Subjective symptomatology in nasal obstruction and the impact of septorhinoplasty with spreader graft placement on patient-perceived nasal appearance and nasal obstruction

Subjective symptomatology in nasal obstruction and the impact of septorhinoplasty with spreader graft placement on patient-perceived nasal appearance and nasal obstruction

by

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ABSTRACT

Purpose: (A) To investigate the differences between unilateral versus bilateral nasal obstruction with subjective symptomatology in nasal obstruction, (B) to assess satisfaction and nasal appearance and correction of nasal obstruction in patients who have undergone septorhinoplasty (SRP) with standard spreader graft (SSG) versus extended spreader graft (ESG), and (C) to evaluate satisfaction with nasal appearance and correction of nasal obstruction in patients who have undergone SRP with spreader graft placement without upper lateral cartilage release and compare to the traditional upper lateral cartilage release cohort.

Methods: (A) A retrospective chart review of prospectively collected data of 1646 patients with nasal obstruction presenting to a Facial Plastic and Reconstructive Surgery Clinic for evaluation and treatment was performed. Patient demographics including age and gender were recorded along with nasal physical exam findings, including internal valve narrowing (IVN), external valve narrowing (EVN), internal valve collapse (IVC), external valve collapse (EVC) and septal deviations (inferior and superior). Findings were reported for left, right, and both sides. Nasal valve and septal findings were recorded on 3- and 4-point Likert scales, respectively for each side or the nose. (B) A retrospective chart review of prospectively collected data of patients who underwent septorhinoplasty with SSG or ESG was performed. 568 patients who underwent septorhinoplasty with SSG and 126 patients who underwent septorhinoplasty with ESG between 2012 and 2018 were administered the Nasal Obstruction Symptom Evaluation (NOSE) scale and FACE-Q Satisfaction with Nose, FACE-Q Satisfaction with Nostrils, and FACE-Q Social Functioning scales pre- and postoperatively. Pre- and postoperative NOSE and FACE-Q scores, negative inspiratory force (NIF), and changes in these values were compared between groups. (C) A prospective cohort study was performed with 559 patients who underwent

septorhinoplasty with spreader graft placement with upper lateral cartilage release and 30 patients septorhinoplasty with spreader graft placement without upper lateral cartilage release between 2012 and 2020. All patients were administered the NOSE scale and FACE-Q Satisfaction with Nose, and FACE-Q Social Functioning scales pre- and postoperatively. Pre- and postoperative NOSE and FACE-Q scores, negative inspiratory force (NIF), and changes in these values were compared between groups.

Results: (A) On univariate analysis, a significant correlation was seen between NOSE scores and all individual exam findings ($p<0.001$). On multiple linear regression, total, left, and right septal deviation ($p<0.001$, $p=.001$, $p=.007$, respectively) and total, left, and right IVN ($p<0.001$, $p=.003$, $p<.001$) were all predictive of an increased NOSE score. (B) Results demonstrated clinically and statistically significant improvement at follow-up for both SSG and ESG groups. There was no significant difference between the SSG and ESG groups in mean improvement of NOSE scores, FACE-Q scores, and NIF at follow-up of 6 months and at 12 months. (C) Results demonstrated clinically and statistically significant improvement at follow-up for both the release and non-release groups. There was no significant difference between the groups in mean improvement of NOSE, FACE-Q, and NIF scores at time of last follow-up or follow-up of 6 and 12 months.

Conclusions: Patients with unilateral septal deviation or internal nasal valve narrowing have symptoms of nasal obstruction similar to those with bilateral nasal obstruction. Unilateral and bilateral septal deviation and internal nasal valve narrowing are predictive of having an increased NOSE score. Unilateral nasal obstruction should be recognized and treated as a cause for severe symptomatic nasal obstruction despite a normal contralateral nasal exam. Furthermore, we demonstrated that SSGs and ESGs, as well as SRP with spreader graft placement with and

without upper lateral cartilage release, provide clinically and statistically significant improvement, and no significant difference in functional outcome as should be considered for specific patient populations. The etiology of the nasal obstruction and/or deformity should be considered when deciding which type of spreader graft to use. This also suggests that upper lateral cartilages do not need to be released to achieve functional improvement and that surgeons should consider whether or not the upper lateral cartilages need to be released to achieve the goals of the surgery.

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Glossary of Abbreviations

ANOVA = analysis of variance

ESG = extended spreader graft

EVC = external valve collapse

EVN = external valve narrowing

IVC = internal valve collapse

IVN = internal valve narrowing

MCID = minimal clinically important difference

NAO = nasal airway obstruction

NAW = Nasal Anatomic Worksheet

NIF = negative inspiratory force

NOSE = Nasal Obstruction Symptom Evaluation

REDcap = Research Electronic Data Capture

SD = standard deviation

SRP = septorhinoplasty

SSG = standard spreader graft

QOL = quality-of-life

VIF = variance inflation factors

Introduction

Nasal airway obstruction (NAO) negatively affects quality of life and presents as a leading complaint to otolaryngologists.[1-3] NAO can negatively impact both disease-specific and global quality of life, as well as sleep. Structural obstruction of the nasal airway is commonly due to septal deviation, turbinate hypertrophy, and/or nasal valve dysfunction. Despite the growing wealth of research on the negative impact of NAO on patient quality of life, little is understood about the impact of unilateral nasal obstruction. As objective techniques to measure nasal airflow and resistance are developed for clinical use, it will be increasingly important to understand the relationship between airflow and subjective nasal symptomatology. The symptomatic patient with unilateral nasal obstruction on physical examination allows an opportunity to examine this relationship.

Medical management for NAO ranges from topical decongestant and steroid nasal sprays to oral allergy medications to nasal strips. When medical treatment does not provide sufficient symptom relief, septorhinoplasty (SRP) is often performed to straighten the septum and correct nasal valve compromise.[4] Standard spreader grafts (SSGs) are a common type of graft placed to treat internal valve narrowing (IVN) and have been shown to improve symptoms of NAO.[5-7] Although SSGs have been criticized due to concern for causing undesirable widening of the nasal dorsum, our group has demonstrated in a previous study that SSGs can be placed to successfully correct nasal obstruction from internal nasal valve compromise without adversely impacting the aesthetic outcome.[8]

In addition to SSGs, the extended spreader graft (ESG) technique in FSRP has been shown to have aesthetic and functional advantages with a low rate of complications.[9] ESGs are longer than SSG, extending past the caudal edge of the upper lateral cartilage to the anterior

septal angle. This alternative approach also has been described to prevent postoperative retraction and recurrence of the deviation for patients with a history of failed septoplasty or rhinoplasty.[9] However, symptoms of nasal obstruction and patient satisfaction with nasal appearance have yet to be compared following FSRP using SSGs versus ESGs.

At the same time, there has been a focus on maintaining the integrity of the connections in the middle vault. Preservation rhinoplasty has emerged as an increasingly popular option for managing the dorsum to preserve structure and provide a natural and long-lasting outcome.[10-12] The major goal of dorsal preservation is to avoid creating an open-roof deformity that can be seen with classic hump reduction and to maintain favorable dorsal contours.[10, 12] Furthermore, when the middle vault is not opened, irregularities, asymmetries, and long-term distortion can potentially be avoided.[11] Avoiding release of the upper lateral cartilages in certain patient groups undergoing SRP for the treatment of nasal obstruction may represent an early step in this paradigm shift beyond patients presenting for cosmetic dorsal hump reduction.

Valid patient-reported outcome measures offer important insight into patient perception following SRP.[8] The Nasal Obstruction Symptom Evaluation (NOSE) survey, a validated quality of life instrument for patients with nasal obstruction, is often used to evaluate outcomes after septoplasty and rhinoplasty.[13] The FACE-Q scale is a also a validated, multi-modular patient-reported outcome instrument that assesses a patient's perception of nasal appearance and its impact on social functioning.[14]

We have previously demonstrated significant improvements in NOSE score after functional rhinoplasty; and revealed that history of septoplasty, snoring, and IVN are associated with increased NOSE scores in patients presenting preoperatively for functional septorhinoplasty.[13, 15, 16] However, the impact of unilateral nasal obstruction on symptom severity

has not been thoroughly evaluated. Here, we utilized systematic physical examination reporting to study the relationship of unilateral nasal characteristics on NOSE score severity. We also aimed to utilize these validated patient-reported outcome measures to demonstrate the impact of two different types of spreader grafts and two different spreader graft placement techniques on nasal function and nasal aesthetics and to compare nasal airway obstruction and patient satisfaction with nasal appearance between:

- functional SRP with SSG placement and functional SRP with ESG placement
- SRP with spreader graft placement with release of the upper lateral cartilages and SRP with spreader graft placement without release of the upper lateral cartilages.

Methods

Patient Selection

To investigate the differences between unilateral versus bilateral nasal obstruction with subjective symptomatology in nasal obstruction, a retrospective chart review was performed at a tertiary care medical center under an approved protocol by the institutional review board human subjects research committee. The study period spanned 6 years (2012-2018). Eligible subjects involved adult and pediatric (less than 18 years old) patients who presented to the Massachusetts Eye and Ear Facial Plastic and Reconstructive Surgery (Boston, MA) clinic for assessment of NAO by Dr. Robin W. Lindsay. The subjects were referred due to concern for NAO to discuss medical and surgical options, or for surgical intervention. The subjects completed a preoperative NOSE survey in the clinic electronically and underwent a standardized nasal history and physical exam.[17]

To assess satisfaction and nasal appearance and correction of NAO in patients who have undergone SRP with SSG versus ESG, a prospective cohort study was performed at a single tertiary care medical center between June 2012 and October 2019 with institutional review board approval from the Human Subjects Research Committee of Massachusetts Eye and Ear. After we obtained written informed consent, patients presenting to the Massachusetts Eye and Ear Facial Plastic and Reconstructive Surgery (Boston, MA) clinic were administered the NOSE survey and the FACE-Q Satisfaction With Nose, Satisfaction With Nostrils, and Social Functioning surveys preoperatively and at 2, 4, 6, and 12 months postoperatively. All patients who underwent open FSRP with SSG placement or ESG placement by Dr. Robin W. Lindsay for the treatment of NAO and who completed both the NOSE and FACE-Q surveys both preoperatively and at one or more postoperative time points were included in this study.

To evaluate satisfaction with nasal appearance and correction of nasal obstruction in patients who have undergone SRP with spreader graft placement without upper lateral cartilage release and compare to the traditional upper lateral cartilage release cohort, a prospective cohort study was performed at a single tertiary care medical center between June 2012 and April 2020 with institutional review board approval from the Human Subjects Research Committee of Massachusetts Eye and Ear. After we obtained written informed consent, patients presenting to the Massachusetts Eye and Ear Facial Plastic and Reconstructive Surgery (Boston, MA) clinic were administered the NOSE survey and the FACE-Q Satisfaction With Nose, Satisfaction With Nostrils, and Social Functioning surveys preoperatively and at 2, 4, 6, and 12 months postoperatively. All patients who underwent open SRP with spreader graft placement by Dr. Robin W. Lindsay for the treatment of NAO and who completed both the NOSE and FACE-Q surveys both preoperatively and at one or more postoperative time points were included in this study.

Surveys were administered in a manner compliant with the Health Insurance Portability and Accountability Act either in paper or electronic format at their scheduled clinic appointment or electronically via email through REDcap (Research Electronic Data Capture), an electronic data-capture platform designed for academic clinical and translational database development.[18] All patient demographics, nasal history, nasal exam, and outcomes were reported and analyzed.

Outcome Measures

The subjective symptoms of NAO were measured using the NOSE questionnaire, a validated, patient-reported, disease-specific quality-of-life (QOL) assessment instrument that contains five questions related to nasal obstruction rated along a five-point Likert scale.[13, 19-21]

Question response scores are summed and converted to a total score from 0 (no nasal obstruction) to 100 (severe nasal obstruction).

Perception of nasal appearance was measured using the FACE-Q satisfaction with Nose, Satisfaction with Nostrils, and Social Functioning scales, which consist of 10, 5, and 8 validated questions, respectively, that the patient rates on a 4-point Likert scale. Rasch transformation is used to transform the results into a score from 0 to 100, with higher scores indicating greater satisfaction with appearance or quality of life.[14]

Objective measurement of nasal airflow was performed using an In-Check portable inspiratory flow meter (Clement Clarke International Ltd., Harlow, UK) to measure peak nasal inspiratory flow (NIF) pre- and post-operatively. NIF was measured with a tight-fitting anesthetic mask that did not affect the shape of the nose. Patients were instructed to inhale with maximum inspiratory effort through the mask while keeping their mouth closed and were allowed to practice with the device before formal testing. At formal testing, the patients performed three trials at maximal effort while sitting. The highest flow rate (L/min) of these three measurements was recorded, as has been previously described.

Physical Exam

Physical exam findings were recorded on a nasal exam and Nasal Anatomic Worksheet (NAW) in REDCap (Vanderbilt University). The nasal exam worksheet focused on external nasal anatomy and the NAW on intranasal anatomy.[17] On the NAW, deviation of the septum and nasal valve narrowing and collapse were analyzed by unique categories: left superior septal deviation, right superior septal deviation, left inferior septal deviation, and right inferior septal deviation on a 4 point Likert scale (rated 0 if not present, 1 for mild, 2 for moderate, 3 for severe), and left internal valve narrowing at rest, right internal valve narrowing at rest, left

external valve narrowing at rest, right external valve narrowing at rest, left internal valve collapse with inspiration, right internal valve collapse with inspiration, left external valve collapse with inspiration, and right external valve collapse with inspiration on a 3 point Likert scale (rated 1 for absent/mild, 2 for moderate, 3 for severe). Each item was scored individually. The individual scores were combined to create the total NAW score.

Surgical Technique

A full description of the surgical technique used for the placement of spreader grafts with release of the upper lateral cartilages has been previously published.[15] For SSGs, a 2- to 3-mm-thick strip of either septal or costal cartilage is placed between the septum and the upper lateral cartilages. The SSG is placed slightly under the nasal bones and extend to the caudal portion of the upper lateral cartilage at the scroll region. The ESG is placed using a similar technique, but the ESG is longer extending beyond the caudal edge of the upper lateral cartilage to the anterior septal angle. Both graft types are carefully beveled on the inferior and caudal edge to allow the mucosa to smoothly re-drape over the grafts. The ESGs are beveled caudally as thin as possible without losing the structural integrity of the graft. If a dorsal deviation is present, the upper lateral cartilages are released from the dorsum of the septum. The spreader grafts are then sutured to the dorsum of the septum using a 5-0 polydioxanone horizontal mattress suture. The upper lateral cartilages are then sutured to the spreaders and the septum with horizontal mattress and interrupted sutures ensuring to secure the upper lateral cartilages slightly superior to the spreaders reconstituting the normal contour of the middle vault. If a dorsal deviation does not exist, often the upper lateral cartilages are not released, and the spreader grafts are placed in pockets between the upper lateral cartilages and the dorsum of the septum (Figure 1). Care must be taken when elevating the mucoperichondrial flap for the septoplasty to main the continuity

between the mucoperichondrium and dorsal portion of the septal L-strut, so that a tight pocket under the dorsal edge of the septum can be elevated for spreader graft placement. ESGs were utilized in patients with a dorsal deviation or septal fracture involving the dorsal component of the septal L-strut.

Statistical Analysis

Statistical analyses were conducted using Microsoft Excel, version 16.31, and STATA 16.0. For all tests, $P < 0.05$ was considered significant. Univariate analysis was performed using one-way analysis of variance (ANOVA) tests to determine the association between interval variables and NOSE scores. Multivariable linear regression for NOSE scores was performed using a backward stepwise approach. Variance inflation factors (VIF) were calculated to determine multicollinearity (VIF < 4).

The minimal clinically important difference (MCID) for NOSE scores was set at 30 points, as previously described.[19, 22] Although MCIDs for FACE-Q scores have yet to be determined in the literature, this value was approximated using one-half of the mean baseline standard deviation (SD), as previously described.[5, 23] The MICD for NIF was set at 20, as previously described.[19, 22] An unpaired *t* test was used to compare mean preoperative NOSE and FACE-Q scores, mean postoperative NOSE and FACE-Q scores, and mean change in score between the SSGs and ESGs and between the release and non-release cohorts at various time points. Scores at the time of each patient's last follow-up were used to calculate means, unless otherwise specified.

Student Role

My role involved organizing data, performing statistical analyses, interpreting results, writing the manuscripts, submitting the manuscripts for publication, and revising the manuscripts during the submission process. Robin W. Lindsay, M.D. supervised the project, overseeing the design, execution, analysis and writing. Allen L. Feng M.D., Natalie S. Justicz M.D., and Shekhar K. Gadkaree M.D. contributed to the project with data analysis and manuscript edits.

Results

Unilateral NAO Causes Symptom Severity Scores Similar to Bilateral NAO

Patient Characteristics

Retrospective chart review identified 1081 patients who presented to the Massachusetts Eye and Ear Infirmary Facial Plastic and Reconstructive Surgery (Boston, MA) clinic for evaluation of NAO (Table 1). 53.9% of patients were female, while 46.1% of patients were male. The mean patient age was 38.0 ± 16.5 years. The mean NOSE score was 59.7 ± 25.0.

Physical Exam

In the univariate analyses, the variables of left-sided external valve narrowing (EVN) ($p = 0.011$), right-sided EVN ($p < 0.001$), left-sided external valve collapse (EVC) ($p < 0.001$), right-sided EVC ($p < 0.001$), left-sided internal valve narrowing (IVN) ($p < 0.001$), right-sided IVN ($p < 0.001$), left-sided internal valve collapse (IVC) ($p < 0.001$), right-sided IVC ($p < 0.001$), left-sided inferior septal deviation ($p < 0.001$), right-sided inferior septal deviation ($p < 0.001$), left-sided superior septal deviation ($p < 0.001$), and right-sided superior septal deviation ($p < 0.001$) were significantly correlated with NOSE scores (Table 2).

In the multivariate analyses, inferior and superior septal deviations were found to be collinear and were taken instead as a total septal score. The total septal score and other nasal exam findings on each side of the nose were found to be predictive of an increased NOSE score. On the left-hand side, IVN score ($p = 0.003$) and total septum score ($p = 0.001$) were found to be significant predictors of an elevated NOSE score. On the right-hand side, similar results were seen with IVN score ($p < 0.001$) and total septum score ($p = 0.007$) being significant predictors of an elevated NOSE score. When looking at combined (bilateral) physical exam findings, similar results are shown with IVN score ($p < 0.001$) and total septum score ($p < 0.001$) being

significant predictors. All regression variables for unilateral or bilateral analyses demonstrated VIF ≤ 3. When considering unilateral or bilateral physical exam findings IVC, EVN, EVC were not predictive of an elevated NOSE score. Age and sex were similarly not associated with NOSE scores (Table 3).

Patient-Perceived Nasal Appearance After SRP With SSG vs. ESG

Patient Characteristics

A total of 694 patients underwent functional SRP, with SSG placement performed in 568 (81.8%) patients (293 male [51.9%]), whereas the remaining 126 (18.2%) patients (68 male [54.0%]) underwent ESG placement. Table 4 presents clinical characteristics of the two patient populations. Mean (SD) age varied between groups, with 34.8 (14.8) years in the SSG cohort and 42.7 (16.4) years in the ESG cohort ($p < 0.001$).

There was also a statistically significant difference in history of nasal surgery between groups (269 [47.4%] in the SSG cohort, compared to 121 [96.0%] patients in the ESG cohort; $p < 0.001$). More specifically, history of rhinoplasty (42 [7.4%] patients in the SSG cohort, compared to 47 [37.3%] patients in the ESG cohort; $p < 0.001$), history of septoplasty (116 [20.4%] patients in the SSG cohort, compared to 83 [65.9%] patients in the ESG cohort; $p < 0.001$), and history of turbinoplasty (36 [6.3%] patients in the SSG cohort, compared to 17 [13.5%] patients in the ESG cohort; $p = 0.006$) varied between groups.

In addition, use of rib cartilage as an additional graft source was significantly higher in the ESG cohort (58 [10.2%] patients in the SSG cohort, compared to 67 [53.2%] patients in the ESG cohort; $p < 0.001$), while use of septal cartilage as an additional graft source was significantly higher in the SSG cohort (486 [85.6%] patients in the SSG cohort, compared to 19

[15.1%] patients in the ESG cohort; $p < 0.001$). Otherwise, cohorts were well-matched with no statistically significant differences in patient characteristics.

Outcomes

Among the SSG cohort, there was a clinically and statistically significant improvement in NOSE scores in all patients (at their time of last follow-up), those with follow-up of at least six months (n = 276), and those with follow-up of at least twelve months (n = 210) (mean [SD]: 39.8 [25.9], 39.4 [26.2], and 37.7 [26.0], respectively; $p < 0.001$) (Table 5). FACE-Q Satisfaction With Nose, FACE-Q Satisfaction With Nostrils, FACE-Q Social Functioning, and NIF scores also had statistically significantly improvements at time of last follow-up, with a mean (SD) change of 18.9 (23.9), 20.3 (26.5), 8.7 (19.2), and 20.9 (35.6), respectively ($p < 0.001$). The changes in FACE-Q Satisfaction With Nose, FACE-Q Satisfaction With Nostrils, and NIF scores were clinically significant, while the change in FACE-Q Social Functioning was not (Table 6). Furthermore, there was a clinically and statistically significant improvement in NOSE scores in all patients who underwent SSG placement (mean [SD]: 20.9 [35.6]; $p < 0.001$).

Among the ESG cohort, there was a statistically significant improvement in NOSE scores in all patients, those with follow-up of at least six months (n = 41), and those with follow-up of at least twelve months (n = 31) (29.0 [29.9], 32.0 [28.2], and 30.1 [31.9], respectively; $p < 0.001$) (Table 5). Only the patients with follow-up of at least six months and at least twelve months who underwent ESG placement experienced clinically significant improvement. FACE-Q Satisfaction With Nose, FACE-Q Satisfaction With Nostrils, FACE-Q Social Functioning, and NIF scores also had statistically significantly improvements at time of last follow-up, with a mean (SD) change of 22.7 (26.3), 14.7 (30.2), 9.9 (19.2), and 23.5 (30.5), respectively ($p < 0.001$). The change in FACE-Q Satisfaction With Nose, FACE-Q Satisfaction With Nostrils, and NIF scores

were clinically significant, while the change in FACE-Q Social Functioning was not (Table 6). In addition, there was a statistically significant improvement in NOSE scores in all patients who underwent ESG placement (mean [SD]: 23.5 [30.0]; $p < 0.001$) (Figure 2).

Preoperative mean NOSE score was not significantly different between the SSG and ESG cohorts. However, at time of last follow-up, the mean (SD) postoperative NOSE score was significantly higher in the ESG cohort, compared to the SSG cohort (27.6 [26.3] and 20.4 [19.4], respectively; $p = 0.008$). In patients with follow-up of at least six months, the mean (SD) postoperative NOSE score was also significantly higher in the ESG cohort, compared to the SSG cohort (29.5 [27.2] and 20.5 [20.3], respectively; $p = 0.023$) (Table 5). This difference in mean postoperative NOSE score was lost at follow-up of 12 months. The mean (SD) change in NOSE score was significantly higher in the SSG cohort, compared to the ESG cohort (39.8 [25.9] and 29.0 [29.9], respectively; $p = 0.003$). However, at follow-up of 6 months and of 12 months, there was no significant difference in the mean change in NOSE score, and both cohorts had significant statistical and clinical improvement from baseline (Table 5).

There was no statistically significant difference in mean (SD) change in FACE-Q Satisfaction With Nose (18.9 [23.9] points in the SSG cohort, compared to 22.7 [26.3] points in the ESG cohort; $p = 0.309$), FACE-Q Satisfaction With Nostrils (20.3 [26.5] points in the SSG cohort, compared to 14.7 [30.2] points in the ESG cohort; $p = 0.200$), FACE-Q Social Functioning (8.7 [19.2] points in the SSG cohort, compared to 9.9 [19.2] points in the ESG cohort; $p = 0.669$), and NIF (20.9 [35.6] points in the SSG cohort, compared to 23.5 [30.0] points in the ESG cohort; $p = 0.473$) scores between the SSG and ESG cohorts (Table 6).

The Impact of Upper Lateral Cartilage Release on Patient-Perceived Nasal Appearance and Nasal Obstruction After Spreader Graft Placement

Patient Characteristics

A total of 589 patients underwent SRP with spreader graft placement, with release of the upper lateral cartilages performed in 559 (94.9%) patients (287 male [51.6%]), whereas the remaining 30 (5.1%) patients (18 male [60.0%]) did not undergo release of the upper lateral cartilages. Table 7 presents clinical characteristics of the two patient populations. There was a statistically significant difference in reason for SRP between groups. In the release cohort, 155 (27.7%) patients underwent cosmetic SRP, compared to 2 (6.7%) patients in the non-release cohort ($p = 0.010$).

In addition, use of PDS plate as an additional graft source was significantly higher in the release cohort (111 [19.9%] patients in the release cohort, compared to 3 [10.0%] patients in the non-release cohort; $p = 0.028$). Use of columellar strut/caudal extension graft as an additional graft source was also significantly higher in the release cohort (196 [35.1%] patients in the release cohort, compared to 2 [6.7%] patients in the non-release cohort; $p = 0.001$). Otherwise, cohorts were well-matched with no statistically significant differences in patient characteristics.

Outcomes

Among the release cohort, there was a clinically and statistically significant improvement in NOSE scores in all patients (at their time of last follow-up), those with follow-up of at least six months (n = 315), those with follow-up of at least twelve months (n = 186), and those who underwent functional SRP (n = 404) (mean [SD]: 43.4 [25.4], 43.1 [25.1], 41.3 [25.0], and 42.9 [25.6], respectively; $p < 0.001$) (Table 8). FACE-Q Satisfaction With Nose, FACE-Q Social Functioning, and NIF scores also had statistically significantly improvements at time of last follow-up, with a mean (SD) change of 19.1 (24.1), 8.8 (11.2), and 20.9 (35.8), respectively ($p <$

0.05). The changes in FACE-Q Satisfaction With Nose and NIF scores were clinically significant, while the change in FACE-Q Social Functioning were not (Table 9).

Among the non-release cohort, there was a clinically and significant improvement in NOSE scores in all patients, those with follow-up of at least six months (n = 10), those with follow-up of at least twelve months (n = 4), and those who underwent rhinoplasty for functional purposes (n = 28) (43.8 [18.7], 44.4 [19.9], 43.8 [21.8], and 43.5 [19.4], respectively; $p < 0.001$) (Table 8). FACE-Q Satisfaction With Nose, FACE-Q Social Functioning, and NIF scores also had statistically significantly improvements at time of last follow-up, with a mean (SD) change of 16.5 (24.6), 7.9 (15.5), and 25.9 (34.8), respectively ($p < 0.05$). The changes in FACE-Q Satisfaction With Nose and NIF scores were clinically significant, while the change in FACE-Q Social Functioning was not (Table 9).

Pre- and post-operative mean NOSE scores, as well as mean change in NOSE score, were not significantly different between the release and non-release cohorts at time of last follow-up, follow-up of at least six months, or follow-up of at least 12 months, or between the release and non-release functional rhinoplasty patients. Both cohorts also had significant statistical and clinical improvement from baseline (Table 8).

Pre-operative mean FACE-Q Satisfaction with NOSE and FACE-Q Social Functioning scores and post-operative FACE-Q Satisfaction with NOSE, FACE-Q Social Functioning, and NIF scores were not significantly different between the release and non-release cohorts at time of last follow-up. However, the mean (SD) pre-operative NIF score was significantly higher in the release cohort, compared to the non-release cohort (71.9 [33.8] and 52.7 [25.2], respectively; $p < 0.001$). There was no statistically significant difference in mean (SD) change in FACE-Q Satisfaction With Nose (19.1 [24.1] points in the release cohort, compared to 16.5 [24.6] points

in the non-release cohort; p = 0.576), FACE-Q Social Functioning (8.8 [11.2] points in the release cohort, compared to 7.9 [15.5] points in the non-release cohort; p = 0.756), and NIF (20.9 [35.8] points in the release cohort, compared to 25.9 [34.8] points in the non-release cohort; p = 0.450) scores between the release and non-release cohorts (Table 9).

Discussion, Conclusions, and Suggestions for Future Work

Unilateral NAO Causes Symptom Severity Scores Similar to Bilateral NAO

Unilateral nasal obstruction is an incompletely understood problem. Clinical experience suggests that unilateral obstruction can create bothersome symptoms, but quantitative evidence of this phenomenon is lacking. Interestingly, the effect of unilateral nasal obstruction was investigated in snoring and sleep outcomes in the 1990's where unilateral nasal obstruction was found to impact snoring and sleep apnea as strongly as bilateral obstruction.[24] Experiments in murine models of taste bud acquisition have also noted dramatic abnormalities of papillae development in rats subjected to unilateral nasal obstruction, demonstrating the importance of bilateral airflow for normal physiologic functions.[25] Here, we attempted to study the independent effect of unilateral nasal obstruction on the overall subjective symptom of nasal obstruction using the NOSE score and a standardized physical exam. We found that lateralizing internal nasal valve narrowing and septal deviation were predictive of higher NOSE scores, and thus increased severity of nasal obstruction. Internal nasal valve narrowing and septal deviation was predictive of symptomatic nasal obstruction for patients with both unilateral and bilateral nasal obstruction.

The use of NOSE scores as a validated patient-reported outcome measure has become a standard means of assessing patients with NAO in clinical research. The 2017 Clinical Practice Guide on Rhinoplasty recommends patient-reported outcome measures for clinical use and is supported by the American Academy of Facial Plastic and Reconstructive Surgery and the American Society of Plastic Surgeons.[26] Although the demographic and anatomic factors that influence NOSE scores have been previously analyzed, the relationship between NOSE scores and specific unilateral nasal physical exam finds has not been previously reported.[16] In this study

all demographic and anatomic variables were first tested with univariate analysis to identify associations, which were then reviewed in multivariate analysis to control for confounding relationships. Multivariate analysis demonstrated that bilateral and unilateral septal deviation and IVN physical exam scores were predictive of elevated NOSE scores. This finding demonstrates the importance of unilateral nasal obstruction even when the opposite side it not obstructed.

Physical exam scales for specific anatomic regions of the nose have previous been developed (turbinoplasty grading and lateral nasal wall insufficiency).[20, 27] The NAW used by Dr. Robin W. Lindsay incorporates physical exam grading scales for multiple areas including the septal deviation, internal nasal valve narrowing, external nasal valve narrowing, and lateral wall insufficiency.[17, 20, 28, 29] Measurements are reported for both the left and the right sides of the nose. For the septal deviation component of the NAW, a Likert scale from 0-3 was used so that 0 was used to describe no septal deviation. For the nasal valve narrowing and collapse components a Likert scale from 1-3 was used as previously validated for lateral wall insufficiency.[30] In 2013 Tsao et al. validated a scale for lateral wall insufficiency with grade 1 representing < 33% collapse, grade 2 representing 33-66% collapse, and grade 3 representing > 66% collapse.[30] A previous study demonstrated a composite NAW score combining all 12 parameters was predictive of increased NOSE score on multivariate analysis.[16] Our focus was to utilize the NAW to determine the impact of unilateral nasal obstruction on symptom severity. Through the NAW score, we uniquely demonstrate the association between specific physical exam finding scores and the severity of NAO.

Understanding the impact of unilateral nasal obstruction will help to inform providers caring for patients with nasal obstruction, highlight to insurance companies that patients with unilateral obstruction require correction, and to assist in the development clinically meaningful

objective outcomes measures. Given this information providers can better communicate with patients about the impact of unilateral nasal obstruction on their personal symptoms to explain the severity of their symptoms despite unilateral obstruction. Understanding the disease-specific and global quality of life impact of unilateral nasal obstruction will allow for future health utility evaluations to determine patients that are surgical candidates. Furthermore, as objective measures are developed to directly or indirectly measure nasal airflow and resistance it is important to understand how to utilize these results to improve the diagnosis and treatment of nasal obstruction. Normal total airflow for a patient with unilateral obstruction may not mean that the patient is asymptomatic if the majority of the nasal airflow is only on one side.

This study has several limitations. Given that the study was performed at a single tertiary academic center with a single surgeon, selection bias may have been introduced where patients may have required higher acuity or complex care and all physical exams were performed by a single surgeon. In addition, patients were only included in the NOSE correlation portion of the study if they completed a preoperative NOSE survey and agreed to have their information used for research purposes. Patients completed the baseline NOSE on the day of initial clinic visit, which may have caused patients to focus on their disease and rate their disease as having a more negative impact on their QOL compared to their average baseline; however, this should be true for patients with unilateral and bilateral nasal obstruction. Despite these limitations, the study has a large sample size of patients and offers valuable insight into the relationship between physical exam findings and symptomatic nasal obstruction.

Future research is needed to understand the reason that bilateral nasal airflow is important for the perception of appropriate nasal airflow. Recent research has discussed the importance of mucosal cooling and sensory feedback to prevent symptoms of nasal obstruction, but unilateral

versus bilateral symptoms have not been previously discussed.[31] As the field of nasal obstruction moves towards the use of objective measures, including computational fluid dynamic models, it is important for clinicians and investigators to understand the clinical importance of unilateral nasal obstruction on a patient's overall perception of nasal airflow.

Patient-Perceived Nasal Appearance After SRP With SSG vs. ESG

Both SSGs and ESGs are used in FSRP to improve nasal airway obstruction. However, the effectiveness of ESGs using patient-reported outcome measures has not been demonstrated, and results of ESGs have not been compared to SSGs. It is critical to study not only improvement in nasal airway obstruction in patients who have undergone septorhinoplasty with SSG versus ESG, but also aesthetic results, as patient perception of nasal appearance after surgery is an important component of surgical outcomes.

ESG use has been limited due to concern of widening the middle third of the nose, yielding an unfavorable cosmetic result.[32] However, we demonstrate that ESG placement results in improvement of patient perception of nasal appearance (Figure 3). We found that in addition to statistically and clinically significant improvement in NOSE and NIF scores, ESG placement produces statistically and clinically significant improvement in FACE-Q Satisfaction With Nose and FACE-Q Satisfaction With Nostrils scores, as well as statistically significant improvement in FACE-Q Social Functioning scores at time of last follow-up. In fact, aesthetic outcomes were significantly and clinically improved even in purely functional cases for the ESG cohort. When comparing the SSG and ESG cohorts, we found no statistically significant difference in mean change in FACE-Q Satisfaction With Nose, FACE-Q Satisfaction With Nostrils, FACE-Q Social Functioning, and NIF scores, suggesting comparable aesthetic improvement (Table 6). Dr. Robin W. Lindsay recommends utilization of ESG in patients that have a dorsal septal deviation as the

cause of their internal nasal valve narrowing, a S or C shaped deviation to the dorsal or caudal portion of the septum that is not corrected with SSG, septal fracture involving the dorsal L-strut, patients with a history of septoplasty that resulted in over resection of the L-strut (less than one cm), and cartilaginous saddle nose deformities. ESGs are particularly useful when a fracture involves the junction of the dorsal or caudal L-strut or when this region has been over resected during a previous septoplasty (Figure 4).

Beyond patient perception of nasal appearance, we found that ESG placement results in improvement of nasal airway obstruction with statistically and clinically significant improvement in NOSE scores at follow-up at 6 months and at 12 months. Although both SSGs and ESGs met the MCID for NOSE scores, patients who underwent SSG placement demonstrated a significantly higher improvement in mean change in NOSE score, compared to the ESG cohort. This is likely attributed to confounding due to differences in the two patient populations. Patients with dorsal septal deviation are more likely to undergo ESG placement for significant dorsal support and to have recurrent septal deviation, thereby potentially increasing their postoperative NOSE scores and resulting in a lower mean change in NOSE score.[33] However, these significant differences seen at earlier follow-up time points were lost at follow-up of 6 months and 12 months. Therefore, the ESG cohort, which is made up of revision patients who may have also required rib grafting, likely need a longer period to heal and improve symptoms of nasal airway obstruction.

It is important to note additional distinctions in patient demographics between the two cohorts. There was a statistically significant increase in history of rhinoplasty, septoplasty, and turbinoplasty ($p < 0.001$, $p < 0.001$, and $p = 0.006$, respectively) in patients who underwent ESG placement, compared to those who underwent SSG placement. We presume that this patient

cohort had a higher rate of failed nasal surgeries due to uncorrected dorsal septal deviation, necessitating ESG placement. This also explains the significant increase in use of rib cartilage as an additional graft source in patients who received ESGs (Table 6). The ESG cohort therefore represents a more complicated patient population than the SSG cohort. Although this is not a direct patient comparison due to these differing underlying characteristics, comparing the cohorts provides increased power and level of evidence to assess patient perception of nasal airway obstruction and aesthetic appearance in the extended spreader group.

While this study demonstrates that both patient-perceived nasal function and aesthetics improve following FSRP with ESG placement, this study has limitations. First, given that the study was performed at a single tertiary academic center with a single surgeon, selection bias may have been introduced where patients may have required higher acuity or complex care and all physical exams were performed by a single surgeon. Second, patients were only included in the NOSE, FACE-Q, or NIF correlation portions of the study if they completed a preoperative survey and agreed to have their information used for research purposes. Patients completed the baseline NOSE, FACE-Q, or NIF on the day of initial clinic visit, which may have caused patients to focus on their disease and rate their disease as having a more negative impact on their QOL compared to their average baseline; however, this should be true for patients who underwent SSG and ESG placement.

Furthermore, we do not directly measure the width of the nasal dorsum before or after surgery and do not assess patient satisfaction with nasal dorsum in isolation. Also, because SSGs and ESGs are placed in different patient populations, this is not a direct comparison. Still, this comparison provides useful clinical insight into patient perception of nasal airway obstruction and cosmetic appearance and demonstrates that despite prior history of nasal surgery, ESGs can

be used to improve nasal breathing without negatively affecting patients' overall perception of nasal aesthetics.

The Impact of Upper Lateral Cartilage Release on Patient-Perceived Nasal Appearance and Nasal Obstruction After Spreader Graft Placement

Internal nasal valve narrowing is a common cause of symptomatic nasal obstruction. More recently, using computational fluid dynamic modeling, our group has demonstrated the internal nasal valve to be an area of increased resistance, which can be reversed by the placement of spreader grafts (publication pending – accepted to PRS). The traditional approach to SRP with spreader graft placement involves release of the upper lateral cartilages from the dorsum of the septum.[7] Our group has previously reported on the functional and aesthetic outcomes of the placement of spreader grafts with the release, and demonstrated improvement in nasal obstruction without a negative impact on patient perceived nasal appearance.[8] However, as there is a shift toward preservation rhinoplasty to improve NAO while maintaining natural structure of the dorsum, release of the upper lateral cartilages may be reconsidered. The impact of avoiding release of the upper lateral cartilages in patients undergoing SRP with spreader graft placement has not been demonstrated using patient-reported outcome measures, and results of non-release have not been compared to release. It is important not only to evaluate improvement in NAO in patients who have undergone SRP with spreader graft placement with release versus without release of the upper lateral cartilages, but also to analyze aesthetic results, as patient perception of nasal appearance after surgery is a critical part of surgical outcomes.

This study demonstrates that SRP with spreader graft placement without release of the upper lateral cartilages results in improvement in NAO and patient perception of nasal appearance. Avoiding release of the upper lateral cartilages produces statistically and clinically

significant improvement in NOSE and NIF scores at time of last follow-up, follow-up at six months, and follow-up of 12 months. In addition, the non-release cohort demonstrated statistically and clinically significant improvement in FACE-Q Satisfaction With Nose and statistically significant improvement in FACE-Q Social Functioning scores at time of last follow-up. In fact, even in purely functional cases, there is statistically and clinically significant improvement in aesthetic outcomes. When comparing the non-release and release cohorts, there is no statistically significant difference in mean change in NOSE, FACE-Q Satisfaction with NOSE, FACE-Q Social Functioning, and NIF scores, suggesting comparable improvement.

Despite no statistically significant difference in mean change of NIF scores between cohorts, mean pre-operative NIF score was significantly higher in the release cohort, compared to the non-release cohort. We theorize that this is due to the smaller sample size of the non-release cohort. We also previously showed that NIF values lack a strong correlation with NOSE scores, which limit's NIF's utility as a diagnostic tool for NAO. Rather, NIF is most useful when pre- and post-operative values are compared to detect clinically significant objective improvements in nasal airflow following SRP (i.e., with change in NIF score).[34] Despite having lower nasal airflow at baseline, as measured by the PNIF, this study demonstrates statistically and clinically significant improvement in NIF scores at time of last follow-up for patient undergoing placement of spreader grafts without release of the upper lateral cartilages. This, combined with the statically significant improvement in NOSE scores in the non-release cohort, demonstrates that upper lateral cartilages do not need to be released for successful spreader graft placement.

It is important to consider differences in patient demographics between the release and non-release cohorts. There was a statistically significant difference in reason for SRP between

groups, with significantly more patients undergoing cosmetic SRP in the release cohort ($p = 0.010$). This is consistent with the need to release the upper lateral cartilages from the cartilaginous dorsum for completion of a component cosmetic dorsal hump reduction.[35] Furthermore, use of PDS plate and columellar strut/caudal extension graft as an additional graft source was significantly higher in the release cohort ($p = 0.028$ and $p = 0.001$, respectively). PDS plate is often utilized in cases with significant caudal and dorsal septal deviation, so it is expected that use of PDS plate often necessitates release of the upper lateral cartilages.[36] The release cohort therefore represents a patient population with significant caudal or dorsal septal deviation or one that required dorsal hump reduction. Although these underlying characteristics differ, comparing the groups provides increased power and level of evidence to study patient perception of NAO and aesthetic outcomes in the non-release cohort.

While this study demonstrates that both patient-perceived nasal function and aesthetics improve following SRP with spreader graft placement without upper lateral cartilage release, limitations exist. The study was performed at a single tertiary academic center with a single surgeon, so selection bias may have been introduced. Patients were only included in the NOSE, FACE-Q, or NIF score correlation portions of the study if they completed a pre-operative survey and agreed to have their information used for research purposes. Patients completed the baseline NOSE, FACE-Q, or NIF on the day of initial clinic visit, which may have caused patients to focus on their disease and rate their disease as having a more negative impact on their QOL compared to their average baseline, but this should be true for patients in both the release and non-release cohorts. Also, this study does not directly measure the width of the nasal dorsum before or after surgery and does not assess patient satisfaction with nasal dorsum in isolation. \

Because release of the upper lateral cartilages is performed in a different patient population from that without release, this is not a direct comparison. Still, this comparison provides useful clinical insight into patient perception of NAO and aesthetic appearance and shows that release of the upper lateral cartilages during SRP with spreader graft placement is not necessary to improve nasal breathing without negatively affecting patients' overall perception of nasal aesthetics. Patient selection is important when deciding whether or not upper lateral cartilage release is needed. Patients with a dorsal septal deviation and/or undergoing a component dorsal hump reduction will most likely require release. However, Dr. Robin W. Lindsay recommends that upper lateral cartilage release should not be performed by default for all patients requiring spreader grafts, and careful consideration should be given prior to release as to preserve the native middle vault structure if possible.

Summary

I chose this project due to my deep interest in otolaryngology and facial plastic surgery. Caring for patients suffering from nasal airway obstruction motivated me to investigate clinical outcomes in septorhinoplasty. We demonstrate that physical exam findings, including septal deviation and IVN, are predictive of an increased NOSE score, regardless of laterality. Unilateral nasal obstruction can cause the same level of symptomatic nasal obstruction as patients with bilateral obstruction. Therefore, patients with unilateral symptoms or physical exam findings should be treated for their symptomatic nasal obstruction despite having only unilateral obstruction. Furthermore, we show that, despite concerns that ESGs may negatively affect aesthetics, SSGs and ESGs provide a clinically and statistically significant improvement and no significant difference in functional outcome. Similarly, SRP with spreader graft placement with upper lateral cartilage release and without upper lateral cartilage release provides a clinically and statistically significant improvement and no significant difference in functional outcome. All of these surgical techniques can be effective. ESGs can be used to improve nasal airway obstruction without negatively impacting patient-perceived nasal aesthetics, and release of the upper lateral cartilages should not be the default in all patients. The etiology of the NAO and/or deformity and the reason for SRP should inform clinical decision making when considering which technique to perform.

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Table 1. Unilateral NAO Causes Symptom Severity Scores Similar to Bilateral NAO:

Patient Characteristics

Patient Characteristics (n = 1081)	**Value**
Sex (n = 1075)	
Female (%)	53.9
Male (%)	46.1
Age (n = 1015)	
Mean (years)	38.0
Standard Deviation (years)	16.5
NOSE (n = 1081)	
Mean	59.7
Standard Deviation	25.0

Table 2. Unilateral NAO Causes Symptom Severity Scores Similar to Bilateral NAO:

Physical exam results stratified by NOSE score with corresponding univariate analysis

	Left Side		Right Side	
Physical Exam	**NOSE Score (St. Dev)**	**p-value**	**NOSE Score (St. Dev)**	**p-value**
External Valve Narrowing				
1	57.9 (1.0)		57.1 (1.0)	
2	62.4 (1.3)	0.011	64.8 (1.3)	<0.001
3	62.9 (2.0)		63.4 (2.2)	
External Valve Collapse				
1	57.4 (0.9)		57.4 (0.9)	
2	64.9 (1.3)	<0.001	65.5 (1.3)	<0.001
3	66.5 (2.9)		65.1 (2.6)	
Internal Valve Narrowing				
1	50.1 (1.8)		50.3 (1.7)	
2	62.1 (1.2)	<0.001	61.9 (1.2)	<0.001
3	63.0 (1.1)		64.0 (1.1)	
Internal Valve Collapse				
1	56.9 (1.0)		56.5 (1.0)	
2	65.7 (1.3)	<0.001	67.0 (1.2)	<0.001
3	63.6 (2.7)		62.7 (2.3)	
Inferior Septal Deviation				
0	54.9 (1.3)		56.5 (1.2)	
1	64.0 (1.8)	<0.001	62.4 (1.7)	<0.001
2	61.7 (1.6)		63.6 (1.5)	
3	64.3 (1.4)		63.8 (1.7)	
Superior Septal Deviation				
0	55.1 (1.4)		55.4 (1.3)	
1	63.6 (1.8)	<0.001	62.1 (1.7)	<0.001
2	61.4 (1.7)		62.4 (1.6)	
3	63.2 (1.2)		64.7 (1.3)	

Table 3. Unilateral NAO Causes Symptom Severity Scores Similar to Bilateral NAO: Multiple linear regressions for NOSE scores based on bilateral and unilateral physical exam findings

NOSE Score	Coefficient	95% CI	p-value
Bilateral Scores			
IVN Score	3.133	1.783 – 4.482	<0.001
IVC Score	1.962	(-0.426) – 4.350	0.107
EVN Score	-0.238	(-1.705) – 1.230	0.751
EVC Score	1.145	(-1.403) – 3.693	0.378
Total Septum core	0.803	0.371 – 1.235	<0.001
Age	0.073	(-0.020) – 0.167	0.123
Sex			
Male	Ref		
Female	1.072	(-1.962) – 4.106	0.488
Left Sided Scores			
IVN Score	3.340	1.122 – 5.558	0.003
IVC Score	3.646	(-0.722) – 8.014	0.102
EVN Score	-0.499	(-2.968) – 1.969	0.692
EVC Score	2.968	(-1.590) – 7.525	0.202
Total Septum core	1.346	0.570 – 2.122	0.001
Age	0.072	(-0.022) – 0.166	0.134
Sex			
Male	Ref		
Female	0.817	(-2.245) – 3.879	0.601
Right Sided Scores			
IVN Score	4.230	1.991 – 6.470	<0.001
IVC Score	4.077	(-0.271) – 8.424	0.066
EVN Score	1.059	(-1.646) – 3.763	0.443
EVC Score	1.570	(-3.132) – 6.271	0.513
Total Septum core	1.073	0.290 – 1.855	0.007
Age	0.050	(-0.043) – 0.143	0.295
Sex			
Male	Ref		
Female	0.734	(-2.313) – 3.781	0.637

Table 4. Patient-Perceived Nasal Appearance After SRP With SSG vs. ESG: Patient Characteristics

	Spreader	Extended spreader	P-value
Number of patients, n (%)	568 (81.8)	126 (18.2)	
Age, mean (SD), y	34.8 (14.8)	42.7 (16.4)	**< 0.001**
Gender, n (%)			0.668
Female	272 (48.1)	58 (46.0)	
Male	293 (51.9)	68 (54.0)	
History of snoring, n (%)	272 (49.1)	63 (51.6)	0.611
History of smoking, n (%)	346 (96.9)	65 (91.6)	**0.034**
History of nasal steroid use, n (%)	159 (28.2)	36 (29.0)	0.860
History of nasal fracture, n (%)	273 (48.8)	63 (50.4)	0.739
History of nasal surgery, n (%)	269 (47.4)	121 (96.0)	**< 0.001**
Closed nasal reduction	47 (8.3)	11 (8.7)	0.867
Rhinoplasty	42 (7.4)	47 (37.3)	**< 0.001**
Septoplasty	116 (20.4)	83 (65.9)	**< 0.001**
Sinus surgery	28 (4.9)	10 (7.9)	0.180
Turbinoplasty	36 (6.3)	17 (13.5)	**0.006**
Reason for rhinoplasty, n (%)			0.850
Functional	524 (92.3)	120 (95.2)	
Cosmetic	44 (7.7)	6 (4.8)	
Additional graft source, n (%)			
Rib cartilage	58 (10.2)	67 (53.2)	**< 0.001**
Septal cartilage	486 (85.6)	19 (15.1)	**< 0.001**
Conchal cartilage	6 (1.1)	1 (0.8)	0.999
PDS plate	112 (19.7)	13 (10.3)	**0.013**
Cadaveric rib	16 (2.8)	49 (38.9)	**< 0.001**
Additional graft type, n (%)			
Columellar strut	196 (34.5)	36 (28.6)	0.201
Alar rim	89 (15.7)	16 (12.7)	0.400
Alar batten	2 (0.4)	1 (0.8)	0.452
Lateral crural strut	127 (22.4)	26 (20.6)	0.673
Dorsal onlay	3 (0.5)	9 (7.1)	**< 0.001**
Lateral crural replacement	6 (1.1)	21 (16.7)	**< 0.001**
Other procedures, n (%)	30 (5.3)	3 (2.4)	0.466

Table 5. Patient-Perceived Nasal Appearance After SRP With SSG vs. ESG: Preoperative and Postoperative NOSE Scores by Graft Type

	Mean (SD) Score		Mean (SD) Change in Score	Clinically Significant?[a]
	Preoperative	Postoperative		
All patients				
Spreader	63.9 (22.5)	20.4 (19.5)[b]	39.8 (25.9)	Yes
Extended spreader	63.9 (24.6)	27.6 (26.3)[b]	29.0 (29.9)	No
P value[c]	0.995	**0.008**	**0.003**	
Follow-up ≥ 6 months				
Spreader	49.7 (25.2)	20.5 (20.3)[b]	39.4 (26.2)	Yes
Extended spreader	50.0 (28.7)	29.5 (27.2)[b]	32.0 (28.2)	Yes
P value[c]	0.978	**0.023**	0.102	
Follow-up ≥ 12 months				
Spreader	44.6 (23.3)	20.8 (21.4)[b]	37.7 (26.0)	Yes
Extended spreader	49.3 (27.1)	30.0 (27.0)[b]	30.1 (31.9)	Yes
P value[c]	0.672	0.079	0.229	

Abbreviations: MCID, mean clinically important difference; NOSE, Nasal Obstruction Symptom Evaluation.

[a] Clinical significance was determined by a change greater than the NOSE score MCID of 30.

[b] Statistically significant change within each cohort ($p < 0.001$).

[c] The *P* value rows indicate the statistical difference between the spreader graft and extended spreader graft cohorts.

Table 6. Patient-Perceived Nasal Appearance After SRP With SSG vs. ESG: Preoperative and Postoperative FACE-Q & NIF Scores by Graft Type[a]

	Mean (SD) Score		Mean (SD) Change in Score	Clinically significant?[b]
	Preoperative	Postoperative		
FACE-Q Satisfaction With Nose				
Spreader	57.6 (21.5)	77.0 (21.2)[c]	18.9 (23.9)	Yes
Extended spreader	53.7 (22.3)	76.1 (21.9)[c]	22.7 (26.3)	Yes
P value[d]	0.191	0.734	0.309	
FACE-Q Satisfaction With Nostrils				
Spreader	64.3 (25.2)	84.4 (20.4)[c]	20.3 (26.5)	Yes
Extended spreader	63.4 (29.3)	81.0 (23.6)[c]	14.7 (30.2)	Yes
P value[d]	0.820	0.219	0.200	
FACE-Q Social Functioning				
Spreader	74.0 (20.6)	82.9 (20.1)[c]	8.7 (19.2)	No
Extended spreader	71.6 (20.1)	82.2 (19.5)[c]	9.9 (19.2)	No
P value[d]	0.364	0.850	0.669	
NIF				
Spreader	70.2 (33.7)	92.7 (43.8)[c]	20.9 (35.6)	Yes
Extended spreader	66.4 (35.7)	89.7 (42.2)[c]	23.5 (30.0)	Yes
P value[d]	0.328	0.538	0.473	

Abbreviations: MCID, mean clinically important difference; NIF, negative inspiratory force.

[a] Reported are the mean (SD) preoperative and postoperative FACE-Q and NIF scores at time of last follow-up, by those with spreader graft placement (n = 568) and those with extended spreader graft placement (n = 126).

[b] Clinical significance was determined by a change greater than the MCID for each scale: FACE-Q Satisfaction with Nose MCID, 11.0; FACE-Q Satisfaction with Nostrils MCID, 13.6; FACE-Q Social Functioning MCID, 10.2; and NIF MCID, 20.

[c] Statistically significant change within each cohort ($p < 0.001$).

[d] The *P* value rows indicate the statistical difference between the spreader graft and extended spreader graft cohorts.

Table 7. The Impact of Upper Lateral Cartilage Release on Patient-Perceived Nasal Appearance and Nasal Obstruction After Spreader Graft Placement: Patient Characteristics

	Release	Non-release	P-value
Number of patients, n (%)	559 (94.9)	30 (5.1)	
Age, mean (SD), y	34.8 (14.8)	35.3 (14.8)	0.818
Gender, n (%)			0.371
Female	269 (48.4)	12 (40.0)	
Male	287 (51.6)	18 (60.0)	
History of nasal steroid use, n (%)	156 (28.2)	8 (26.7)	0.859
History of nasal fracture, n (%)	268 (48.6)	18 (62.1)	0.159
History of nasal surgery, n (%)	368 (66.9)	23 (76.7)	0.267
Closed nasal reduction	47 (8.4)	1 (3.3)	0.500
Rhinoplasty	42 (7.5)	2 (6.7)	1.000
Septoplasty	115 (20.6)	4 (13.3)	0.484
Sinus surgery	27 (4.8)	2 (6.7)	0.654
Turbinoplasty	36 (6.4)	2 (6.7)	1.000
Reason for rhinoplasty, n (%)			**0.010**
Functional	404 (72.3)	28 (93.3)	
Cosmetic	155 (27.7)	2 (6.7)	
Additional graft source, n (%)			
Rib cartilage	57 (10.2)	1 (3.3)	0.346
Septal cartilage	478 (85.5)	25 (83.3)	0.742
Conchal cartilage	6 (1.1)	0 (0.0)	1.000
PDS plate	111 (19.9)	1 (3.3)	**0.028**
Cadaveric rib	16 (2.9)	3 (10.0)	0.066
Columellar strut/caudal extension graft	196 (35.1)	2 (6.7)	**0.001**
Alar rim	89 (15.9)	6 (20.0)	0.554
Alar batten	2 (0.4)	0 (0.0)	1.000
Lateral crural strut	124 (22.2)	7 (23.3)	0.883
Dorsal onlay	3 (0.5)	0 (0.0)	1.000

Table 8. The Impact of Upper Lateral Cartilage Release on Patient-Perceived Nasal Appearance and Nasal Obstruction After Spreader Graft Placement: Preoperative and Postoperative NOSE Scores by Spreader Graft Method

	Mean (SD) Score		Mean (SD) Change in Score	Clinically Significant?[a]
	Preoperative	Postoperative		
All patients				
Release	63.7 (22.3)	20.4 (19.5)[b]	43.3 (25.4)	Yes
Non-release	65.2 (19.1)	21.4 (16.0)[b]	43.8 (18.7)	Yes
P value[c]	0.681	0.895	0.282	
Follow-up ≥ 6 months				
Release	63.4 (22.3)	20.4 (20.2)[b]	43.1 (25.1)	Yes
Non-release	65.0 (4.6)	20.6 (17.2)[b]	44.4 (19.9)	Yes
P value[c]	0.368	0.950	0.280	
Follow-up ≥ 12 months				
Release	62.0 (22.8)	20.8 (21.4)[b]	41.3 (25.0)	Yes
Non-release	58.8 (9.5)	15.0 (14.7)[b]	43.8 (21.8)	Yes
P value[c]	0.553	0.514	0.501	
All functional SRP patients				
Release	63.4 (22.5)	20.5 (18.9)[b]	42.9 (25.6)	Yes
Non-release	65.0 (19.7)	21.5 (16.4)[b]	43.5 (19.4)	Yes
P value[c]	0.362	0.397	0.458	

Abbreviations: MCID, mean clinically important difference; NOSE, Nasal Obstruction Symptom Evaluation.

[a] Clinical significance was determined by a change greater than the NOSE score MCID of 30.

[b] Statistically significant change within each cohort ($p < 0.001$).

[c] The *P* value rows indicate the statistical difference between the spreader with release and spreader without release cohorts.

Table 9. The Impact of Upper Lateral Cartilage Release on Patient-Perceived Nasal Appearance and Nasal Obstruction After Spreader Graft Placement: Preoperative and Postoperative FACE-Q & NIF Scores by Spreader Graft Type[a]

	Mean (SD) Score		Mean (SD) Change in Score	Clinically significant?[b]
	Preoperative	Postoperative		
FACE-Q Satisfaction With Nose				
Release	57.5 (21.6)	76.5 (21.5)[c]	19.1 (24.1)	Yes
Non-release	61.0 (16.2)	77.5 (18.1)[c]	16.5 (24.6)	Yes
P value[d]	0.266	0.772	0.576	
FACE-Q Social Functioning				
Release	73.5 (20.3)	82.3 (20.4)[c]	8.8 (11.2)	No
Non-release	76.9 (21.9)	84.8 (21.2)[c]	7.9 (15.5)	No
P value[d]	0.412	0.533	0.756	
NIF				
Release	71.9 (33.8)	92.8 (43.5)[c]	20.9 (35.8)	Yes
Non-release	52.7 (25.2)	78.6 (39.2)[c]	25.9 (34.8)	Yes
P value[d]	**< 0.001**	0.063	0.450	

Abbreviations: MCID, mean clinically important difference; NIF, negative inspiratory force.

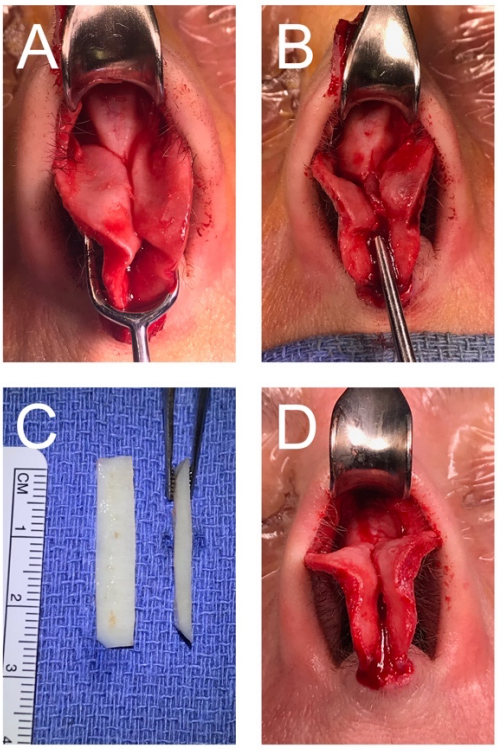
[a] Reported are the mean (SD) preoperative and postoperative FACE-Q and NIF scores at time of last follow-up, by those with spreader with release (n = 559) and those with spreader without release (n = 30).

[b] Clinical significance was determined by a change greater than the MCID for each scale: FACE-Q Satisfaction with Nose MCID, 11.0; FACE-Q Satisfaction with Nostrils MCID, 13.6; FACE-Q Social Functioning MCID, 10.2; and NIF MCID, 20.

[c] Statistically significant change within each cohort ($p < 0.05$).

[d] The *P* value rows indicate the statistical difference between the spreader with release and spreader without release cohorts.

Figure 1. Spreader Graft Placement without Upper Lateral Cartilage Release



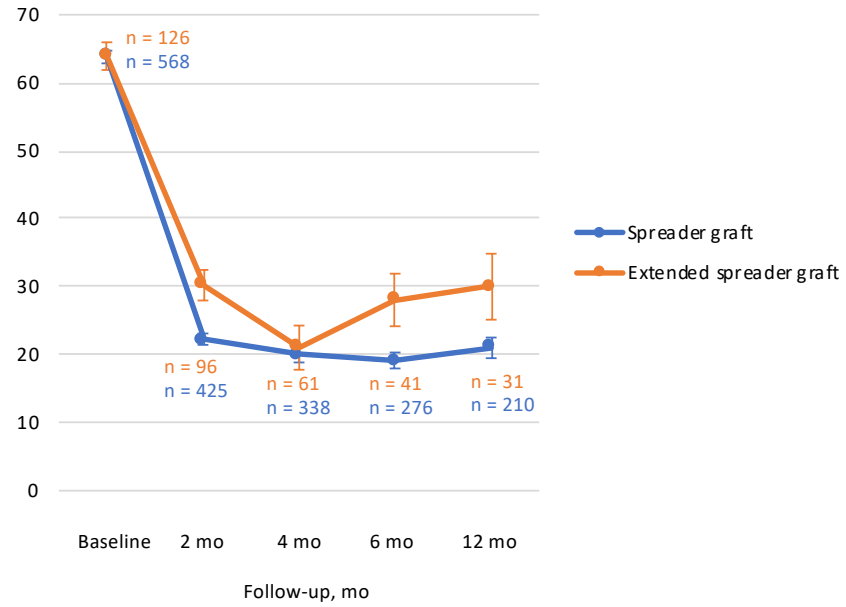
A) Narrow middle vault in a patient with internal nasal valve narrowing and a h/o previous septoplasty and midline dorsal septum

B) Caudal elevator in a pocket created between the dorsal septum and the mucoperichondrium for the placement of the spreader graft without release of the upper lateral cartilages

C) Spreader grafts carved from cadaveric rib because of the patient's previous septoplasty

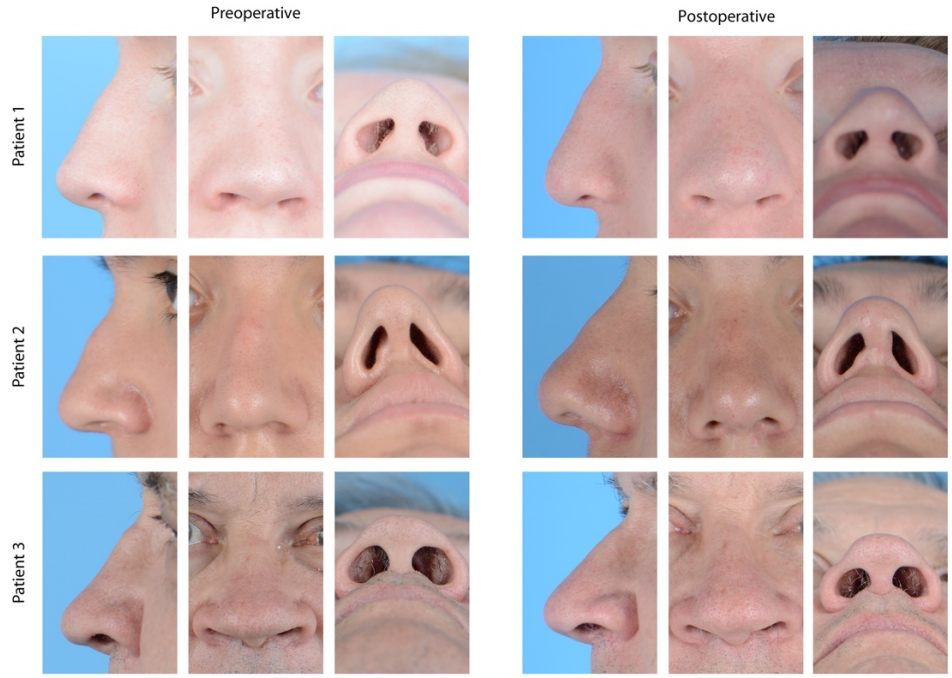
D) Bilateral spreader grafts in place.

Figure 2. Patient-Perceived Nasal Appearance After SRP With SSG vs. ESG: Preoperative and Postoperative NOSE Scores at Each Measurement Point



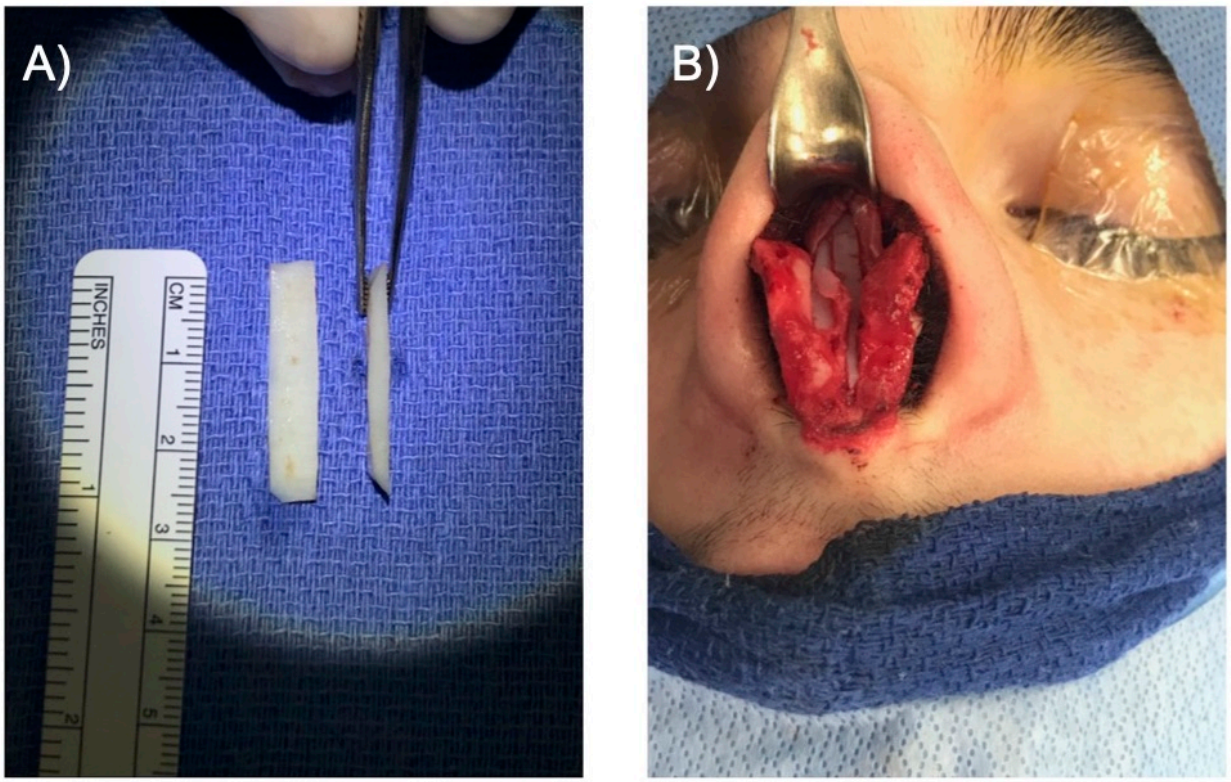
Baseline and 2-, 4-, 6-, and 12-month follow up scores of Nasal Obstruction Symptom Evaluation (NOSE) scores. There are no significant differences between follow-up time point scores. All postoperative NOSE scores show statistically significant improvements from baseline. For the spreader graft cohort, NOSE scores show a clinically significant improvement at all time points. For the extended spreader graft cohort, NOSE scores show a clinically significant improvement at 6 and 12 months.

Figure 3. Preoperative and Postoperative Nasal Photographs After Extended Spreader Graft Placement



Patient 1 is an adult male with a history of nasal trauma, septoplasty, and a closed nasal reduction who underwent an open functional septorhinoplasty with extended spreaders grafts (cadaveric rib) to correct the dorsal septal deviation and internal nasal valve narrowing. NOSE score at baseline was 45 and 12-month post-operatively was 10. FACE-Q baseline 90 and 12-month post-operatively was 100. Patient 2 is a teenage girl with a history of nasal trauma treated with a functional SRP with PDS plate, extended spreader grafts (septal cartilage), a swinging door, and osteotomies. NOSE score at baseline was 45 and 12-month post-operatively was 5. FACE-Q baseline 56 and 12-month post-operatively was 100. Patient 3 is an adult male with a history of a septoplasty and nasal trauma with a cartilaginous saddle nose deformity and bilateral internal nasal valve narrowing who underwent an open functional septorhinoplasty with extended spreader grafts (cadaveric rib) NOSE score at baseline was 60 and 12-month post-operatively was 30. FACE-Q baseline 67 and 12-month post-operatively was 100.

Figure 4. Extended Spreader Grafts



A) Beveled extended spreader graft from rib graft.

B) Intra-operative view of extended spreader grafts after being sutured to the dorsal septum with a 5.0 PDS suture for correction of a dorsal septal deviation, and prior to the upper lateral cartilage being brought back to length and sutured in place.