nasal
MCA was determined by the AR computer software (Rhin 98, version 2.6; Rhinometrics A/S) for the regions corresponding to the external nasal valve (0 to 1.5 cm) and the internal nasal valve (1.5 to 3.0 cm). To eliminate any confounding caused by the nasal cycle, conservation of the total cross-sectional area in the vicinity of the left and right nasal valves was assumed. The MCAs for the left (MCAₐ) and right (MCAₐ) side were added together to arrive at a total MCA. Regardless of the nasal cycle, \( \text{MCA} = \text{MCAₐ} + \text{MCAₐ} \) does not change as a function of time.

After the procedures, all patients returned at 1 week (7.2 days for patients; 7.0 days for controls) and 1 month (32.5 days for patients; 34.0 days for controls) for additional measurements. All patients were surveyed with regard to subjective assessment of nasal airway patency at both postoperative visits. Statistical analysis was performed in the Department of Statistics at the University of California, Davis, using analysis of covariance.

**RESULTS**

Twenty patients (17 patients and 3 controls) were enrolled and completed the study (**Table 1**). In the region of the internal nasal valve, the test cohort exhibited an average increase in total MCA of 0.190 cm² (\( P < .001 \)) from the preoperative measurement to the first postoperative measurement (**Table 2** and **Figure 4**). This is an increase of 22% from the preoperative value. Fifteen (88%) of 17 of patients demonstrated an increased internal valve cross-sectional area at T₁ (time from surgery to the first postoperative measurement), and 12 (70%) demonstrated a persistent increase at T₂ (time from surgery to the second postoperative measurement). Fourteen patients (82%) experienced some decrease in MCA during the interval from T₁ to T₂. The control cohort did not demonstrate a significant change in total MCA for either the T₁ interval (\( H₁ = 0.013; P = .10 \)) or T₂ interval (\( H₂ = −0.057; P = .42 \)), and none of the controls (0%) reported subjective nasal airway improvement.

In the region of the external nasal valve, the test cohort demonstrated an average increase in MCA of 0.056 cm² (\( P = .02 \)) in the T₁ interval and 0.072 cm² (\( P = .009 \)) in the T₂ interval. The former represents a 4% area increase, whereas the latter, a 5% increase. Nineteen patients (53%) exhibited an increased area in the external nasal valve region at T₁ and 10 (59%) at T₂. The control cohort had no increase in external nasal valve area at T₂ (\( H₂ = −0.060; P = .73 \)), but at T₁ there was actually a significant decrease in external valve MCA (\( H₁ = −0.140; P = .03 \)).

**Table 1. Patient Data**

<table>
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<tr>
<th>Patient No.</th>
<th>Age, y</th>
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<th>T₂, d</th>
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<td>1.64 (1.42)</td>
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<tr>
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<td>28</td>
<td>24.09</td>
<td>0.87 (0.63)</td>
<td>1.06 (0.76)</td>
<td>1.19 (0.74)</td>
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</tr>
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<td>1.10 (0.81)</td>
<td>1.12 (0.84)</td>
<td>No</td>
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</table>

Abbreviations: BMI, body mass index (weight in kilograms divided by the square of height in meters); MCA₀, MCA₁, MCA₂, minimal cross-sectional areas as measured preoperatively and at T₁ and T₂, respectively; T₁, time from surgery to the first postoperative measurement; T₂, time from surgery to the second postoperative measurement.

*All subjects were women.
†Control subject.
‡Cheek-lift.
superficial musculoaponeurotic system tissues of the cheek and pulling them superolaterally with sutures, not unlike Paniello’s nasal valve suspension technique. While the desired effect is facial rejuvenation with effacement of the melolabial folds, this is accompanied by visible widening of the nostrils. Anecdotally, relief of nasal airway obstruction after such procedures has been postulated both by the gross appearance of the external nasal valve immediately after surgery and by the patients’ reports of easier nasal breathing. Pictures were taken of patient number 15 immediately prior to the start of the procedure and immediately on its conclusion, revealing an increase in the nasal base angle of roughly 10° (Figure 5). Despite search of the English language plastic surgery literature, no report could be identified that has previously quantified the mutability of this angle, although it undoubtedly changes with alar base excision and tip rhinoplasty/lept lip repair. While Figure 5 reflects the typical appearance after rhytidectomy in our practice, only this patient had intraoperative base view photography, and no further quantitative measurement of the change of the nasal appearance was performed in this study.

The data presented herein confirm that, at least in the short term, the deep-plane rhytidectomy produces an internal Cottle maneuver, opening the internal and external nasal valves causing an improvement in nasal airflow. This effect was not seen in the control group undergoing nonrhytidectomy aesthetic procedures; however, the sample size of controls is inadequate (power analysis indicates that 13 controls are needed to determine if significant differences exist between patient and control cohorts). Therefore, while there is statistical significance within the test cohort that confirms true changes in valve area, the difference with respect to the control cohort could be owing to chance alone.

Of interest is that the largest increase in cross-sectional area occurs in the region of the internal nasal valve (Δ of ~0.190 cm² and ~0.125 cm²). This seems intuitive as the tissue retraction in rhytidectomy occurs not at the ala or vestibule but in deeper tissues proximate to the internal valve. The external valve motion (Δ of ~0.056 cm² and ~0.072 cm²) is likely a passenger effect: an indirect result of forces acting near the internal valve. If one examines the ratio of these values, the effect on the internal valve at 1 week is nearly 3.5-times greater than that on the external valve but less than twice as great by 1 month.

Comparing the subjective response rates to the measured data, there is likely a complex interplay of factors that determine when a patient feels that nasal airway pat-

### Table 2. Average Values for the Internal and External Valve Regions

<table>
<thead>
<tr>
<th>Region, cm</th>
<th>Cohort</th>
<th>Age, y</th>
<th>T₁, d</th>
<th>T₂, d</th>
<th>BMI</th>
<th>MCA₀, cm²</th>
<th>MCA₁, cm²</th>
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<th>Δ₂, cm²</th>
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<tbody>
<tr>
<td>1.5-3</td>
<td>Test</td>
<td>53.6</td>
<td>7.2</td>
<td>32.5</td>
<td>23.7</td>
<td>0.845</td>
<td>1.035</td>
<td>0.970</td>
<td>0.190</td>
<td>0.125</td>
</tr>
<tr>
<td>Control</td>
<td>41.3</td>
<td>7.0</td>
<td>34.0</td>
<td>23.0</td>
<td>0.967</td>
<td>0.980</td>
<td>0.910</td>
<td>0.013</td>
<td>-0.057</td>
<td></td>
</tr>
<tr>
<td>0-1.5</td>
<td>Test</td>
<td>53.6</td>
<td>7.2</td>
<td>32.5</td>
<td>23.7</td>
<td>1.228</td>
<td>1.284</td>
<td>1.300</td>
<td>0.056</td>
<td>0.072</td>
</tr>
<tr>
<td>Control</td>
<td>41.3</td>
<td>7.0</td>
<td>34.0</td>
<td>23.0</td>
<td>1.113</td>
<td>0.973</td>
<td>1.053</td>
<td>-0.140</td>
<td>-0.060</td>
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</table>

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); MCA₀, MCA₁, MCA₂, minimal cross-sectional areas as measured preoperatively and at T₁ and T₂, respectively; T₁, time from surgery to the first postoperative measurement; T₂, time from surgery to the second postoperative measurement; Δ₁, average change in cross-sectional area for T₁; Δ₂, average change in cross-sectional area for T₂.

**Figure 4.** Acoustic rhinometry data showing a difference in area between T₀ (green) and T₁ (red). Note the enlargement in the region of the internal nasal valve (2.3 cm).

Twelve patients (70%) noted subjective improvement in their nasal airway by the end of their participation. Eight (47%) had increased area of both their internal and external nasal valves by T₁ and by T₂. None of the data were statistically significant with regard to patient age, body mass index, cheek-lift vs rhytidectomy, or prior septrhinoplasty.

In his dealings with patients plagued by nasal airway obstruction, Maurice Cottle (1898-1982) first described the habitual maneuver that now bears his name. The Cottle maneuver works by action-at-a-distance: a gentle force applied to the cheek skin in a lateral direction results in an increase in the radius of the airway and increasing the flow of air according to Poiseuille’s law. In patients with dynamic limitation of their nasal introitus by the Bernoulli effect and its associated valve collapse, the maneuver anchors the valve in the open position, preventing its collapse. The deep-plane rhytidectomy (cheek-lift or facelift) achieves analogous results by acting on the sub—
ency has improved. This interplay is further compounded by the potential variability in AR results, although all efforts to limit this variability (only 1 examiner performed all measurements) were made. The fact that 88% of subjects (15 of 17) had a demonstrable improvement in their internal nasal valve MCA but only 69% (11 of 17) reported sensation of decreased nasal obstruction indicates this. Increased MCA at both the internal and external nasal valves is also not a sufficient condition as 2 patients of 8 who demonstrated this denied subjective improvement (patient numbers 1 and 14). It stands to reason that there is some threshold of change in airflow resistance that, if superseded, will result in a patient sensing subjective improvement. Returning to the concept of external and internal nasal valves as resistors in series helps to understand this. If the flow-limiting segment is opened such that the second minimum now becomes the new flow-limiting segment, the patient may not have subjective improvement because the threshold of subjective airway increase may not have been attained. Also, airflow pattern influences subjective sense of nasal airway patency.6 One can imagine a scenario in which the cross-sectional area of the flow-limiting segments is increased; however, the geometry of airflow is redirected away from the mucosa responsible for sensing airflow, thus limiting any subjective improvement. Conditions likely to result in subjective improvement, therefore, include (1) increased cross-sectional area of the flow-limiting segment(s), (2) supersession of the change in resistance threshold, and (3) increased airflow across the sensory mucosa.

Yet another interesting concept born from these data is that of the rhytidectomy relaxation rate, ρ, which can yield information concerning the relaxation of facial soft tissues between the time of surgery and the time when enough fibrosis has occurred to secure the lift. While in vitro studies have been performed on skin and the superficial musculoaponeurotic system to assess viscoelastic properties that influence quantities such as tissue creep and relaxation, the relaxation rate presented herein provides an in vivo assessment.7,8 As the internal valve seems to be correlated more closely with the forces involved, the rate ρ can be calculated as follows:

\[
\rho = \frac{(\Delta_1 - \Delta_2)}{(T_2 - T_1)}
\]

\[
= \frac{(0.190 \text{ cm}^2 - 0.125 \text{ cm}^2)}{(32.5 \text{ d} - 7.2 \text{ d})}
\]

\[
= 0.065 \text{ cm}^2/25.3 \text{ d}
\]

\[
\rho = 0.00257 \text{ cm}^2/\text{d}.
\]

This rhytidectomy relaxation rate can then be used to extrapolate the length of time it may take for the nasal valve to return to its preoperative position, or

\[
\tau = \Delta_1/\rho
\]

\[
= \frac{0.190 \text{ cm}^2}{0.00257 \text{ cm}^2/\text{d}}
\]

\[
= 73.9 \text{ d}
\]

\[
\tau \approx 2.5 \text{ mo}.
\]

The equation for the line using these data is

\[y = -0.00257t + 0.2085\]

where \(y\) represents the change in MCA and \(t\) is time. Because the relaxation of tissues after rhytidectomy is more likely an exponential decay than a linear one, \(\tau\) potentially underestimates the actual value. Simple curve fitting yields \(y = 0.214e^{-0.01655t}\) as the best-fit for an exponential curve passing through the same points. Remember, however, that somewhere prior to this time \(\tau\), fibrosis occurs and tissue migration halts, so this may indeed provide a rough estimate. Of interest, \(\tau\) corresponds to what is observed clinically. Many surgeons do not take postoperative photographs until roughly 3 months have passed, as this is when the face has arrived at a natural rejuvenated look. Gone is the ecchymosis, the edema, and the “operated look.”

CONCLUSIONS

While there is a statistically significant increase in both the internal and external nasal valve cross-sectional areas even 1 month after rhytidectomy, the permanency of this effect is unknown. In support of these findings, a sizable number of rhytidectomy patients in this study subjectively reported an increase in their ability to breathe through their noses. Further investigation would i-
clude additional AR measurements to generate a complete nasal valve relaxation curve that could be used to quantify both the end point of valve area change and an in vivo rhytidectomy relaxation rate, τ. Acoustic rhinomanometry data could be collected to further support the rhinometry data. Also, inclusion of a larger number of control subjects is mandatory to determine whether the absence of the effect in controls is true. In addition, all patients would undergo photography to quantify changes in the nasal base angle to see if this angle corresponds to AR findings and/or subjective reports of breathing improvement. Regardless of future research, however, the current study demonstrates the existence of a posthypotidectomy melonasal effect and provides another example of how form and function are integral components of facial plastic surgery.

Accepted for Publication: September 2, 2004.

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Acknowledgment: We thank Mitchell Watnik, PhD, Hilary Brodie, MD, PhD, Edward Snyder, BS, and Rhinometrics A/S for their assistance with this project.

REFERENCES


Call for Papers. The Archives of Facial Plastic Surgery plans to publish a theme issue on vascular birthmarks in late 2005. Marcelo Hochman, MD, will edit this series of articles. Please direct questions or suggestions to Dr Hochman at 843-571-4742 or hochman@facialsurgerycenter.com. Manuscripts on all aspects of the etiology, pathophysiology, diagnosis, and treatment of vascular lesions (including hemangiomas; port-wine stains; and venous, lymphatic, and arteriovenous malformations and associated syndromes) are welcome. Please submit manuscripts to the ARCHIVES editorial office with the usual requirements as detailed in the instructions for authors (available at www.archfacial.com). Include a cover letter stating that the article is to be considered for the theme issue.