Costal Cartilage Lateral Crural Strut Graft vs Cephalic Crural Turn-in for Correction of External Valve Dysfunction

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The nasal valve is the narrowest point for airflow. First described in 1903, it is divided into an internal nasal valve (INV) and an external nasal valve (ENV). The ENV, anterior to the INV, is bound medially by the caudal nasal septum and medial crus of the lower lateral cartilage and laterally by the lateral crus of the lower lateral cartilage and the fibrofatty tissue of the alar rim. The floor of the ENV consists of the nasal sill. In a normal physiological state, the INV is the site of greatest airflow resistance. The diameter of the nasal cavity is the most important variable in determining nasal airflow, explained by Poiseuille's Law \[ Q = \frac{nPr^4}{8\eta} \], as minor radius decreases can have a large effect on flow. Additionally, acceleration of air through the ENV results in a decrease in transnasal pressure; a phenomenon described by Bernoulli. The inward force generated by this pressure gradient is balanced by the supporting cartilaginous and fibrous components, maintaining patency of the ENV and allowing air entry into the nose. In cases of ENV dysfunction (EVD), the ENV becomes the restriction point, and the lateral structures are directly held only by the strength of the cartilage and indirectly held by ligamentous attachments to the piriform aperture. External nasal valve dysfunction results when the ENV is narrower and obstructs normal nasal airflow. Reduced airflow leads to symptoms such as congestion, pressure, and fullness in the nose. Classification of EVD may be static or dynamic. Static ENV stenosis causes a constant obstruction that results from a greater intranasal pressure being required to facilitate airflow. Dynamic ENV collapse causes more noticeable obstructive symp-
toms on inspiration at lower transmural pressures. These 2 types of dysfunction are not mutually exclusive; the narrower ENV at baseline may produce a greater Bernoulli effect, which results in ENV collapse. Surgery to correct EVD aims to overcome the intranasal pressure changes and prevent nasal obstruction. Techniques may vary widely but typically either increase rigidity and/or diameter.

The aim of this study was to evaluate the effectiveness of 2 commonly employed techniques of correcting EVD: cephalic crural turn-in maneuver and costal cartilage lateral crural strut grafts.

Methods

A clinical surgical cohort was studied. Patients complaining of nasal obstruction and with clinically diagnosed EVD who were undergoing functional reconstructive rhinoplasty were recruited. 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 a medially displaced lateral crus with dynamic collapse on mild to moderate inspiratory effort. Patients underwent either a lateral crural cephalic turn-in alone (Figure 1) or a lateral crural underlay strut graft using costal cartilage surgery (Figure 2). All surgical interventions were performed by a single surgeon (G.N.M.) and the technique was chosen on clinical grounds and surgeon preference.

The data was collected prospectively as part of routine care for patients undergoing rhinoplasty surgery. All patients provided written informed consent. This study was approved by the St Vincent’s Hospital Human Research Ethics Committee.

Surgical Intervention

Open structured rhinoplasty for correction of clinically diagnosed EVD included concomitant correction of septal deformities and concomitant turbinoplasty. Cosmetic alteration was always an additional surgical aim.

For the patients undergoing primary surgical intervention, the lateral crura were augmented by a cephalic turn-in maneuver. The procedure requires a scoring incision made parallel to the caudal edge of the lateral crura at approximately the mid cephalic-caudal distance to allow the cephalic por-
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Assessment of Surgical Outcome
Five tools were used to assess patient-perceived functional benefit, 3 objective measures of the nasal airway (in the postdecongested state), and a cosmesis score as perceived by the patient were used as assessments of the surgical outcomes. These outcomes were assessed at baseline and then again at least 6 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 no problem (1) to problem as bad as it can be (5). 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 0 (neither good nor bad) to +6 (excellent), with 0 representing neither good nor bad.

Objective Assessment of Airflow
Three tools were used to assess objective parameters of nasal breathing. The tests were performed 15 minutes after 0.15 mg of oxymetazoline was applied to each nasal cavity topically. This was to ensure that the structure 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 flow meter (Clement Clarke International) with an attached anesthetic mask. A tight seal was ensured 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

Nasal airway resistance (NAR) was measured by active anterior rhinomanometry with a NR6 rhinomanometer (GM Instruments Ltd) using a fixed reference level of 150 Pa as per international standardization of rhinomanometry.53 The patient was seated and allowed to rest for 15 minutes prior to testing, which was performed in a climate-controlled room. An airtight anesthetic mask was held by the patient over the nose with the nostril opposite to the testing side sealed. The patient was instructed to breathe smoothly and consistently through the nose with the mouth closed while measurements were recorded. The other side was then tested using the same method. Once both sides were tested, the entire process was repeated again until 2 consistent baseline total NAR measurements were produced.14

Minimum cross-sectional area (MCA) was measured with an A1 acoustic rhinometer (GM Instruments). Patients were seated upright and the sound tube was applied to the caudal end of the nostril with the appropriately sized nose piece. Once an airtight seal was established, the patient was instructed to breathe in and hold his or her breath. This was repeated at least 3 times until 2 consistent MCA results were obtained.15 The process was then repeated for the other side.

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

Statistical Analysis
To perform statistical analysis SPSS version 21 (SPSS Inc, Chicago) was used. A 2-tailed paired sample t test was used to analyze presurgical and postsurgical values for VAS scores, NOE scores, SNOT-22 scores, NPIF values, NAR values, and MCA values. All continuous data was 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
Forty-one patients (21 [61%] female) with a mean (SD) age of 35.38 (12.73) years; (range, 16-62 years) were assessed preoperatively and at a minimum 6 months follow up (median, 6.90 months; range, 6-39 months). Sixteen patients underwent costal cartilage lateral crural strut grafts for correction of EVD, and twenty-five underwent cephalic crural turn-in maneuvers. Sixteen (39%) procedures were revision rhinoplasties. The mean (SD) patient body mass index (calculated as weight in kilograms divided by height in meters squared) was 22.81 (3.30); height, 168.44 (10.83) cm; and weight, 65.29 (14.54) kg.

Baseline Characteristics Between Groups
When evaluating the 2 groups at baseline, the costal cartilage lateral crural strut group was older and was made of a greater proportion of males (Table 1). The crural strut group were all undergoing revision rhinoplasty vs all primary rhinoplasty in the cephalic crural turn-in group. The VAS (left), NOSE scores, and the total NAR were higher in the crural strut group (Table 1). Nasal obstruction scores were significantly worse in the crural strut group (Kendall’s τ-b = 0.011). Both global scores were...
also statistically worse in the crural strut group for function (Kendall’s τ-b = 0.006) and cosmesis (Kendall’s τ-b = 0.031).

Effect of Surgical Intervention for EVD
All patients had significantly improved VAS (both left and right), NOSE, SNOT-22, global function, and cosmesis scores postoperatively (Table 2). The only objective test that statistically improved was NPIF (114.76 [60.48] L/min vs 126.46 [61.17] L/min; P = .02).

Effect of Surgical Intervention Between Groups
When evaluating outcomes between the 2 techniques, statistically significant results were found in total NAR and total MCA favoring the crural strut group (Table 3). The nasal obstruction score (Kendall’s τ-b P = 0.18) and global score for function (Kendall’s τ-b P = .55) were similar between the 2 groups. Change in global cosmesis score favored the cephalic turn-in group (Kendall’s τ-b P = .007). Improved cosmesis was seen in 100% of the cephalic turn-in group whereas 75% of the lateral crural strut group reported improvement.

Discussion
A variety of surgical options are available to improve nasal airflow in patients with EVD. The underlying pathophysiology is assumed to be resulting from weak or deficient lower lateral crura and their attachments to the piriform aperture. Surgery
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Conflict of Interest Disclosures: Dr Harvey has served on an advisory board for Schering Plough and Glaxo-Smith-Kline, previous consultant with Medtronic, Olympus and Stallergenes, speakers bureau for Merck Sharp Dolme, and Arthrocare and has received grant support from NeilMed. No other conflicts are reported.

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