Contemporary Review of Rhinoplasty

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We conducted a contemporary review covering advances and trends in primary and functional rhinoplasty as published during the past decade. Specifically, we reviewed studies supporting the evidence for functional rhinoplasty, nasal valve surgery, and septal reconstruction. In addition, key articles discussing cephalic malpositioning of the lower lateral cartilages and tip contouring are reviewed. We also report studies involving lateral osteotomy techniques, computer imaging, and the use of homologous, alloplastic, and absorbable implants. When appropriate, we review outcomes data from key studies because these data are becoming increasingly important for evidence-based medicine, physician grading, and procedure reimbursement. Using evidence-based approaches whenever possible will help to ensure predictable patient outcomes.


Rhinoplasty may be the most challenging procedure in all of facial plastic surgery. This is evident in the fact that entire textbooks are devoted solely to the topic. While basic principles remain largely unchanged, new concepts and techniques are continuously evolving (Table). This contemporary review seeks to cover some of the more recent advances in rhinoplasty surgery.

OUTCOMES IN FUNCTIONAL RHINOPLASTY AND NASAL VALVE REPAIR

One of the continuing challenges in rhinoplasty has been the lack of randomized controlled trials. This lack is in part due to the inherent ethical concern in blindly randomizing surgical procedures. Therefore, much of the current evidence is based on observation and retrospective studies. Rhee and colleagues5 performed a 25-year systematic literature review to search for evidence supporting the role of functional rhinoplasty and nasal valve repair. After a multistep search, the authors filtered information, including various interventions and outcomes measures. In data extraction and quality assessment, 44 articles ultimately met inclusion criteria based on quality review and were assigned a level of evidence. These studies collectively enrolled more than 2293 patients, and the procedures included batten grafts, spreader grafts, butterfly onlay grafts, structural bone grafts, and suture suspension. Rhee et al5 graded 42 of the 44 studies as level IV (case series/case report) evidence and only 2 studies as level IIb (cohort studies). Owing to the lack of studies with higher levels of evidence and the heterogeneity of study designs and outcomes measures reported, pooling of the data was not possible and a true meta-analysis could not be conducted. However, in that review, all 44 studies reported improvements as a whole for treated cohorts with nasal valve collapse in a consistent effect.

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Another limitation in studying outcomes in functional rhinoplasty is the lack of objective tools for the preoperative and postoperative assessments of nasal valve insufficiency. Rhinomanometry, which measures nasal cavity

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Table. Overview of Studies Evaluated

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<th>Source</th>
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<tr>
<td>Gryskiewicz and Gryskiewicz, 2004</td>
<td>Comparison of perforating vs continuous lateral osteotomy techniques on postoperative ecchymosis and edema</td>
<td>75 Total patients divided into 3 arms of 25 patients each, testing various osteotomy techniques</td>
<td>Prospective, randomized, partially blinded study</td>
<td>After testing both methods, the perforating internal method was superior (group A; P &lt; .01 in both tests)</td>
<td>Perforating lateral osteotomies with a 2-mm straight osteotome reduce postoperative ecchymosis and edema in rhinoplasty patients compared with the continuous osteotomy (4-mm curved, guarded osteotome)</td>
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<td>Constantian, 2005</td>
<td>Review and evaluate thesis that the boxy or ball nasal tip are not unique entities but rather variants of alar cartilage malposition</td>
<td>100 Consecutive patients undergoing primary and 100 consecutive patients undergoing secondary rhinoplasties</td>
<td>Retrospective analysis</td>
<td>68% Of primary rhinoplasty patients and 87% of secondary patients had alar cartilage malposition (P &lt; .001); orthotopic lateral crura were significantly more common than malpositioned lateral crura in primary rhinoplasty (P &lt; .001); frequency of malpositioned crura was significantly higher in secondary rhinoplasty (P &lt; .001)</td>
<td>Although patients undergoing open rhinoplasty have more complaints and more postoperative deformities, these outcomes may be inherent with their initial problems, necessitating an open approach initially</td>
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<td>Most, 2006</td>
<td>Review outcomes in functional rhinoplasty describing a modified extracorporeal septoplasty technique</td>
<td>12 Consecutive patients</td>
<td>Prospective observational outcomes study</td>
<td>Significant improvement in mean postoperative NOSE score for entire cohort (P &lt; .01)</td>
<td>Anterior septal reconstruction technique improves nasal airway function and aesthetics in severe septonal deviation and avoids the most common complication of standard extracorporeal septoplasty by preserving the dorsum and septal cartilage and its attachment to the nasal bones at the keystone area</td>
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<td>Toriumi, 2006</td>
<td>Identify ideal tip characteristics and describe new concepts in nasal tip contouring</td>
<td>No patients</td>
<td>Computer model and clinical review</td>
<td>Numerous aesthetically pleasing nasal tips were evaluated and a series of images was created to demonstrate how specific contours create highlights and shadows</td>
<td>These concepts will help surgeons focus more on creating favorable shadows and highlights and less on narrowing; contouring will look more natural and better withstand the forces of scar contracture and its negative effect on rhinoplasty outcomes</td>
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<tr>
<td>Rhee et al, 2008</td>
<td>Systematic review of evidence supporting functional rhinoplasty or nasal valve repair</td>
<td>82 Articles reviewed, of which 44 met inclusion criteria</td>
<td>Systematic review</td>
<td>Most studies were level IV evidence; 2 were level IIb; all generally supported effectiveness of functional rhinoplasty</td>
<td>Substantial level IV evidence supports the efficacy of modern-day rhinoplasty techniques for treatment of nasal valve collapse; use of comparison cohorts and standardized objective outcome measures will improve future studies</td>
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<tr>
<td>James and Kelly, 2008</td>
<td>Review cartilage recycling in rhinoplasty using PDS foil as an absorbable biomechanical scaffold, indications, complications, and long-term stability</td>
<td>58 Primary and secondary rhinoplasties in which PDS foil was used with autologous cartilage for aesthetic and valvular reconstruction</td>
<td>Retrospective outcome analysis</td>
<td>The PDS foil was used most often to construct columellar struts, septal extension grafts, and alar battens; other uses included revision septoplasty and upper lateral replacement grafts; minor complications (1 infection, 1 partial extrusion); long-term postoperative stability of the nose was satisfactory (mean FU, 18 mo) for structural and aesthetic purposes</td>
<td>Technique is simple and effective; making maximal use of otherwise discarded cartilage fragments protects other graft harvest sites and decreases incidence of graft depletion</td>
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<td>Peled et al, 2008</td>
<td>Perform meta-analysis of commonly used materials and describe removal rates</td>
<td>14 Studies</td>
<td>Meta-analysis</td>
<td>The most commonly used materials are silicone, expanded PTFE, and porous HDPE; the removal rate for PTFE and HDPE implants was 3.1%; for silicone implants, significantly higher at 6.5%</td>
<td>Alloplastic implants have acceptable complication rates and can be used when autogenous materials are unavailable or insufficient; outcomes with HDPE or PTFE implants may be slightly better than those with silicone; improved reporting of implant failures and FU times are needed to better define specific guidelines for use of these materials</td>
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<td>Kridel et al, 2009</td>
<td>Evaluate the use of IHCC grafts</td>
<td>357 Patients undergoing primary or secondary rhinoplasty with IHCC grafts</td>
<td>Retrospective analysis</td>
<td>Total complication rate of 3.25%, including graft warping, infection, resorption, and mobility; patient satisfaction was &gt;94% after a mean FU of 7.87 y</td>
<td>As a grafting material in rhinoplasty, IHCC is well tolerated and yields superb functional, structural, and cosmetic results</td>
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<td>Boahene and Hilger, 2009</td>
<td>Review indications, technique, and outcomes of alar rim grafting in rhinoplasty</td>
<td>31 Patients</td>
<td>Retrospective analysis</td>
<td>Indications were cephalic position of the LCOs, correction of alar flare, and alar collapse; no complications at a mean FU of 6 mo</td>
<td>Alar rim grafting is a simple and versatile approach to providing additional support to external nasal valve and for improving nasal base contour</td>
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<td>Friedman and Cook, 2009</td>
<td>Review use of conchal cartilage butterfly graft in primary functional rhinoplasty</td>
<td>100 Patients</td>
<td>Retrospective analysis</td>
<td>90 Patients (90%) had improved breathing, 88 (88%) were satisfied with postoperative cosmesis, and 89 (89%) would recommend procedure to a friend who had similar preoperative symptoms</td>
<td>Conchal cartilage butterfly graft can be successful in primary functional rhinoplasty, as previously observed in secondary rhinoplasty; conchal cartilage butterfly graft can be another outstanding technique for appropriately selected patients</td>
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<td>Mahajan et al., 2009</td>
<td>Perform analysis of patient-determined PCI to compare with ideal variables</td>
<td>20 Consecutive female rhinoplasty patients</td>
<td>Retrospective analysis</td>
<td>Mean nasolabial angle fell within the ideal range before and after image manipulation; however, Goode ratio and ratio of alar base width to interpupillary distance were statistically similar to ideal values only after image manipulation; nasofacial angle and ratio of alar base width to dorsal length showed a trend toward the ideal ratio</td>
<td>Patients' preferences were similar to the ideal in 3 of 5 variables, and remaining variables approached the ideal; these variables were useful in creating satisfying proportions in aesthetic rhinoplasty and reconstructive surgery within their population; computer imaging software holds a wealth of data regarding common patient preferences</td>
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<td>Sepehr et al., 2010</td>
<td>Using a computer model, describe implications of cephalic positioning of lateral crura for nasal tip-plasty</td>
<td>No patients</td>
<td>Computer model</td>
<td>Using Tip-Plasty Simulator, a directionality of the change in projection, rotation, and nasal length produced by various tip-plasty maneuvers is largely the same as that expected and observed clinically; cephalically positioned lateral crura affected results of the maneuvers studied</td>
<td>By demonstrating a difference in magnitude of change resulting from various rhinoplasty maneuvers, ability of the rhinoplasty surgeon to predict the effects of various tip-plasty maneuvers is enhanced given the variable range in alar cartilage orientation likely to be encountered</td>
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<td>Zoumalan et al., 2010</td>
<td>Perform quantitative comparison between microperforating osteotomies and continuous lateral osteotomies in rhinoplasty</td>
<td>60 Patients</td>
<td>Retrospective analysis</td>
<td>20 Patients underwent continuous osteotomies; 40, intranasal perforating osteotomies; continuous osteotomy techniques had a preoperative to postoperative decrease in ventral width of 7.0% (P &lt; .01); perforating osteotomy techniques, 3.6% (P &lt; .001); neither technique resulted in statistically significant change in dorsal width (P &gt; .25), with no significant difference in ventral and dorsal narrowing between procedures</td>
<td>Continuous and perforating osteotomy techniques decreased ventral nasal bone width; no statistical difference was found between osteotomy techniques in amount of nasal bone narrowing (P &gt; .25)</td>
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<tr>
<td>Boenisch and Nolst Trenité, 2010</td>
<td>Review outcomes and complications after use of PDS plates</td>
<td>396 Patients</td>
<td>Retrospective analysis</td>
<td>Functional and cosmetic outcomes were satisfactory; all patients experienced varying degrees of improvement in nasal blockage; no immediate (bleeding, septal hematomas, inflammatory reactions, or necrosis) or long-term (septal perforation, thickening of the nasal septum, or rejection of implant) complications were observed</td>
<td>Use of PDS plate attached to nasal septal cartilage facilitates surgical correction of severe septal deformities and supports nasal dorsum until healing</td>
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<td>Warner et al., 2010</td>
<td>Describe an algorithmic approach to alar soft-tissue techniques and review scar outcomes</td>
<td>100 Patients</td>
<td>Retrospective analysis</td>
<td>Of procedures reviewed, 47% involved alar soft-tissue excision; alar base reduction was performed in 46 (46%), alar flare reduction in 16 (16%), and alar hooding reduction in 2 (2%); mean scar outcome scores, 0.55-0.69</td>
<td>Alar soft-tissue techniques are often necessary to achieve a balanced outcome and superior results in rhinoplasty and therefore should be an integral part of every rhinoplasty evaluation and surgical plan as indicated</td>
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<td>Mehta et al., 2010</td>
<td>Perform quantitative analysis of accuracy of PCI and determine patient satisfaction with outcomes</td>
<td>38 Primary and revision rhinoplasty patients</td>
<td>Retrospective analysis</td>
<td>2 Panels used Likert scale to compare 6-mo postoperative photographs with PCI simulations; results were stratified according to primary and revision surgery and degree of difficulty; patient survey results determined correlation between patient satisfaction and accuracy of PCI</td>
<td>Mean overall accuracy was moderate; supratip height was lowest-rated variable, and upper-third measurements were most accurate; accuracy in primary rhinoplasty was comparable to that for revision rhinoplasty, although tougher cases were rated lower in overall accuracy and projection score; satisfied patients had significantly higher PCI accuracy scores, and most patients found PCI extremely useful</td>
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<tr>
<td>Lee et al., 2011</td>
<td>Systematic review of techniques, outcomes, and complications of nasal dorsum surgery</td>
<td>Prospective and retrospective 60-y study review; 83 articles met criteria</td>
<td>Systematic review</td>
<td>Most studies (89%) focused on dorsal augmentation; use of PTFE and silicone implants was associated with more complications</td>
<td>Most published data related to management of nasal dorsum consist of low-level evidence</td>
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pressure and flow, and acoustic rhinometry, which analyzes the nasal cross-sectional area as a function of distance from the nostrils, are objective measures of nasal obstruction, but these measures are used primarily for research purposes and are not commonly used in the clinic. Studies have shown little or no correlation between these techniques and the patient’s subjective symptoms or the severity of nasal airway obstruction. Peak nasal inspiratory flow is another tool used to measure the highest airflow a patient can achieve during maximum forced nasal inspiration through both nostrils. Inherent weaknesses of this technique include being effort dependent and its incorporation of lung function. Studies have found a poor correlation between peak nasal inspiratory flow vs rhinomanometry and acoustic rhinometry. All objective tests currently available share the common weakness of poor correlation with patient symptom scores. Therefore, other tools are needed to objectively measure nasal airway obstruction.

Historically, no disease-specific quality-of-life instrument has been available to assess rhinoplasty techniques, and reports have used general rhinologic quality-of-life measures and other non–disease-specific measures. In response to the lack of a disease-specific quality-of-life instrument, the Nasal Obstruction Symptom Evaluation (NOSE) scale was developed. In the NOSE trial, Stewart and colleagues used this instrument to measure subjective sensation of nasal obstruction. The NOSE scale serves as one of the primary accepted tools to assess postoperative nasal obstruction subjectively.

Using the NOSE instrument, Most conducted a prospective study of 41 patients to assess the efficacy of functional rhinoplasty techniques in improving disease-specific quality of life. Selected patients had nasal obstruction for at least 1 year as the result of an identifiable anatomic cause, including septal deviation, turbinates hypertrophy, and internal or external valve collapse. Mean NOSE scores decreased in all patients who underwent functional rhinoplasty (38.4 v. 15.7; P < .001), with lower scores indicating improvements in nasal obstruction. Most also based the examination of NOSE scores on the procedure performed, including spreader grafting (all inclusive), spreader grafting with septoplasty and turbinate modification, spreader grafting without turbinate modification, external valve suspension, and septoplasty with turbinate reduction. Each subgroup of patients demonstrated significant improvements in postoperative NOSE scores.

In a recent study to measure the efficacy of a midvault reconstruction technique (the autospreader flap) in dorsal reductive rhinoplasty, Yoo and Most collected outcomes data regarding patient satisfaction, nasal obstruction, and cosmesis in 100 patients who were identified as having nasal valve collapse on examination using a modified Cottle maneuver. After septorhinoplasty with conchal cartilage butterfly grafting (without concurrent turbinate procedures), approximately 90% of the patients reported improved breathing, were satisfied with their cosmesis, and would recommend the procedure. Friedman and Cook concluded that this graft is effective in primary functional rhinoplasty; however, their study was limited by its retrospective nature and lack of a validated instrument such as the NOSE scale.

In a recent study to measure the efficacy of a midvault reconstruction technique (the autospreader flap) in dorsal reductive rhinoplasty, Yoo and Most performed a prospective observational study using this technique and analyzed outcomes using the NOSE scale. The authors hypothesized that patients undergoing cosmetic rhinoplasty without preexisting nasal obstruction...
and those undergoing combined aesthetic and functional rhinoplasty would not exhibit worsening nasal obstruction. In their study, patients were divided into those without nasal obstruction who underwent aesthetic rhinoplasty and those with concomitant severe nasal obstruction due to septal deviation, turbinate hypertrophy, or valvular insufficiency who required aesthetic and functional rhinoplasty. The NOSE scale was used to assess preoperative and postoperative degrees of nasal obstruction. Thirty-eight patients completed all questionnaires. In the 21 patients undergoing aesthetic rhinoplasty alone, the preoperative mean NOSE scores were low and, although postoperative scores improved, the change did not reach statistical significance. In the group undergoing combined functional rhinoplasty and aesthetic rhinoplasty, significant improvement in mean postoperative NOSE scores occurred. The preoperative NOSE scores for the combined rhinoplasty group were significantly higher than the scores for the cosmetic rhinoplasty group.

These results, as noted by the senior author, compare favorably with the previously published studies on functional rhinoplasty.

OUTCOMES IN SEPTAL RECONSTRUCTION

Nasal septal deformity is a significant contributor to nasal obstruction and is an extremely common problem encountered in rhinoplasty. With adequate preservation of the dorsal-caudal L-strut, mild septal deviation may be treated with traditional septoplasty procedures involving submucous resection techniques. More severe and complex deformities may require advanced techniques, including caudal-septal extension and replacement grafts. In an effort to measure the efficacy of a modified extracorporeal technique for anterior septal reconstruction, Most reported the outcomes in a series of 12 patients. In that prospective observational study, preoperative and postoperative evaluations were performed using photographs and the NOSE scale. The reported technique for anterior septal reconstruction was a modified extracorporeal technique designed to preserve a dorsal remnant at the keystone area. This technique used an external rhinoplasty approach with a hemitransfixion incision of the left side. In analysis of the outcomes, no notching or saddling occurred during the average follow-up of 5.4 months. Nasal obstruction was improved, with average NOSE scores decreased for patients who underwent anterior septal replacement, with or without turbinectomy (P < .01).

CEPHALIC MALPOSITIONING OF LOWER LATERAL CARTILAGES AND NASAL TIP CONTOURING

Currently one of the popular topics in rhinoplasty is cephalic orientation or malposition of the alar cartilages, specifically, the lateral crura of the lower lateral cartilages (LLCs) (Figure 2). Although this concept is not new, increasing attention and studies have led to better description of this anatomic variant and techniques for altering position and ultimately tip shape.
toward the ipsilateral medial canthus. Constantian found cephalically malpositioned lateral crura ran toward the lateral genu. Orthotopic lateral crura were described as running toward the lateral canthus of the ipsilateral eye; cephalically malpositioned lateral crura ran toward the lateral genu. Orthotopic lateral crura were more common in primary rhinoplasty patients; malpositioned lateral crura were more common in secondary rhinoplasty patients. In all patients with alar cartilage malposition, including primary and secondary rhinoplasty patients regardless of lobular configuration, valvular reconstruction as measured by rhinomanometry at least doubled the geometric mean nasal airflow in most patients. For surgical correction, all primary rhinoplasty patients underwent dissection of the lateral crura and replacement along the alar rim, whereas some secondary rhinoplasty patients also required composite grafts. From these results, the author concluded that patients with a boxy or a ball tip are much more likely to have malpositioned lateral crura and the associated functional deficits.

In a mathematical model to determine the relative effectiveness of various tip rhinoplasty (tip-plasty) maneuvers on cephalic positioning of the lateral crura, Sepehr et al estimated the results of changes in projection, rotation, and nasal length for overall changes in the length of the lateral crura. Various commonly used rhinoplasty techniques, including alar strut grafts and lateral crural repositioning, were modeled in a software program (the Matlab Tip-Plasty Simulator; MathWorks). The authors found that the modeled changes in projection, rotation, and nasal length of various surgical maneuvers are largely the same as those observed clinically. Specifically, cephalically positioned lateral crura (as compared with orthotopic lateral crura) affect the results of the various tip-plasty maneuvers, including changes in projection, rotation, and nasal length. Sepehr et al concluded that the cephalically positioned lateral crura can affect the results of various tip-plasty surgical maneuvers, at least as measured geometrically in a computer model.

Nasal tip refinement is one of the more common and challenging goals in rhinoplasty, especially in creating a natural-appearing tip, because this procedure is complex and 3-dimensional. In an effort to identify the characteristics that make an ideal nasal tip, Toriumi evaluated numerous aesthetically pleasing nasal tips and created a series of images to demonstrate how specific contours create shadows and highlights that can help guide the surgeon in creating a natural-appearing tip. A more natural-appearing tip, as the composite images demonstrated, possessed a horizontally oriented tip highlight with a smooth transition from the tip lobule to the alar lobule. A key indicator of a favorable tip shape was a straight undisturbed line from tip lobule to alar lobule on the base view (Figure 3). This treatise in tip rhinoplasty also covered various concepts in the analysis of nasal contours, tip aesthetics, stabilization of the base of the nose, and techniques to control nasal tip contour. The article included a discussion on cephalic positioning of the lateral crura and provided surgical techniques, including lateral crural strut grafts with caudal repositioning of the lateral crura (Figure 4).

Alar rim grafts are useful in repositioning of the alar margin, providing support, correcting asymmetries, and helping to prevent external valve collapse along the nostril margin. These long narrow grafts are placed in a precise pocket just caudal to the area of the marginal incision at the caudal border of the lateral crus (Figure 5). These grafts provide moderate support against caudal lateral wall collapse but are often not needed in cases of lateral crural strut grafting with caudal repositioning. In a retrospective review to determine the potential indications for placement of alar rim grafts in primary and revision rhinoplasty, Boahene and Hilger reported their indications and technique and reviewed the functional and aesthetic outcomes in a series of 150 patients. They identified 31 cases (26 primary and 5 revision rhinoplasties) in which alar rim grafting was used. The most frequently identified indications for placement of alar rim grafts were cephalic malposition of the LLCs (29%) and correction of alar flare (29%). Other reported indications included dynamic external valve collapse, alar re-
traction, and contour asymmetries. At a mean 6-month follow-up, no patients experienced graft displacement or extrusion. Boahene and Hilger\textsuperscript{9} illustrated a series of cases and discussed LLC malposition, which can be identified as a boxy tip with “parenthesis” deformity or as internal recurvature of the LLC. In their study, alar flaring was improved with a rim graft alone or in combination with wedge resection. In a similar study evaluating the effects of alar rim grafts to correct alar deformities, including alar retraction, Rohrich et al\textsuperscript{25} found that 91% of primary rhinoplasty patients experienced correction or prevention of alar notching or collapse. However, correction was achieved for only 73% of the patients who underwent secondary rhinoplasty, many of whom had alar retraction secondary to scarring or lining loss. Because of this, Rohrich et al\textsuperscript{25} recommended placement of lateral crural strut grafts in patients with moderate or significant lining loss or scarring.

One of the most commonly used grafts in rhinoplasty is the columellar strut graft. To formally define its role in primary and secondary rhinoplasty, Rohrich et al\textsuperscript{19} reviewed the indications and rationale for the use of columellar strut grafts and their relationship to nasal tip projection and LLC symmetry. In their review of 1734 primary rhinoplasties, 86% of these patients underwent placement of a columellar strut. These struts were most commonly placed to maintain adequate tip projection (34%), to address tip asymmetry (26%), for a combina-

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**Figure 4.** Correction of cephalically positioned lateral crura. A, Cephalically positioned lateral crura create excess vertical supratip tip fullness. Before manipulation, the caudal margin of the lateral crura lies below the cephalic margin. B, The lateral crura are dissected from the underlying vestibular skin. C, Lateral crural strut grafts are sutured to the undersurface of the lateral crura. D, A more caudally positioned pocket is created to accommodate the lateral crus. E, After lateral crural strut grafts are sutured to the undersurface of the lateral crura, the lateral crura are repositioned into the new, caudally positioned pockets to correct the cephalic positioning. After graft placement and repositioning, the lateral crura are now oriented close to 45° off midline instead of the preoperative cephalic orientation. Reprinted from Toriumi.\textsuperscript{4}

**Figure 5.** The alar rim graft (in green) is placed directly along the alar margin to effect contour changes and provide resilience. A, Basal view. B, Front view. C, Profile view. Reprinted from Boahene and Hilger.\textsuperscript{9}
tion of the previous two (22%), and to address the intraoperative loss of tip projection (12%). Rohrich et al\textsuperscript{19} described short struts, long floating struts, and long fixed struts and the indications for each based on strength and symmetry of the LLCs and adequacy of tip projection. In this series, 6% of patients who had a strut required revision surgery for excessive columellar show secondary to improper carving, placement, or fixation of the strut.

Alar soft-tissue techniques, especially alar base and/or flare reduction, are commonly used in rhinoplasty. Until recently, little in the literature summarized these techniques and reported outcomes with scar analysis. In a description of alar soft-tissue techniques in rhinoplasty, Warner et al\textsuperscript{26} presented an algorithmic approach and identified quantifiable guidelines and scar outcomes in a series of 100 patients undergoing rhinoplasty. In their series, 47% of patients underwent alar soft-tissue excision, highlighting how common these procedures are in rhinoplasty. Alar base resection was by far the most common alar soft-tissue technique performed, followed by alar flare reductions; alar hooding resections were performed very infrequently. By quantitatively examining scar outcomes, findings from their study suggest that scars after the use of these techniques heal exceptionally well, even without dermabrasion, which was performed in some patients in a similar study by Kridel and Castellano.\textsuperscript{30}

**OSTEOTOMIES**

Nasal osteotomies are commonly used to narrow a wide bony vault, to close an open-roof deformity, or to straighten deviated nasal bones. Two basic techniques are used for performing lateral osteotomies. The first, a continuous technique, creates a single continuous fracture line. The second, a perforating technique, creates a post-age-stamp fracture pattern that can be made into a continuous fracture by digital manipulation.

In a clinical comparison between osteotomy techniques in rhinoplasty,\textsuperscript{1} a prospective, randomized, partially blinded study was designed to test the hypothesis that the perforating method causes less postoperative ecchymosis and edema compared with the continuous lateral osteotomy technique. Gryskiewicz and Gryskiewicz\textsuperscript{2} demonstrated, by means of a subjective clinical impression, that perforating lateral osteotomies with a 2-mm straight osteotome reduced postoperative ecchymosis and edema in rhinoplasty patients compared with the continuous osteotomy (with a 4-mm curved, guarded osteotome).

In another study to compare microperforating and continuous lateral osteotomies quantitatively in rhinoplasty, Zoumalan et al\textsuperscript{13} determined the difference in nasal bone narrowing between the 2 techniques. Their study was a retrospective analysis of 2 groups of patients each undergoing 1 technique. The first group consisted of 20 consecutive patients from 2000 through 2003 who had isolated lateral continuous osteotomies. The second group consisted of 40 consecutive patients from 2003 through 2005 who received isolated lateral perforating osteotomies. Preoperative and postoperative photographs were used for a blinded analysis of ventral (junction of the flattened surface of the maxilla and the ascending process of the maxilla) and dorsal (width of the plateau or dorsal nasal highlight) widths as measured on the frontal view with a fixed interpupillary distance to create a multiplier. Zoumalan et al\textsuperscript{13} found that both techniques resulted in a decrease in ventral nasal width, neither technique resulted in a significant change in dorsal width, and there was no difference in ventral and dorsal narrowing when comparing the 2 techniques.

**HOMOLOGOUS, ALLOPLASTIC, AND ABSORBABLE GRAFTING MATERIALS**

Homologous grafts that are commonly used in rhinoplasty include irradiated rib cartilage (IHCC) grafts in 357 patients. Their retrospective review included 1025 irradiated rib grafts that were evaluated for warping, infection, resorption, mobility, and extrusion. A total of 1025 IHCC grafts (including 201 dorsal grafts) and 373 other grafts (including 218 autogenous cartilage grafts) were used. The total complication rate related to IHCC grafts was 3.25%, which included warped grafts, infections, resorption, and graft mobility. Of the 218 autologous cartilage grafts used at the same operative intervention along with IHCC grafts, 3 (1.38%) underwent minimal resorption. The overall comparative resorption rates were 1.01% for IHCC vs 1.37% for autologous cartilage. Kridel et al\textsuperscript{8} concluded that these results justify the use of IHCC grafts in rhinoplasty based on safety, reliability, time, and cost-effectiveness.

In a recent meta analysis on the use of alloplastic materials in rhinoplasty surgery, Peled et al\textsuperscript{7} reported their findings with the 3 most commonly used implants. After a systematic review, additional search, and independent extraction, they selected 20 articles for meta-analysis with a mean follow-up ranging from 1 month to 11 years. The alloplastic materials most commonly used included silicone, expanded polytet (Gore-Tex; WL Gore & Associates, Inc), and porous high-density polyethylene (Medpor; Porex Surgical, Inc). The overall implant removal rate was highest for silicone at 6.5%. The polytet and high-density polyethylene implants had similar removal rates at 3.1%. Although these data may not capture the overall or true removal rates for alloplastic materials, they provide evidence of the safety of these implants. Peled et al\textsuperscript{7} conclude that improved reporting of implant failures and longer follow-up are needed to better define the specific guidelines for the use of these materials.

In a systematic review of techniques addressing the nasal dorsum, Lee et al\textsuperscript{37} isolated articles providing data...
on outcomes and complications of various techniques. Of the 83 articles meeting inclusion criteria, 89% focused on augmentation, showing acceptable results with generally low levels of complications with the use of various types of cartilage, bone, and soft tissue. The use of synthetic implants, such as polytef and silicone, showed higher complication rates, including displacement and extrusion, but overall acceptable results. Lee et al noted that most of the published data related to management of the nasal dorsum is low-level evidence, and further level I, II, and III studies are warranted.

A new and increasingly popular method of grafting and scaffolding in rhinoplasty involves the use of polydioxanone (PDS) resorbable plates (Mentor Worldwide) in combination with cartilage grafts. These plates, initially developed for use in orbital reconstruction, are being used for septal reconstruction and in combination with autologous cartilage for various grafts in rhinoplasty. In an outcomes analysis of 58 primary and secondary rhinoplasties in which PDS plates were used in combination with autologous cartilage for aesthetic and valvular reconstruction of the nose, James and Kelly reported graft performance, complications, and technical aspects of PDS plate use. These authors evaluated comparative photographic documentation at postoperative intervals for a mean of 18 months. In primary and secondary rhinoplasty, the PDS plate/cartilage graft construct was most commonly used to fashion a floating columellar strut. This combination method was also commonly used for septal extension grafts and alar batten grafts. Other uses included revision septoplasty and upper lateral cartilage replacement grafts. During 6 to 40 months of follow-up, they observed no loss of tip projection. No operative revisions were required, and the PDS plates were well tolerated by all patients with only 2 minor complications, including 1 infection and 1 partial intranasal extrusion.

Boenisch and Nolst Trenite evaluated the usefulness of a resorbable PDS plate to support septal cartilage in external septoplasty, assessed its mechanical stability, and described the surgical technique and clinical experience in 396 patients since 1996. The indication was typically posttraumatic severe septal deformity. This technique involves removal of the quadrangular cartilage and division into straight fragments, which are sutured to the plate and replaced as a free graft (Figure 6). All patients experienced varying degrees of functional improvement in nasal blockage. During a mean follow-up of 12 months, straightening of the nasal septum was achieved in almost 90% of the patients, correlating with subjective improvements. To confirm this objectively, the authors performed postoperative rhinomanometry. The results showed remarkably improved nasal flow in 324 patients (81.8%). They reported no immediate postoperative complications, and only 3 patients were reported to have long-term dorsal irregularities.

**COMPUTER IMAGING IN RHINOPLASTY**

Digital imaging is now routinely used in plastic surgery, where it serves as a component of the medical record and aids in preoperative planning and evaluation of postoperative results. Computer imaging in rhinoplasty has the advantages of aiding in communication and setting realistic patient expectations. Two recent studies have evaluated outcomes related to computer imaging in rhinoplasty.

In an effort to compare patients’ goals in aesthetic rhinoplasty with aesthetic ideals, Mahajan et al have looked at changes requested by patients through computer imaging during the initial consultation. They then compared these computer simulations with set ideals and found that the mean nasolabial angle fell within the ideal range before and after image manipulation; however, the Goode ratio and the ratio of alar base width to interpupillary distance were statistically similar to ideal values only after image manipulation. Overall, they found that the patients’ preferences were similar to the ideal in 3 of
To determine the accuracy of preoperative computer imaging (PCI) compared with postoperative results, Mehta et al\textsuperscript{16} quantitatively evaluated results in 38 patients who underwent primary and revision rhinoplasty. Six-month postoperative photographs and “morphed” PCI images were graded on a 5-point Likert scale by 2 panels of judges who assessed a total of 12 variables. The judges found that the supratip height was the lowest-rated variable, whereas measurements of the upper third were the most accurate. As one might expect, satisfied patients had significantly higher PCI accuracy scores, and most patients found the PCI extremely useful. That study supports the use and accuracy of PCI but is limited by an average follow-up of approximately 8 months. More studies evaluating the long-term outcomes of PCI are clearly warranted.

CONCLUSIONS

Rhinoplasty and the associated aspects of evaluation and treatment will continue to evolve and challenge surgeons with their complexity and nuances. For this reason, many facial plastic surgeons prefer rhinoplasty to other procedures.\textsuperscript{27} Nevertheless, as rhinoplasty continues to evolve, surgeons and patients clearly would benefit from more evidence-based approaches and outcomes studies to further validate specific techniques.

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