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FACIAL PLASTICS: FUNCTIONAL RHINOPLASTY( TD WANG AND CZ JOHNSON, SECTION EDITORS)

# Does the Butterfly Graft *Really* Work?

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## Abstract

**Purpose of Review** The goal is to review the current evidence related to the butterfly graft (BG), specifically to address functional and aesthetic comparisons to other frequently used surgical techniques to repair nasal valve compromise.

**Recent Findings** Several clinical reports and cadaveric studies using computational fluid dynamics (CFD) have compared the BG to other techniques, demonstrating superior functional outcomes and CFD flow characteristics for the BG, respectively. Recent evidence exists comparing the aesthetic outcomes for the BG to other techniques, demonstrating non-inferiority.

**Summary** Successful rhinoplasty maximizes both form and function. Although the functional success of the BG is undisputed, questions remain about the aesthetic outcomes. Future research to investigate these questions, including a multi-institutional prospective comparative study of the BG versus other techniques including spreader grafts, lateral crural strut grafts, and alar rim grafts, will be discussed.


**Keywords** Butterfly graft · Rhinoplasty · Internal nasal valve · Nasal airway obstruction · Nasal valve compromise

## Introduction

Otolaryngologists, like all clinicians make many decisions under conditions of uncertainty, and proper surgical management of nasal airway obstruction is no exception. With the expanding use of the butterfly graft (BG) across the world, it is appropriate to ask the question–does the BG *really* work? This article will review the evidence surrounding the use of the BG–including recognition of the need for techniques that improve upon the current "standard" techniques (septoplasty and spreader grafts, for example), improved methods of diagnosis of nasal valve compromise (NVC), challenges in scientific measurements of outcomes, and predictions of future studies intended to answer the question more definitively.

Agreement exists among experts in nasal valve surgery that successful rhinoplasty outcomes should maximize both form and function. However, the techniques used to achieve those results differ–based on surgical training and continuing education, aggregate clinical experience, and bias.

It is well known that nasal airway obstruction (NAO) is a societal economic burden and one of the most common reasons patients seek consultation with an otolaryngologist. Septoplasty ranks third in frequency behind only tonsillectomy and myringotomy/tubes in procedures performed by an otolaryngologist. However, a recent systematic review of the literature confirms that septoplasty alone is often unsuccessful in long-term resolution of NAO [1••].

So, the question posed by the title of this review is *really* a microcosm of the question we as otolaryngologists should ask one another-How can our specialty improve our outcomes for all of our surgical procedures?

> "For the past century, the prevailing belief in Western medicine was that the nose was more or less an ancillary organ. We should breathe out of it if we can, the thinking went, but if not, no problem. That's what the mouth is for."
> "**James Nestor. Breathe: The New Science of a Lost Art. 2020.** p 5 [2••]."

This article is part of the Topical Collection on *FACIAL PLASTICS: Functional Rhinoplasty*

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## Recognition of the Problem

Patients who present to their primary care physician (PCP) with a "stuffy nose" are sometimes dismissed as nuisance complaints—nothing that compares to "more serious" conditions such as coronary artery disease (CAD) or congestive heart failure. This is certainly not meant as a criticism of PCPs, as it is deeply ingrained in human nature to use visual cues in creating our impressions of one another. Modern medicine encourages PCPs to see more patients and spend less time with each patient, creating a stressful environment, often leading to physician burnout [3]. According to Malcolm Gladwell (Blink), rapid cognition often fails for anyone placed in a highly stressful situation and strongly correlates with visual information [4]. Therefore, while our NAO patient population most often visually appears to be healthy-especially to the casual observer, the impact on their quality of life (QOL) is frequently profound.

In fact, the protean effects on QOL associated with nasal congestion and NAO are among the most costly physical health conditions for employers, costing significantly more than osteoarthritis, renal failure, and breast cancer [5•]. Disruptions in sleep, fatigue, and poor concentration reduce work productivity and academic performance, not only affect our patients individually but are also a significant economic burden on society [6•].

Appropriate recommendations for referral from PCPs to otolaryngologists include patients who are resistant to maximal medical management (nasal hygiene, nasal steroids, and other allergy treatments) and those with symptomatic structural abnormalities [7]. I also encourage referral of patients who rely on chronic use of systemic decongestants for the treatment of nasal congestion, as the long-term adverse sequelae of these medications on hypertension and CAD may be obviated with surgical correction of NAO.

## Patient History

The history of present illness (HPI) is where the search for the ideal method of surgical treatment of NAO begins. Consideration of mucosal factors in NAO is critical, and their contribution to the problem should be maximally medically controlled before proceeding with surgical intervention [8••]. The difference between nasal congestion (medically reversible factors) and nasal obstruction (surgically reversible factors) should be discussed with the patient. Also, the patient should be informed that mucosal contributors to NAO may require ongoing medical management, even after successful surgery to correct NVC. Most insurance companies require that a patient "fail" a trial of 4–6 weeks of an intranasal steroid as a prerequisite for approval of nasal surgery. We routinely recommend daily nasal irrigations, used 5–10 min prior to intranasal steroid use (provided there are no contraindications), to optimize nasal mucosal hygiene prior to making any decision on nasal surgery. This is also our postoperative medical regimen and allows for the patient to "practice" before surgery.

Many patients who present with NVC have undergone prior nasal surgery including septoplasty, inferior turbinate surgery, rhinoplasty, and other more recent technologies (radiofrequency mucosal treatment, absorbable nasal implants, etc.). Often, there is a history of nasal trauma, especially during puberty when the septum is growing rapidly, and loss of contact inhibition results in severe septal deviations and nasal deformities. The deleterious effects of trauma (including surgical trauma) on the sensation of nasal airflow is poorly understood, but should be discussed with the patient before surgery. Proprioceptive feedback is sometimes altered in patients after trauma and may be a contributing factor in the well-recognized discordance between objective clinical evaluation and subjective nasal patency.

There has been an increase in the use of external nasal dilators (ENDs) and intranasal cones among patients with NAO, and I find the use of these devices helpful in surgical decision-making. I have observed that patients who find at least partial relief with the use of ENDs respond most significantly to BG for treatment of NVC, and the physics of the BG is easily understood as an "internal" version of an END (see video). My patients routinely report that the effects on NAO are more profound with the BG, described by most patients as "significantly better" than ENDs, but this has not yet been formally studied. A study is underway to evaluate the predictive value of ENDs in the surgical treatment of NVC at our institution.

However, there are certain types of nasal anatomic variations that do not tend to be predictive with the use of ENDs–tension nose deformities and very thick skin, soft tissue envelopes. Interpretation of negative results from patients with these anatomic variations should be interpreted with caution. I discuss the difficulty the ENDs may have with transmission of the force to the sensation in the intranasal mucosa in these patients and state clearly that, although expectations should be moderated, I do not eliminate the BG from consideration altogether.

A thorough patient history should also include at least one disease-specific patient QOL measure. Although the NOSE scale has emerged as the optimal patient-reported outcome measure (PROM), correlation of patient-reported symptoms does not correlate with objective measures [9]. Given the lack of correlation between PROMs and objective measures of NAO, continued exploration for novel nasal airway structural measures is necessary.

> "The whole art of medicine is in observation… but to educate the eye to see, the ear to hear and the finger to feel takes time, and to make a beginning, to start a man on the right path, is all that you can do."
> "**William Osler. "The Hospital as a College" Aequanimitas. 1914:332** [10]."

## Diagnosis (Table 1)

There is great heterogeneity in the nasal examination among otolaryngologists. We have previously published our experience with teaching nasal analysis to otolaryngology residents, but this study only evaluated visual evaluation [11]. Regardless of the sequence, certain components of the complete examination are necessary to completely appreciate the nuances of NAO. In my experience as an educator of fellows and residents, during the clinical evaluation of NAO, palpation is the most often "overlooked" part of the complete examination of the nose. Valuable information is obtained by palpation of the transition of the nasal process of the maxilla to the nasal bones, the length, and orientation of the nasal bones, tip recoil, the inherent strength, position and shape of the lower lateral cartilages (LLCs), and the palpable strength of the upper lateral cartilages (ULC) in the midnasal vault. Since there is no objective measure of "normal" ULC strength, palpation must be a routine part of the exam to get "the finger to feel" (Osler) over time. With practice, both in the clinic and in the operating room before injection of local anesthetic into the nose, the astute diagnostician will gain an appreciation for the subtle patient differences in ULC strength.

Visualization must include the "context" of the nose, including the nasal muscle (dilator nasi, transverse nasalis) movement, asymmetries in muscular pull on the perinasal tissues (depressor septi nasalis, zygomaticus), asymmetries in projection and support of the maxilla, differences in the interincisor midline, and intercanthal midlines of the face, and overall differences in the width of the 2 sides of the face. External nasal visualization is well described in the literature and should proceed in a deliberate, repeatable sequence to avoid focusing too much on certain more obvious aspects and missing important (but less obvious) details. For example, deep supra-alar creases often indicate lateral crural recurvature, an occasional contributor to NVC. All of this information, both visual and tactile, must be integrated to make an accurate diagnosis of the problem.

The intranasal examination begins without manipulation of the nostrils, noticing the movement of the nostrils with deep and baseline nasal inspiration. The nasal speculum exam should deliberately dedicate time for detailed evaluation of both the inferior and superior nasal corridors [12•]. Superior corridor deformities may include dorsal septal keel deviations (especially in postseptoplasty patients), thickness of the dorsal septum, septal swell body, vertically oriented ULCs, mucosal contact at the apex of the INV, mucous cohesion of the ULC and dorsal septum, and subtle movement of the ULC and lateral nasal walls during respiration. Use of ear curettes to gently lateralize the caudal margins of the ULCs (modified Cottle maneuver) often yields immediate subjective relief in patients with NVC.

For complete evaluation of the nasal airway, I prefer that the patient undergo nasal endoscopy to rule out other intranasal pathology or sources of obstruction. In my practice, patients are often referred from other otolaryngologists and rhinologists, and if the referring provider has performed nasal endoscopy, I use it only to evaluate just the anterior superior and inferior corridors. I find this especially helpful in visual examination of the superior corridor (without the inevitable movement of the tissues during anterior rhinoscopy using a nasal speculum). However, I try to avoid having the patient incur the additional expense of formal nasal endoscopy more than once preoperatively, especially since it is not universally-accepted as required for surgical decision-making [8••].

Occasionally, a middle turbinate concha bullosa (MTCB) may cause a superior deformity of the perpendicular plate

**Table 1** Pearls (modifications) for butterfly graft camouflage

| |
|---|
| Release the ULCs from their attachments to the dorsal septum |
| Match the size of the graft to the dorsal inset |
| Match the taper of the cephalic edge of the graft to the cephalic edge of the inset |
| Make the graft as narrow (cephalo-caudal orientation) as possible |
| Place the graft as caudal as possible (especially careful to lower the anterior septal angle through endonasal approach) |
| Make the graft long in axial orientation (from piriform aperture to piriform aperture)–Wang modification [28•] |
| Make the graft short in axial orientation (only what is necessary to laterally distract the apex of the valve-depending on the patient's anatomy)–Clark modification [29] |
| Adjust the "spring" of the cartilage using Brown-Adson forceps to weaken, as necessary |
| When possible, lower the dorsal projection to allow for iatrogenically thicker SSTE |

*ULCs* upper lateral cartilages, *SSTE* skin, soft tissue envelope of the ethmoid (PPE), or vice versa. Regardless of the etiology of this anatomic variation, it is commonly observed; no consensus exists regarding management in the patient undergoing surgery for NAO. Early in my career, I routinely treated MTCB with endoscopic removal of the medial wall to allow the superior septum to move midline after removal of the appropriate PPE. I stopped doing this about 10 years ago and have found no difference in patient outcomes. My decision to stop addressing the MTCB was based on teaching residents and fellows that my goal in surgery is to easily visualize the axilla of the middle turbinate through anterior rhinoscopy at the conclusion of surgery. While CFD provides some insight into airflow characteristics associated with MTCB, the role in these patients' perception of nasal airflow remains poorly defined [13].

## Surgical Decision-Making

After the patient-reported data has been collected and a thorough examination has been performed, the surgical decision-making is discussed in detail with the patient. The first bifurcation in my treatment algorithm is whether to use the BG. In most patients including those in whom the BG is not recommended, I discuss the BG (including showing them an animation of the technique) and advise them that this technique can be reserved for "surgical salvage". Using a shared decision model, the patient is provided with as much evidence-based medicine as they require in their individual decision-making before ultimately deciding among the various surgical techniques that we use to correct their NVC.

### Functional Considerations

It is well known that subjective perception of nasal airflow does not correlate well with objective assessment of nasal airways. Partly due to this poor correlation, it is generally accepted that PROMS are more important than objective measures in assessing NAO [8••]. It is also intuitive that since the patient's complaint is a subjective complaint, our success should be measured in subjective terms. However, the search for more correlative objective measurements of NAO continues at many institutions, including our own. Since most traditional objective assessment instruments (acoustic rhinometry, rhinomanometry, peak nasal inspiratory flow (PNIF)) have correlated poorly with patient perception of nasal airflow [9]. Based on the early data from Dr. Julia Kimball's work at our institution, we sought to use CFD as our objective assessment tool in our foundational work [14]. We then sought to establish an experimental protocol for comparison of BG and SG techniques [15, 16]. We repeated this protocol before collaborating with our Physics colleagues using anatomic optical coherence tomography (aOCT) to determine its utility in the objective assessment of NAO [17].

From these cadaveric model protocols, the evidence is clear that CFD data comparing SG to BG (CFD variables-nasal resistance, heat flux, and partitioning) suggested at least non-inferiority of the BG [15, 16]. As we discussed in our study limitations; however, this was obviously in a static (cadaveric) model, and since CFD analyses assume "steady state inspiratory laminar airflow simulations", these studies fail to adequately assess normal nasal airflow. The significance of the dynamic component of NAO cannot be overstated, which is why many patients experience their most severe symptoms during exercise.

Therefore, our group recently published our use of aOCT as a means of translating the CFD data from a static model to a dynamic model [18•]. By validating aOCT as an instrument that has the potential for assessing objective changes in the dynamic nasal airway, the opportunity for comparison of various surgical techniques during physiologic inspiratory nasal airflow seems possible. We intend to use aOCT as an objective measure and correlate with at least one PROM to compare outcomes from BG and SG, but have not begun patient recruitment for that study.

A single surgeon comparison of BG versus SG showed greater improvement for the BG patient cohort (using a novel patient questionnaire) [19]. Although I admittedly use SG in my practice, I have always remained skeptical that SG provided any strength to the lateral nasal sidewall. If placed in the traditional manner by disarticulating the ULCs from the dorsal septum, SG likely weakens the support of the ULCs (Fig. 1). At best, the apical lateral nasal wall is lateralized, maintaining its presurgical support, and depending on the precise technique for SG placement. However, the apical valve area is often narrowed in many cases of SG that I have corrected with BG [20•].

The recent prospective study of scroll reconstruction which attempts to re-suspend the lateral caudal border of the ULCs to the nasal SMAS performed with SG offers some potential for increased lateral nasal wall strength. In their small cohort, they found a statistically significant improvement in postoperative PNIF values for those patients in whom the scroll was reconstructed compared to those treated with SG alone [21].

Although to date there has not been a direct comparison using validated PROMS, anecdotally our patients also report greater improvement with BG over SG (unpublished internal data comparison). A multi-institutional study is underway to compare PROMs in these 2 groups.

Finally, there is a trend in the CFD literature moving from the traditional thought that nasal resistance is the most important CFD variable in the assessment of NAO. Heat flux is emerging as the CFD variable that most strongly correlates with patient perception of nasal

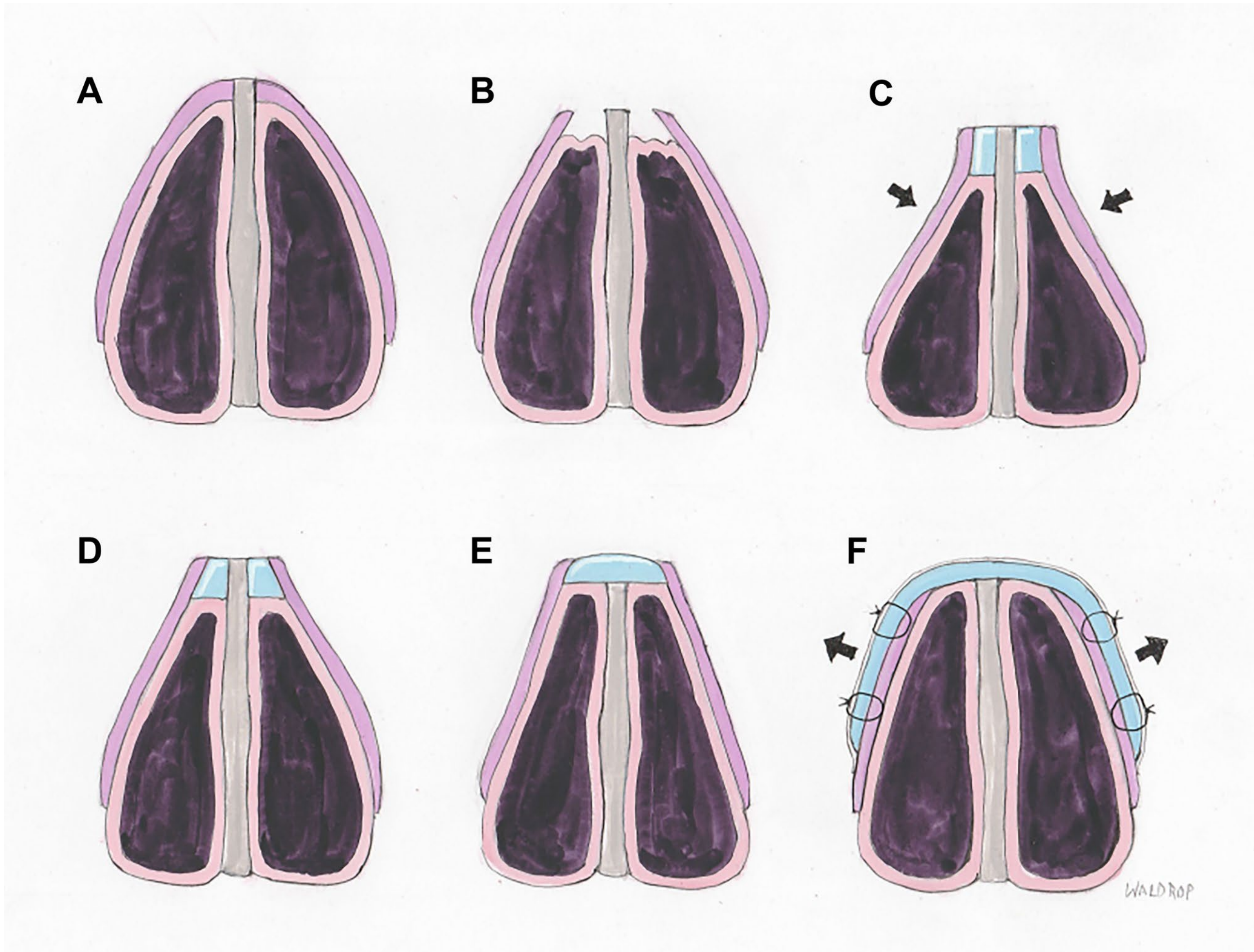


**Fig. 1** **A** Ideally, the inherent resilience of the upper lateral cartilages (ULCs) prevent stenosis and collapse of the apex of the internal nasal valve (INV). Note the positions of the septum (*brown*), nasal mucosa (*light pink*), and ULCs (*lavender*). **B** Following release of the ULCs from their dorsal septal attachments, the ULCs must be reattached in some fashion to avoid inevitable internal nasal valve (INV) stenosis. **C** Spreader grafts (*blue*) provide width to the mid-nasal vault, but if sutured or structured inappropriately, they may narrow the apex of the INV (*arrows*). **D** Trapezoidal shape of the spreader grafts (*blue*) provide a more physiologic reconstruction of the mid-nasal vault. **E** Another variation, the dorsal onlay graft (*blue*) allows for more substantial widening of the mid-nasal vault, but does not provide strength to the nasal sidewall, likely resulting in INV collapse over time. **F** The butterfly graft (*blue*) allows for controlled mid-nasal vault width and support through the graft's inherent spring. (*arrows*). (Adapted with permission from: Howard and Clark [20]

airflow [22]. This helps to explain a clinical observation I have made in a small subset of patients who have subtotal nasal septal perforations, with only a diminutive dorsal septal keel remaining and collapsed ULCs. Although there is no observable resistance to inspiratory nasal airflow, but these patients still complain of NAO. I have (initially reluctantly) performed BG on some these patients, resulting in dramatic postoperative reduction in NOSE scores (unpublished data). It raises the possibility that either there is a greater concentration of mucosal cool receptors at the apex of the INV, or the absence of other sensation makes this area much more sensitive in this subgroup of patients.

## Aesthetic Considerations

To help the patient make an informed decision about whether to employ the BG, I show before and after photographs of the BG patients. The photographs were intentionally selected to clearly demonstrate the small increase in midvault width postoperatively. As the patients are shown these pre/post photographs, they will most often provide verbal or non-verbal cues that suggest that they would be willing to accept a slight increase in midvault width postoperatively. I am careful to emphasize that they must be aware that this is an expected trade-off for this technique, as it is for SG [23], and they should acknowledge that they see this difference in the photographs before proceeding with the surgery scheduling.

Regarding the aesthetic “sacrifice” that some rhinoplasty surgeons still misperceive as being more significant with BG than SG, more re-education is necessary. As with any surgical paradigm shift, those surgeons who have not been taught a specific technique during their surgical training tend to be critical of the as-yet unlearned technique until the evidence is overwhelming that the technique should be part of their surgical armamentarium [24]. Evidence is mounting that the aesthetic difference in the postoperative midvault width between SG and BG is negligible. In early reports using the original technique, only a minority of patients reported worsening of aesthetic outcomes [25••, 26]. As a co-author of one of the early reports, I did agree that the graft was often visible (to a trained eye)-primarily due to discrete highlights and shadows when the graft was not sufficiently camouflaged. Chaiet and Marcus reported an average increase in supratip width by 6.4% and an average in supratip projection by 8.5% [27]. In my opinion, the more aesthetically negative feature was the increase in supratip projection because the cephalic margin of the graft was visibly distinguishable by a shadow and palpable small depression between the cephalic edge of the graft and the native dorsal cartilaginous septum. In my experience, using the originally described technique [25••] of placing morselized leftover auricular cartilage to camouflage this transition was often inadequate to create a long-lasting, aesthetically pleasing dorsal nasal contour.

Modifications to the original technique have recently been described by the OHSU group and by Howard and Clark [20•, 28•] (Table 1). These modifications have led to significant improvements in postoperative appearance, both reported by patients, by the surgeons (myself and Dr. Tom Wang—personal communication), and by medically-trained observers [20•, 28•]. In a recently completed, but unpublished study by Mims et al., a novel strategy of asking non-medical observers to rate nasal aesthetic impressions of photographs of patients randomly selected from a group of pre and postoperative patients undergoing SG and BG was employed. The results demonstrated that there was no statistically significant difference in aesthetic rating means between the 2 groups (unpublished data). Given the fact that the increase in midvault width is estimated at ~6% for both BG and SG, this lack of difference in aesthetic rating is not surprising, especially if the recent technical modifications are utilized.

## Combining Form and Function

All rhinoplasty surgery should consider both form and function—put simply, a beautiful nose must function beautifully. The patient seeking surgery to correct NVC should be provided with an honest assessment of the likelihood of providing the results that they seek, including an open discussion investigating any aesthetic changes as part of their nasal surgery. The patient must be encouraged to provide clear expectations, describing the emphasis they wish to exert in both form and function. As such, PROMs that include both function and form data collection such as the SCHNOS have been recommended [29].

In a recent Expert Rhinoplasty Panel Discussion at the 2021 AAFPRS Annual meeting, there was heterogeneity in how the experts decided which patients were charged cosmetic fees, and which patients were purely charged insurance coverage. In my opinion, if the primary concern is function, and the patient expectations are primarily focused on maximal improvement “but I don’t want my nose to look worse”, and the surgical modifications of the nose are targeted solely at improvement in function, then no additional cosmetic fees are charged. However, if the patient wishes to change the external appearance of the nose that would require additional techniques that I would not otherwise use in improvement of the function, then there is an additional “add-on cosmetic” charge that is collected by my institution.

## Future Directions

A recently published prospective trial comparing SG alone, SG and lateral crural strut grafts, and SG and alar rim grafts using PNIF, NOSE scale, and FACE-Q Rhinoplasty Module, found improvement in all cohorts [29]. Given its simplicity and low cost, PNIF is currently the favored objective measure of NAO, but the use of aOCT to compare objective outcomes of the various surgical techniques for surgical correction of NVC holds great promise. A prospective trial correlating aOCT with PROMs such as the NOSE scale or SCHNOS tool (to include aesthetic outcomes) [30] is needed. Additional prospective trials designed to compare the most commonly-used techniques for treatment of NVC using validated PROMs are needed. A multi-institutional prospective trial designed to compare the use of BG and SG using NOSE and other PROMs is underway.

Until the results of these prospective trials are available and relying on both the current literature and extensive experience using both techniques, the evidence is clear that the BG is functionally superior to SG for the surgical treatment of NVC. Evidence is mounting that the aesthetic outcomes are indistinguishable between SG and BG. Therefore, if the question is “Does the Butterfly Graft Really Work?”, the answer is unequivocally “yes”.

**Video** (Nasal Butterfly Graft Surgery): Here is a link to my animation on YouTube for the interested reader. It is not narrated, so that the surgeon may improvise with whatever description he or she may want to incorporate while discussing with the patient for potential surgery.

https://www.youtube.com/watch?v=VImWR9Jx2jE

## Compliance with Ethical Standards

**Conflict of Interest** J. Madison Clark, MD, FACS declares that he has no conflict of interest.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

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