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Costal Cartilage Lateral Crural Strut Graft for Correction of External Nasal Valve Dysfunction in Primary and Revision Rhinoplasty

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Abstract

Objective: To evaluate and compare the costal cartilage lateral crural strut graft's (LCSG) ability to support a weak lateral crus in patients with external nasal valve dysfunction (EVD) undergoing primary versus revision functional rhinoplasty. **Methods:** This is a prospective cohort study of 26 patients (mean [SD]: 40.23 [6.75] years of age; 10 [38%] females) with clinically diagnosed EVD, who underwent primary versus revision functional rhinoplasty with the use of a costal cartilage LCSG (10 [38%] primary functional rhinoplasty patients and the 16 [62%] revision patients). Preoperative and 12-month postoperative subjective and objective functional measurements along with statistical analysis were performed. **Results:** While all baseline demographic and preoperative functional measurement scores were similar between the 2 groups, the primary cohort's preoperative scores were higher overall. Follow-up was a mean of 14.58 months. The primary group demonstrated a greater difference in score improvement postoperatively in all categories. All patients had significantly improved visual analog scale (VAS), Nasal Obstruction Symptom Evaluation Scale, 22-Item Sinonasal Outcome Test, and nasal peak inspiratory flow (NPIF) scores. When comparing the overall score outcome and surgical efficacy of the LCSG, both groups had near equal final score outcomes with the exception of VAS_L and NPIF. **Conclusion:** The LCSG is a viable and versatile option in the management of EVD for both primary and revision rhinoplasty patients.

Keywords

costal cartilage, external valve, lateral crura, rhinoplasty

Introduction

Nasal valve dysfunction is a major cause of nasal obstruction. The nasal valve, which can be divided into internal and external components, is the narrowest point of airflow. Boundaries of the external nasal valve (ENV) include the caudal nasal septum and medial crus of the lower lateral cartilage medially, the lateral crus of the lower lateral cartilage and fibrofatty tissue of the alar rim laterally, and the nasal sill inferiorly.[1] Static nasal obstruction from reduced cross-sectional area and dynamic nasal collapse from deficient structural support contribute to external nasal valve dysfunction (EVD), which can also affect the patency of the internal nasal valve.[2,3] Surgical treatment aims to correct intrinsic nasal instability and transmural pressure changes related to nasal valve obstruction.[1]

Augmentation of the nasal tip, especially the lateral crus of the lower lateral cartilage, during rhinoplasty to achieve functional and aesthetic satisfaction is challenging secondary to the

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variability in pathologic conditions. Injury or alteration can drastically affect nasal tip shape, orientation, and resiliency. The anterior and middle segments of the alar require definitive cartilaginous support while the rim is held in position posteriorly by thick alar skin. The diameter of the nasal cavity is the most important variable in determining airflow. As demonstrated by Poiseuille (minor decreases in radius have a large effect on flow) and Bernoulli (acceleration of a fluid occurs simultaneously with a decrease in pressure or energy), ENV patency is the balance of an inspired inward force generated by a decrease in intranasal pressure with the strength of supporting cartilaginous and fibrous components.[1,2] Thus, weakness of the lateral crus results in EVD when either negative pressure in the nasal vestibule during inspiration causes rim collapse or there is a static reduced cross-sectional area of the nasal valve limiting the volume of air that can flow through the nasal airway.

Lateral crural strut grafts offer a rational and versatile solution to a wide array of lateral crural deformities and deficiencies. It also allows for the correction of boxy nasal tip, malpositioned lateral crura, alar rim retraction, alar rim collapse, and concave lateral crura. Gunter and Friedman chosen to place grafts on the vestibular side of the lateral crura to provide strong but invisible support of the lateral crus. They did not recommend placing the graft superficial to the lateral crus because of the risk of a visible step-off at the anterior end of the graft and also would not obviate the need for vestibular undermining which would still be required to avoid suture perforation of the vestibular skin. They opted for the use of open rhinoplasty for the facilitation of accurate graft positioning and suture placement.[4]

The costal cartilage LCSG is a highly regarded technique for stabilizing the lateral crus, improving EVD via increasing cross-sectional area, providing support against dynamic collapse, and affording great versatility for aesthetic improvement of the lateral crus.[5] Barham et al previously demonstrated similar satisfactory functional and aesthetic outcomes when comparing patients with EVD undergoing primary and revision rhinoplasty via cephalic turn-in and LCSG techniques, respectively.[1] The purpose of this study was to evaluate the effectiveness of the LCSG technique for both primary and revision rhinoplasty patients with EVD.

Methods

All aspects of this study were reviewed and approved by the Baton Rouge General Institutional Review Board (IRB000 05439). A clinical surgical cohort was studied. Patients complaining of nasal obstruction due to dynamic valve collapse with inspiration (Figure 1) which is improved with a Cottle and modified Cottle maneuvers were clinically diagnosed with the EVD and were recruited for undergoing functional reconstructive rhinoplasty. The diagnosis of EVD free of rhinitis symptoms or lack of relief of obstruction to intranasal corticosteroid was made clinically by the patients' clinical history along with an endoscopy and/or anterior rhinoscopy that demonstrated medially displaced lateral crus with dynamic collapse on mild to moderate inspiratory effort.[5]

Patients were divided into 2 groups based on primary versus revision functional rhinoplasty. All patients underwent a lateral crural underlay strut graft using costal cartilage. The use of costal cartilage was preferred by the senior author when septal cartilage was absent, deficient or congenitally weak, or in case of traumatic etiology for the deformed nose. The available volume and characteristics of costal cartilage was optimal for a successful rhinoplasty. As with every surgical procedure, there are risks of harvesting costal cartilage and these risks were minimized due to detailed planning and successful adherence to recommended techniques. All surgical intervention was performed by the senior author.

The data were collected prospectively as part of routine care for patients undergoing rhinoplasty surgery. All patients provided written informed consent.

Statistical analyses were performed using SPSS v 22 (SPSS Statistics for Windows, version 22.0; IBM). Descriptive data are presented as percentages and means $\pm$ SD. Kendall's τ-B was used for ordinal values. Chi-square analysis was used for relationships of nominal variables. The prevalence of related comorbidities and the frequency of previous surgical procedures were also compared across treatment cohorts using Pearson χ^2 analysis for relationships of nominal variables. Student *t* test (2-tailed) was used for comparisons of parametric data. Results were deemed significant with a P value of $<.05$.

Surgical Intervention

Open structured rhinoplasty was done for the correction of clinically diagnosed EVD. If the patient was complaining of nasal obstruction also due to septal deviation and inferior turbinate hypertrophy, these issues have been managed with septoplasty and medial flap turbinoplasty under endoscopic guidance.[6,7] Cosmetic alteration was always an additional surgical aim.

All patients, whether primary or revision, underwent surgical intervention in which the lateral crura were augmented or replaced with underlay strut grafts using costal cartilage. Costal cartilage was either homologous or autologous. For the autologous grafting, approximately 5 cm of costal cartilage was harvested from the right fifth to eighth rib, and the perichondrium was removed and used to assist in general cosmetic alteration. The harvested cartilage was remodeled and either replaced or provided underlay support to the lateral crus. The LCSGs were designed, with some patient variability, to be 1.5-mm thick and 35-mm long with a tapered width (8 mm lateral to 3 mm medial). The lateral edge of the strut graft is inserted into a pocket formed lateral to the piriform aperture in a more caudal orientation, while the medial edge lies under the domes for a full bridge of the valve.

Assessment of Surgical Outcome

Five tools to assess patient-perceived functional benefit, one objective measure of the nasal airway (in the post decongested state), and a cosmesis score as perceived by the patient were used as assessments of the surgical outcomes. These outcomes

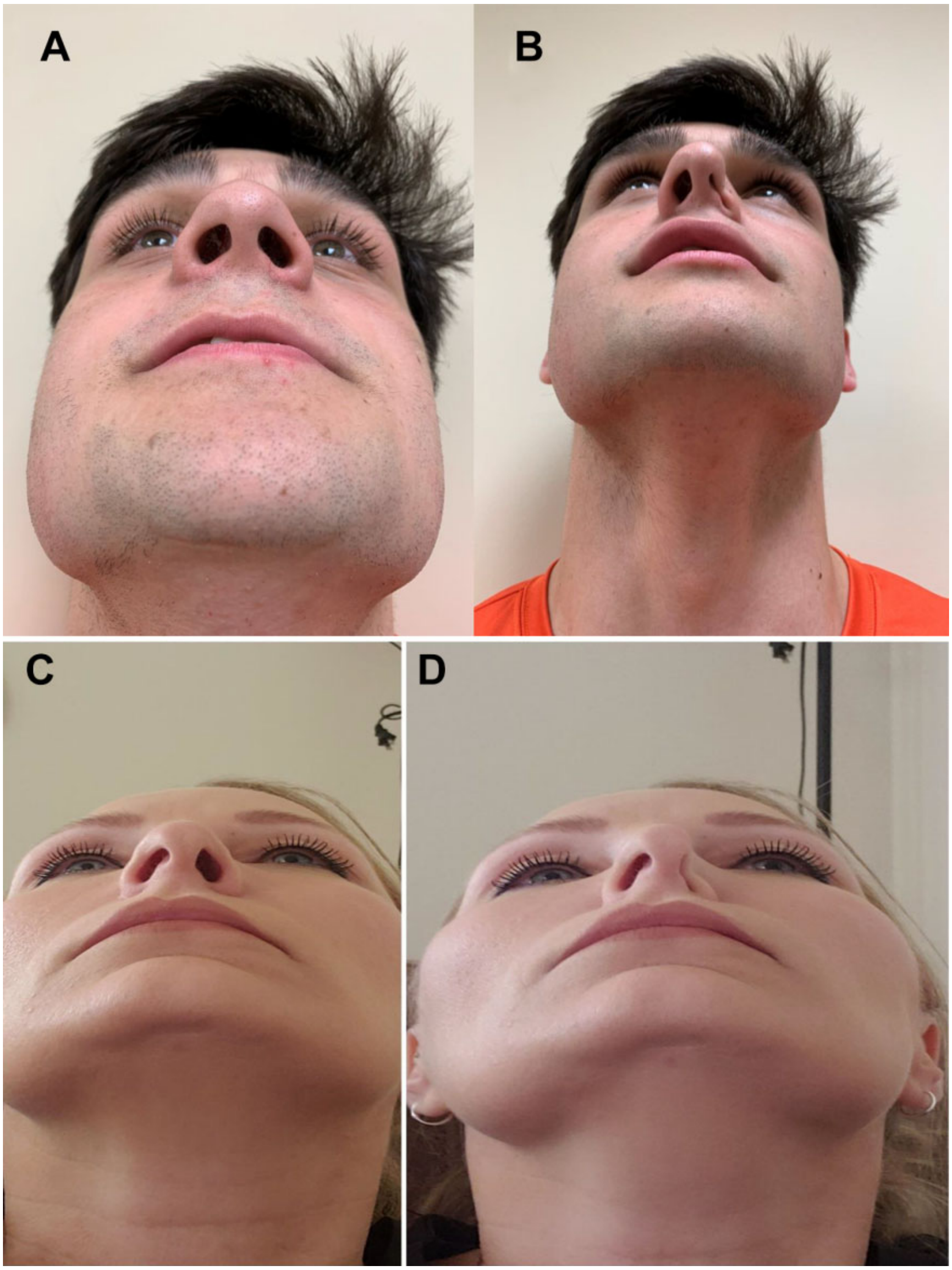

Figure 1. Basal view of 3 preoperative patients, with (A) and (C) showing variable degrees of external nasal valve dysfunction which get intensified in (B) and (D) when they were asked to perform deep inspiration showing nearly total collapse of the valve.

were assessed at baseline and then again at least 12 months postoperatively.

Patient-Reported Nasal Function

Five tools were used to assess patient-perceived benefit. A visual analog scale (VAS) asked patients to rate ease of breathing on each side on a scale of 0 mm (or not blocked) to 100 mm (totally blocked). A number was then obtained from 0 to 100 for severity of nasal obstruction on each side. A 5-point Likert score was used to assess nasal obstruction from 1 (no problem) to 5 (problem as bad as it can be). Additionally, a validated Nasal Obstruction Symptom Evaluation (NOSE) Scale, and a 22-Item Sinonasal Outcome Test (SNOT-22) were completed by the patient.[8,9] A global score of nasal function was assessed on a 13-point Likert scale from −6 (terrible) to +6 (excellent), with 0 representing neither good nor bad.

Objective Assessment of Airflow

One tool was used to assess objective parameters of nasal breathing. The test was performed 15 minutes after 0.15 mg of oxymetazoline was applied to each nasal cavity topically. This was to ensure that the structural component of the nose was assessed on the testing day and mucosal factors were minimized. This was performed to try to decrease the contribution of vascular mucosal changes before and after surgical intervention. Collapsibility of the airway was assessed with a nasal peak inspiratory flow (NPIF), which was measured with the patient seated using an In-Check Nasal Inspiratory Flowmeter (Clement Clarke International) with an attached anesthetic mask. A tight seal was established without compressing the external nares, and the patient was instructed to take a maximal forced inspiratory effort through the nose with the mouth closed. The best recorded result of 3 attempts was used, according to previous studies.[10-12]

Assessment of Cosmesis

At baseline and 12 months, the global score of nasal cosmesis was assessed by patients on a 13-point Likert scale from −6 (terrible) to +6 (excellent), with 0 representing neither good nor bad.

Statistical Analysis

Statistical analyses were performed using SPSS v 22 (SPSS Statistics for Windows, version 22.0; IBM). A 2-tailed paired sample *t* test was used to analyze presurgical and postsurgical values for VAS scores, NOSE scores, SNOT-22 scores, and NPIF values. All continuous data were assessed as parametric and expressed as mean (SD). Global function, cosmesis, and nasal obstruction scores were ordinal scores and assessed by Kendall's τ-B.

Results

Twenty-six patients (10 [38.5%] females), with a mean (SD) age of 40.24 (11) years, range, 25 to 52 years, were assessed preoperatively and at a minimum 12-month follow-up (median, 15 months; range, 12-23 months). Ten patients underwent primary rhinoplasty with costal cartilage LCSGs for correction of EVD, and 16 underwent revision rhinoplasty with costal cartilage LCSGs for correction of EVD. Sixteen (62%) procedures were revision rhinoplasties.

Baseline Characteristics Between Groups

When evaluating the 2 groups at baseline, the primary and revision groups were similar in age (39.7 vs 40.57 years) and sex (40% female vs 38% female) (Table 1). The VAS (both left and right), NOSE, SNOT-22, and NPIF were higher in the primary group (Table 1).

Abbreviations: NOSE, Nasal Obstruction Symptom Evaluation; NPIF, nasal peak inspiratory flow; VAS, visual analog scale; SNOT-22, 22-Item Sinonasal Outcome Test.Effect of Surgical Intervention for EVD

All patients had significantly improved VAS (both left and right), NOSE, and SNOT-22 scores postoperatively (Table 2). The NPIF showed objective improvement in all patients postoperatively (Table 2).

Abbreviations: NOSE, Nasal Obstruction Symptom Evaluation; NPIF, nasal peak inspiratory flow; VAS, visual analog scale; SNOT-22, 22-Item Sinonasal Outcome Test.Effect of Surgical Intervention Between Groups

When evaluating outcomes between the primary and revision groups, statistically significant results, favoring the primary group, were found in subjective patient reporting of VAS (both left and right), NOSE, and SNOT-22 scores (Table 2). Similarly, statistically significant results, favoring the primary group, were found in objective measure of NPIF.

Discussion

Rhinoplasty is a technically challenging surgery, and success is ultimately determined by patient satisfaction. Achieving a favorable outcome is difficult secondary to intricate nasal anatomy, patient aesthetic and functional concerns, and patient psychological state. The lower lateral cartilages play a major role in the definition and structural support of nasal tip. Abnormalities to nasal tip components, especially the lateral

Table 1. Baseline Characteristics Between Groups.

Measurement	Primary	Revision	*P* value
Patients, no.	10	16	–
Age, years (SD)	39.7 (6.3)	40.57 (12.78)	–
Women, no. (%)	4 (40)	6 (38)	–
VAS left (%)	51.3 (8.5)	44.94 (23.59)	.48
VAS right (%)	51.2 (5.31)	41.94 (21.45)	.00
NOSE (%)	80.1 (5.79)	70 (19.05)	.39
SNOT-22 (%)	1.98 (0.24)	1.82 (0.58)	.00
NPIF (L/min)	111 (20.79)	107.5 (73.08)	.00

Table 2. Measured Effect of Surgical Intervention and Their Absolute Postoperative Values.

Measurement	Primary	Postoperative absolute score	Revision	Postoperative absolute score	*P* value
VAS left (%)	−23.6 (6.74)	27.7	−2.44 (5.19)	42.5	.00
VAS right (%)	−24 (3.97)	27.2	−17.81 (3.85)	24.13	.00
NOSE (%)	−42.8 (6.49)	37.3	−31.25 (25.33)	38.75	.00
SNOT-22 (%)	−0.95 (0.17)	1.03	−0.8 (0.14)	1.02	.00
NPIF (L/min)	24 (16.96)	87	8.13 (0.40)	99.37	.00

crura, can both change nasal contour and result in EVD. The costal cartilage LCSG acts as an underlay batten graft at the external nasal valve to support weakened cartilaginous and ligamentous attachments, fill regions devoid of cartilage, and aid in structural reorientation.[2,13,14] This type of graft is a viable and versatile option in the management of EVD for both primary and revision rhinoplasty patients.

In a prospective study comparing the use of the cephalic turn-in maneuver in primary rhinoplasty patients and the LCSG in revision rhinoplasty patients for correction of EVD, Barham et al found that nasal patency and functional outcome were more improved with the LCSG.[1] Our study serves as a sequel. The same LCSG revision rhinoplasty cohort was included, but the cephalic turn-in maneuver primary rhinoplasty cohort was replaced with a new primary rhinoplasty cohort undergoing LCSG for EVD. Functional measurement scores and overall surgical efficacy of the LCSG in correcting EVD between primary and revision rhinoplasty patient cohorts were then compared.

While all patients had significantly improved VAS_L, VAS_R, NOSE, SNOT-22, and NPIF scores, the primary cohort's preoperative scores were higher and demonstrated a greater difference in score improvement postoperatively in all categories. However, the overall score outcome and surgical efficacy of the LCSG between the primary and revision rhinoplasty patients had near equal final score outcomes with the exception of VAS_L and NPIF. The findings in both studies were based on 6-month postoperative measurements; this was chosen on the clinical assessment that all corrections were structurally integrated at this time period.

Surgical success of rhinoplasty is largely dependent on patient satisfaction. Since this is both a complex and multidimensional concept, a combination of subjective and objective nasal measurements has been implemented to aid in specialist assessment of success. The VAS is a subjective measurement questionnaire and psychometric response scale, while the NPIF is an objective measurement of nasal patency and airflow. As noted above, all of the postoperative final outcome scores were near equal with the exception of VAS_L and NPIF; these scores were worse in the revision cohort. A multitude of variables may have alone or in combination contributed to these differences, but this is difficult to determine. Possible etiologies include handedness of the operating surgeon, significant anatomical differences, dynamic collapse, an already partially improved static obstruction from prior rhinoplasty, and/or the inherent overall difficulty of surgical correction in revision rhinoplasty patients.

All patients in both studies underwent septoplasty and inferior turbinate reduction during intraoperative rhinoplasty, which is grossly supported by literature. In a systematic review using surgical methods to correct nasal valve collapse over a 38-year time period, Spielmann et al[3] demonstrated that many surgeons performed septoplasty and nasal valve surgery synonymously for correction of septal deviation or harvesting of cartilage for grafting.[3] Their review determined that it is difficult to control for improvement in airway function gained from septoplasty or inferior turbinate reduction alone as both are significant sources for anterior nasal obstruction.[3] Thus, prior septoplasty and inferior turbinate reduction may be the basis for a better initial symptom score in our revision rhinoplasty cohort when compared to the primary rhinoplasty cohort. While septoplasty success rates range from 43% to 85%, etiologies for persistent nasal obstruction after septoplasty include undiagnosed nasal valve narrowing and/or collapse.[15] Overall, this further emphasizes the importance of nasal valve correction for a successful functional outcome in cases of persistent nasal obstruction following septoplasty.

This study corrects for the inherent allocation bias detailed in the study by Barham et al, as we were able to compare the LCSG in both primary and revision rhinoplasty patients.[1] Expansion to a multicenter trial would further increase the power and strength of the study results. Finally, the addition of a psychological questionnaire and comparison to outcome scores may aid in correlation and interpretation of subjective and objective measurements.

Conclusion

Strength of the lateral crus plays a significant role in external nasal valve functionality and nasal patency. Surgical repair and support of weakened lateral crus is paramount to correct and prevent residual EVD. The costal cartilage LCSG is an effective technique in improving patient-reported and objective outcomes for both primary and revision rhinoplasty patients with EVD.

Declaration of Conflicting Interests

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