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INTRODUCTION
Optimal results in cosmetic rhinoplasty demand much of the surgeon. A detailed knowledge of the complex three-dimensional anatomy of the nose, familiarity with all the described techniques of rhinoplasty, and a well-developed aesthetic sense are essential.

Since the last Selected Readings in Plastic Surgery review of rhinoplasty, numerous articles have been written that further help us achieve a predictable, aesthetically pleasing outcome from rhinoplasty. Nevertheless, many of the classic articles still form the basis for a safe and effective procedure and are highly recommended.

HISTORY
Cosmetic rhinoplasty evolved from and has contributed to reconstructive nasal surgery. From its early origins as an augmentation (reconstructive) operation, rhinoplasty subsequently became a reduction (cosmetic) technique and has progressed full circle to its current dual role as both a reduction and augmentation procedure. Rogers1 and Eisenberg2 offer comprehensive reviews of the history of rhinoplasty.

Indian techniques for reconstructive rhinoplasty began with Sushruta in 500 BC, continued and evolved during Alexander the Great’s invasion of India in 327 BC, and subsequently waned following the Mohammedan conquest in 997 AD. The Indian knowledge of rhinoplasty is recorded in Sanskrit manuscripts, but Western scholars were not aware of it until the British entered India in the 18th century. The legendary clay potters of Satra, India, practiced Sushruta’s methods for recreating noses, and when these ancient techniques were translated into English, rhinoplasty was finally introduced to the European medical community.

Two German surgeons, von Graefe and Dieffenbach, contributed significantly to the advance of rhinoplasty in the early 1800s. In 1887 John O Roe introduced the intranasal approach to rhinoplasty, and in 1891 Roe3 described cosmetic reduction of an entire nose with removal of the bony and cartilaginous hump through an intranasal approach.

In 1898 Jacques Joseph4 of Berlin pioneered modern reduction rhinoplasty with the publication of his first paper. His technique removed a V-shaped segment of the nasal dorsum through an external incision; included in the excision were skin, bone, cartilage, mucosal lining, a full-thickness portion of ala, and a wedge from the lower portion of the septum. Joseph analyzed and classified various nasal deformities and introduced numerous operative procedures for their correction. His monumental two-volume textbook on plastic surgery of the nose5 was published between 1928 and 1931, and a few years later his teachings were brought to the English-speaking world by Joseph Safian6 and Gustave Aufricht.7
ANATOMY

Dingman and Natvig\(^8\) illustrate the general anatomy, skeletal elements, blood supply, and innervation of the nose (Fig 1).

The skeletal framework of the nose is highly variable and frequently asymmetrical. Natvig and associates\(^9\) illustrate several cartilaginous configurations as reported by various authors (Fig 2). Bernstein\(^10\) and Broadbent and Woolf\(^11\) review the anatomy of the upper, middle, and lower third of the nose and its clinical application in rhinoplasty.

The nasal bone is widest at the nasofrontal suture (14mm), narrowest at the nasofrontal angle (10mm), and widens again to a maximum of 12mm some 9–12mm inferior to the nasofrontal angle.\(^12\) The nasal bone is thickest superiorly at the nasofrontal angle (avg 6mm) and thins progressively toward the tip.

Daniel and Lessard\(^13\) note the following:

1. The critical, fixed anatomic landmark of the nose is the medial canthal ligament, which in many noses

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**Fig 1.** General anatomy of the nose. (Reprinted with permission from Dingman RO, Natvig P: Surgical anatomy in aesthetic and corrective rhinoplasty. Clin Plast Surg 4:111, 1977.)

**Fig 2.** The alar cartilages as depicted by various sources. (Reprinted with permission from Natvig P, Sether LA, Gingrass RP, Gardner WD: Anatomical details of the osseous-cartilaginous framework of the nose. Plast Reconstr Surg 48:528, 1971.)
corresponds to the desired level of the transverse fracture line.

2. The soft-tissue coverage consists of skin—thickest at the tip and thinnest at the rhinion; subcutaneous tissue—most prominent in the supra-tip area; and muscles—ranging from 3.5–9.2mm in thickness.

3. The nasofrontal suture is 10.7mm above the intercanthal line (Fig 3) and the intervening solid “bony triangle” is virtually impossible to narrow by digital pressure or to deepen by rasping.

4. The keystone area of nasal bone overlapping the upper lateral cartilage (ULC) extends farther along the septum (7.6mm) than laterally (3.8mm).

5. The dorsal hump is predominantly (57%) cartilaginous rather than bony (43%).

6. The dorsal border of the cartilaginous septum progresses from a Y, with a supraseptal depression at the keystone area, to a T and eventually to an I by the septal angle.

7. In most cases the alar domes project far above and caudal to the septal angle, thus discounting direct septal support for the tip.

McKinney, Johnson, and Walloch14 confirm fusion of the ULC and nasal septum in the dorsal midline. Only at the level of the septal angle are these structures separate (Fig 4) and merely connected to each other by fibrous tissue.

Accessory cartilages are interspersed in the aponeurosis connecting the lateral crus to the piriform aperture.15,16 A continuous, supporting ring of cartilaginous and fibrous tissue circumscribes the nasal lobule, with connections between the medial and lateral crura and the floor,16 as follows:

- the first accessory cartilage underlies the alar crease
- the second accessory cartilage is attached to the piriform aperture by the deep portion of the alar nasal muscle arising from the undersurface of the maxilla
- the third accessory cartilage has a definite fibrous attachment to the nasal spine and forms the internal nostril fold on the floor of the nasal vestibule.

The ring consists of the caudal septum resting on the nasal spine of the maxilla, the medial and lateral crura, and a chain of three or four accessory cartilages. Daniel and Letourneau16 found no deterioration of the cartilage with age, and doubt that attenuation of the cartilage and fibrous supporting structures is responsible for the drooping nasal tip seen in the elderly, but rather believe it is due to resorption of the maxillary alveolar crest.

Rohrich et al17 discuss their approach to the management of the nose in the aging patient. With age, the lower third of the face decreases in height secondary to muscle atrophy of the orbicularis oris, fatty tissue absorption, and maxillary alveolar hypoplasia (from tooth loss and subsequent bony resorption). With advanced age, the nose lengthens and the nasal dor-
sum becomes more convex as a consequence of downward rotation of the lobule and relative columellar retraction. The tip elongates and droops and the flow of air shifts superiorly, often causing functional airway obstruction. Osteotomies are not recommended due to the fragile nature of the bony nasal pyramid.

Daniel emphasizes the importance of the three crura of the lower lateral cartilage—the medial, middle, and lateral crus—and of the three nasal tip angles—the angle of tip rotation, angle of dome definition, and angle of domal divergence (Fig 5). The anatomy of the ULC correlates strongly with tip aesthetics.

Histologically, the bulbous tip consists of collagenous fibrous tissue and skeletal muscle; the adipose tissue component is far less than expected. The tissue makeup, blood supply, and lymphatic drainage are directly related to postoperative edema and scar formation and influence the resection that is performed for tip modification.

Copcu et al describe the interdomal fat pad as a separate anatomic component not structurally attached to the subcutaneous tissue. The fat pad consists purely of adipocytes and varies in size from 1.2x2.4mm to 3.6x5.2mm. Ultrasonography shows larger pads occupying the interdoral space.

Rohrich, Gunter, and Friedman studied the blood supply of the nasal tip before and after transcolumellar incision in a fresh cadaver model. The lateral nasal artery was present in all specimens and was located in the subdermal plexus 2–3mm superior to the alar groove. The columellar branch of the superior labial artery was variable. Even after transcolumellar incision there was consistent crossover flow from the lateral nasal artery arcade to the distal aspect of the transected columellar branches. The authors conclude that external rhinoplasty does not compromise nasal tip blood supply unless extensive tip defatting or extended alar base resection above the alar groove is performed.

Toriumi and others looked at the effect of external rhinoplasty on the vascular anatomy of the nose. The study involved pre- and postoperative clinical evaluation, cadaver dissection, lymphoscintigraphy, and histologic evaluation. The major arterial, venous, and lymphatic vessels course in or above the musculoaponeurotic layer of the nose. The authors suggest that “in the external rhinoplasty approach, dissection in the areolar tissue plane below the musculoaponeurotic layer will minimize tip edema and protect against skin necrosis by preserving the major vascular supply to the nasal tip….There was loss of normal flow of tracer with the external approach using dissection that disrupted the musculoaponeurotic layer with supra-tip debulking.”

To minimize injury to the external nasal branch of the anterior ethmoidal nerve, Han, Shin and Kim performed anatomic dissections in 10 fresh cadavers and conclude that dissection deep to the nasal SMAS is safe. They recommend keeping the dissection to within 6.5mm of the midline and limiting onlay graft widths at the rhinion to 13mm.

Pitanguy describes a dermocartilaginous ligament that may influence dorsum-tip relationships. The ligament is most significant in patients with a bulbous tip and in African noses where a convexity of the lower third of the nose is still apparent after classic modification of the osseocartilaginous structures. Division and partial resection of the dermocartilaginous ligament releases the lower third of the nose and the nasal tip moves upward. In a follow-up article, Pitanguy confirms this subseptal tip-anchoring structure and detaches it subcutaneously through an open browlift approach for the aged, drooping nose.

Figallo describes a dynamic structure in the nasal tip, neither osseous nor cartilaginous, which he believes is a digastric muscle linking the nose to the upper lip. This complex anatomic structure is joined through a pulley to the anterior nasal spine and is felt to account for the plunging tip. A distinction between this “new” structure and the nasal depressor muscles is unclear.
Figallo and Acosta provide a detailed update on the muscles of the nose.

Ozturan et al used EMG to study the intrinsic nasal musculature as it relates to airway collapse before and after rhinoplasty. They caution against inadvertent disruption of the procerus, transverse nasalis, and dilator nasalis muscles during rhinoplasty, which will affect nasal movements postoperatively. The authors emphasize staying in the appropriate tissue plane beneath the musculature and over the perichondrium to achieve the best functional result.

In a cadaver study, Ali-Salaam, Kashgarian, Davila, and Persing found the alar lobule to be an area where dermis interdigitates with muscle throughout and down to the alar rim. The alar groove is defined by a differential in fibrofatty bulging anterior and posterior to it. The authors also studied the soft triangle and described the anatomy of the insertion of the dilator naris muscle down to the nostril rim.

**PHYSIOLOGY**

Baker and Strauss review the physiology of the nose and note that septal deviation and spur formation are anatomic variants prevalent in normal populations. The nasal cycle is a physiologic response characterized by alternate shrinkage and engorgement of the nasal turbinates that repeats every 30 minutes to 4 hours. While on one side of the nasal airway the turbinates are shrinking, and giving off secretions of serous fluid and mucus, on the opposite side the turbinates are engorging. This cycle occurs in 80% of individuals and its exact function is unknown. Total airway resistance remains relatively constant despite continuous changes in the size of the turbinates. Baker and Strauss discuss the physiologic basis of nasal obstruction relative to pathologic states of the nasal turbinates. Rhinitis is classified as allergic, vasomotor, atrophic, hyperplastic, medicamentosa, or postrhinoplastic. The differential diagnosis and treatment of obstructive rhinitis are reviewed.

On the basis of his vast experience treating patients with nasal obstruction, Canady offers a relatively simple algorithm (Fig 6) to identify the causes and management of nasal obstruction. “Of equal or greater importance, however, this algorithm may allow the surgeon to recognize and avoid performing surgery on patients who will not be satisfied, even with a technically good result.”

Jesson and Malm followed 67 patients who were considered candidates for septoplasty because of nasal obstruction and deviated nasal septum. These patients did not have surgery because their nasal airway systems were discovered to be normal on rhinometry. At 5 and 10 years of follow-up, 20% and 36% of patients respectively showed relief of nasal symptoms. The authors conclude that the majority were in fact suffering from vasomotor rhinitis, which tends to disappear with time, and recommend careful evaluation to distinguish between anatomic obstruction and physiologic obstruction.

Deron et al evaluated the influence of septal deviation on Eustachian tube function and conclude that surgical correction improved tubal opening pressure on both the deviated side and the nondeviated side. Fomon and associates and Courtiss and others state: “Unless the internal or external valves are adversely affected or unless a simultaneous septal operation results in septal perforation, aesthetic rhinoplasty does not affect nasal airflow.”

Infracturing of the nasal bones takes place cephalad to the internal nasal valves and presumably does not impair airflow.

Ford and coworkers studied the effects of various osteotomy techniques on the size of the airway in cadavers, and conclude that “an interrupted transperiosteal osteotomy preserving intervening strands of periosteum results in a more stable nose with less compromise of the airway.”

Guyuron studied the effect of osteotomy on the airway of 48 patients (96 nasal bones). The length of the nasal bones and position of the inferior turbinates were recorded preoperatively and correlated with the type of osteotomy performed and extent of bone movement. Each side was assessed independently. The high-to-low osteotomies produced the least narrowing of the nasal passages. Patients with short nasal bones had less constriction of the airway than patients with either normal or long nasal bones. Airway narrowing was more significant when the inferior turbinates were positioned anteriorly. The author concludes that nasal osteotomy does constrict the nasal airway in most instances and to a degree varying with length of the nasal bones, extent of nasal bone repositioning, position of the inferior turbinates, and type of osteotomy.

Grymer and colleagues studied the significance of placement of the lateral osteotomy at levels above and
below the insertion of the inferior turbinates in 16 cadavers and found no difference between noses that received high lateral osteotomy and those that had low lateral osteotomy. Both groups showed 12–16% decrease in mean cross-sectional area at the piriform aperture after lateral osteotomies were performed. This reduction was independent of osteotomy placement but was probably due to detachment of the bony box from the underlying structures.

Becker et al.40 developed a rationale for selecting the correct osteotome in endonasal lateral osteotomy. The mean bony lateral wall thickness was measured by CT scan in 56 adult patients and found to be $2.47 \pm 0.47$ mm in men and $2.29 \pm 0.40$ mm in women. The 4mm osteotome caused intranasal mucosal tears 95% of the time, the 3mm osteotome created tears in 34%, and the 2.5mm osteotome in 4%.

Malm41 introduced the concept of acoustic rhinomanometry, described the technical aspects of the procedure, and listed clinical norms. Grymer42 used acoustic rhinomanometry to measure the internal dimensions of the nasal cavity in 37 patients before and after reduc-

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**Fig 6. Algorithm for managing nasal obstruction.** (Reprinted with permission from Canady JW: Evaluation of nasal obstruction in rhinoplasty. Plast Reconstr Surg 94:555, 1994.)
tion rhinoplasty. There was a 22% reduction in minimal cross-sectional area at the nasal valve and 11% reduction in cross-sectional area at the piriform aperture.

The Vomeronasal Organ
Moran and coworkers and Stensaas and colleagues independently investigated the vomeronasal (Jacobson’s) organ. Interest in this vestigial structure stems from its similarity to the vomeronasal system of other vertebrate species, in which Jacobson’s organ plays a crucial reproductive role by detecting pheromones. The authors collectively evaluated 600 human subjects and found paired vomeronasal pits in the anterior third of the nasal septum in all individuals who had no underlying septal pathology. The pits signified the presence of closed tubes, 2–8mm long and lined by unique pseudostratified columnar epithelium unlike any other in the human body. Two potential receptors were identified in the epithelial lining. The function of Jacobson’s organ in humans is still in question, but in any case it would seem to be immune from injury by submucoperichondrial dissection of the septum.

AESTHETICS AND FACIAL ANALYSIS
Implicit in a surgeon’s ability to correct nasal deformities is an understanding of aesthetic proportions of the face, not just the nose. Farkas and coworkers, Daniel and Farkas, and Ricketts review modern standards in facial aesthetics. Bernstein delineates relationships between facial shape and nasal width, discusses nose-chin proportions, and lists differences between the male and female nose. According to these authors, the aesthetically pleasing face is not divided into equal thirds or fourths, but rather the lower face is longer than the midface, which in turn is longer than the upper face.

Greer and associates reviewed the importance of the submental region in improving the perceived appearance of the nose. They advocated neck-rejuvenating procedures for improving results. Byrd and Hobar find a consistent relationship between vertical dimensions and anteriorly projecting characteristics of the nose, lips, and chin. They propose a dynamic system of analysis that describes key measurements of the nose relative to other facial features and that maintains an overall proportion between nose, chin, and rest of the face. According to their system, for any individual the ideal nasal length (RT) is determined by nonnasal facial measurements (Fig 7). Specifically, RT is equal to 67% of the midfacial height (MFH) and equal to the chin vertical measurement (SMes).

\[ RT = 0.67 \times MFH \text{ or } RT = SMes \]

Fig 7. Ideal relations and proportions of the facial structures on lateral view; legends in text. (From Byrd HS: The dimensional approach to rhinoplasty: perfecting the aesthetic balance between the nose and chin. Presented at the 14th Annual Dallas Rhinoplasty Symposium. Dallas, Feb 28-Mar 3, 1997.)

Nasal tip projection equals 67% of the calculated ideal length. The nose–lip–chin plane (NLCP) is determined by a line drawn through a point halfway down the ideal nasal length and touching the upper lip vermilion. In men the chin projects to this line, but in women it is 3mm posterior to it. Other details of their facial analysis method are as follows:

1. The MFH is measured from glabella (G) to alar base plane (ABP). The lower face height (LFH) is measured from ABP to mentum (Me). MFH should be equal to or slightly less than (<3mm) LFH. If it is not, reaffirm occlu-
sion and look specifically for the presence of long- or short-face syndrome or microgenia.

MFH ≤ LFH (≤3mm)

2. Select the mid- or lower facial subunit as the standard for determining ideal nasal length. When the mandible is normal and MFH and LFH are nearly equal, nasal length should be planned on the basis of chin vertical as measured from stomion (S) to mentum, ie,

\[ RT_1 = SMes \]

In cases of microgenia or maldevelopment of the mandible, the ideal nasal length is determined from the midfacial height, ie

\[ RT_1 = 0.67 \times MFH \]

Similarly, when the midface is overdeveloped and is not to be corrected orthognathically, the nose should be proportional to the midface rather than to the smaller mandibular segment.

3. With the ideal nasal length established, adjustments to the existing nasal length and possibly the chin vertical should approximate the ideal nasal length. The treatment plan is ultimately determined by safe and reliable surgical guidelines.

4. Multiply the ideal nasal length by 0.67 to determine the ideal tip projection.

Ideal tip projection = 0.67 x RT₁

If actual tip projection is equal to or greater than the calculated value, then tip projection is adequate despite its appearance in relation to the dorsum. If actual tip projection is less than the calculated ideal, surgical steps to increase tip support should be considered.

5. Measure the distance between corneal plane (CP) and radix plane (RP). The ideal radix projection should be 28% of the ideal nasal length, or

Ideal radix projection = 0.28 x RT₁ (9–14mm)

If less than the calculated value and a dorsal hump is present, consider a radix graft. If greater than 0.28 RT₁ and the radix breakpoint is poorly defined, consider radix reduction.

6. Note any difference in nasal length when measured from supratarsal fold R and visual radix breakpoint. If nasal length is normal as measured from R but the nose appears short because of a low breakpoint, it can be corrected with a radix graft to raise the visual break.

7. Mark a point on the dorsum of the nose equivalent to one-half the ideal nasal length as measured from R. Drop a line from this point tangential to the vermillion of the upper lip. The projecting point of the chin should touch the line in men and lie ~3mm back of this plane in women.

Chin projection = NLCP (men)
Chin projection = ~3mm NLCP (women)

The aesthetically pleasing female face has a midfacial height that is equal to or slightly less than lower facial height (avg 61mm). Nasal length equals chin vertical distance and averages 41mm (Fig 8).

8. On lateral view, the mean distance between nasal root plane (RP) and corneal plane (CP) is 11mm or approximately 0.28 x RT₁. The nose projects from the face at an angle of 30°–36°, while the nasolabial angle varies from an average of 90° in men to 95°–110° in women. A 2–3mm segment of columella should be seen below the rim of the ala.

McKinney and Sweis sought to define the elements of the ideally balanced Caucasian nose. Ideal dorsal length was 2X rhinion height and tip projection. Ideal radix height was 0.75X tip projection + rhinion height. In his discussion of this paper, Daniel references the ideal nasion relative to its surrounding anatomic landmarks: 15–20mm from medial canthus; 9–14mm anterior to corneal plane on profile; 4–6mm behind glabellar line; and at lower border of upper lid, among others.
VISUAL DOCUMENTATION

Photography
Krugman reviews photoanalysis and emphasizes the neoclassical facial proportions and holistic treatment planning. Guyuron points to the advantage of full-scale, life-sized photography as an adjunct to soft-tissue cephalometric analysis in rhinoplasty and describes his facial analysis system, which includes proportions, angles, measurements, and recommended profile template. Preoperatively the system is used to confirm the treatment plan and to serve as a baseline; postoperatively it can help identify shortcomings in the rhinoplasty technique. Schwartz and Tardy propose a standardized system of photodocumentation in rhinoplasty and make specific recommendations with regard to views, lighting, and equipment.

Galdino, DaSilva and Gunter list additional considerations for maintaining detail and consistency in digital photodocumentation of the nose. Various printing methods are discussed.

Anatomical Drawings
Gunter suggests a pictorial system to graphically record intra-operative maneuvers in rhinoplasty. Into every patient’s chart goes a worksheet that consists of four views of the nose and a checklist of possible surgical details and steps. The type of rhinoplasty; surgical approach; operations on the tip, lateral crura, medial crura, dorsum, and nasal bones; use of grafts or implants; and miscellaneous adjunctive procedures are all recorded here. The actual events during rhinoplasty are drawn in on the anatomical illustrations and marked on the checklist. The value of this standardized graphic record lies in its objective correlation between what was done surgically and the operative outcome.

Computer Imaging
Computer imaging is another graphic tool in the preoperative evaluation of the rhinoplasty patient as well as for postoperative assessment of the result. Sophisticated hardware and software are available in both PC and Macintosh platforms. The more valuable systems can import undistorted, life-size images and alter them by incremental differences in nasal length, tip projection, angles, width, and shadowing.

For computer representations to be realistic, users must project their true surgical skills. Computer imaging is controversial because it is so powerful: Used as a marketing tool, it can mislead patients into expecting a surgical result that is impossible to achieve. Used properly, computer imaging can offer a precise record of the deformity and its proposed correction, a scaled surgical plan, and an exact surgical record.

Mattison reviews facial video image processing, with emphasis on image capture, software modification, development of a surgical plan, and comparison of preand postsurgical results. Schoenrock reports his 5-year experience with computer imaging. Bronz recounts the predictability of surgical planning with a computer imaging system in 100 primary rhinoplasty cases.

Vuyk and colleagues used a patient questionnaire to assess the role of computer imaging in facial plastic surgery. Most patients (80%) found computer imaging helpful in communicating with the surgeon, both for expressing their wishes and expectations and in facilitating the decision for or against a particular surgical change. The majority also felt that computer imaging should be a routine part of preoperative evaluation for plastic surgery. The predictive value of computer tracings was about 80%.
PATIENT SELECTION

Selection of the appropriate patient for rhinoplasty depends on communication. The surgeon must listen and understand the patient’s wishes and balance them against his/her estimate of what can be reasonably achieved surgically.

Thomson lists criteria to be used in the selection and counseling of patients for rhinoplasty and cautions against certain recognizable types of individuals: the super-secretive, the ones unable to identify their desires, those who request urgent operation, are overly concerned with minor deformities, have secondary motivations, are excessively demanding, carry a number of photographs describing their preferred nose, are extremely indecisive, and male patients. Tardy et al stress the importance of preoperative interviews.

Goin discusses the psychology of rhinoplasty patients. Honigman and colleagues reviewed the literature on psychological outcomes after cosmetic surgery and identified consistent predictors of a poor psychosocial outcome.

In a retrospective study of 150 secondary rhinoplasty patients, Constantian noted four anatomic variants that strongly predisposed to unfavorable results: low radix/low dorsum, narrow midvault, inadequate tip projection, and alar cartilage malposition. The triad of low radix, narrow midvault, and inadequate tip projection was the most common combination (40%) in patients seeking secondary rhinoplasty. More recently Constantian reviewed 100 consecutive primary rhinoplasties and reported inadequate tip projection in 67%, cephalic malrotation of the lateral crura in 46%, and a too-prominent tip in 23%.

Male Rhinoplasty

Daniel acknowledges the validity of Gorney’s SIMON profile: Single, Immature Male, Overly expectant, and Narcissistic. These patients are psychologically unstable and poor candidates for rhinoplasty surgery, but constitute only about 15% of men seeking rhinoplasty in his practice. Men’s noses tend to be more variable in aesthetic measurements, with wide ranges in level of nasion, height of nasion, and relation between endocanthus and nasal base. Daniel’s goal in male rhinoplasty is a “strong” profile and no supratip break.

Rohrich and colleagues describe male rhinoplasty patients as typically nonspecific regarding their complaints, more demanding, and less attentive during consultations. It is important to avoid excessive dorsal reduction or tip refinement in this cohort.

ANESTHESIA

General anesthesia is recommended when operating on an apprehensive patient, for procedures involving deep septovomerine manipulation, and in some posttraumatic deformities accompanied by intranasal scarring. The local anesthetic of choice is 1% lidocaine with epinephrine 1:200,000 to 1:50,000.

Moscona and associates compared sedation techniques for outpatient rhinoplasty in 859 cases. Patients were assigned to one of two groups, those who received midazolam and those who had midazolam+ketamine. Sedation scores showed both groups were adequately sedated. The midazolam+ketamine group were less likely to remember the injections and were more satisfied with their surgical experience.

Miller and associates recommend topical administration of 4–5% cocaine solution to enhance anesthesia and induce vasoconstriction while avoiding high plasma concentrations of cocaine. Mixing cocaine with epinephrine offers no advantage, and the toxic effects of “cocaine mud” are well documented.

In a prospective, randomized study of 12 consecutive patients, Liao and associates tried to identify factors that influenced the safe use of topical cocaine during rhinoplasty. Group 1 received cotton pledgets soaked in 4mL of 4% cocaine solution for 10 min; group 2 received 4mL of 4% solution for 20 min; and group 3 received 4mL of 10% solution for 20 min. Serum cocaine concentrations were measured at intervals of 5, 10, 15, and 20 minutes. Of the total cocaine applied, 35% was absorbed systemically within 15 min of application. This absorption rate was 4X higher than expected, and led the authors to conclude that topical use of 10% cocaine was to be avoided.

Metzinger and others recommend adding 1 part sodium bicarbonate to 5 parts local anesthetic to lessen the pain and irritation of injections during rhinoplasty.
SURGICAL TECHNIQUES

The classic concepts of Joseph’s, Aufricht, have evolved significantly in the past 35 years. According to Rees,

...the highly styled retroussé nose of the past has given way to emphasis on a more natural look with higher dorsal profile, less tip elevation, and less sculpturing of the alar cartilages. The ‘operated look’ is to be avoided at all costs.

Rees (1977)

In 1977 Rees listed the trends in rhinoplasty as

• less removal of tissue
• more preservation of structures
• a decided tendency toward ‘underoperation’ rather than ‘overoperation’

To these we can now add

• incisions designed to preserve lining and soft tissue
• resection of only the bare redundancy of the upper lateral cartilages
• correction of the nasal tip first, or at least early in the procedure, before modifying the dorsum
• a tendency to avoid transecting the domes or otherwise avoid interrupting the spring of the alar cartilages
• maximum preservation of the caudal border of the septum
• resection of the nasal spine only in well-defined, isolated cases
• less frequent medial osteotomies
• rare outfracturing

The techniques of Anderson, Peck, Rees, Sheen, and Goodman are representative of current concepts in rhinoplasty. Peck describes the preferred basic approach to rhinoplasty and emphasizes that the most important aesthetic goal is to create a pleasing tip that will stand out gracefully from the straight nasal bridge.

Sheen’s original methods of nasal augmentation, along with his refinements of surgical techniques for the correction of secondary nasal deformities, further expand modern rhinoplastic alternatives. In a retrospective titled “Rhinoplasty: Personal Evolution and Milestones”, Sheen reviews the milestones in this evolution, as follows:

• vestibular stenosis: diagnosis of a surgical consequence
• etiology and treatment of supratip deformity: the dynamic relationship of soft-tissue contour to skeleton
• etiology and treatment of the tip with inadequate projection: tip graft design
• practical aesthetics of balance: the augmentation-reduction approach to rhinoplasty
• support of the middle vault: functional and esthetic effects
• malposition of the lateral crura: recognition and management
• significance of the middle crura: clinical and aesthetic considerations

This paper and the techniques therein should be carefully studied by all rhinoplastic surgeons.

Intranasal Approach

The intranasal approach to rhinoplasty includes several routes of access to the nose (Fig 9), as follows:


• intercartilaginous incisions between the upper and lower lateral cartilages
• transcartilaginous (cartilage-splitting) incisions through the lower lateral cartilages
Infracartilaginous incisions following the caudal border of the lower lateral cartilages

combinations of the above, with or without a transfixion incision through cartilaginous or membranous septum caudally.

Deformities requiring wide exposure, such as tip asymmetries, high dorsal septal deviations, and severe posttraumatic deformities, are frequently approached through cartilage-delivery methods using infracartilaginous or marginal incisions, singly or in conjunction with an intercartilaginous incision. They may also be combined with a transcolumellar incision and converted to an external approach. If the nasal tip morphology is normal, one should avoid dissection of the tip structures as part of the exposure.

External (Open) Approach

The open approach to rhinoplasty consists of bilateral marginal or rim incisions along the inferior border of the alar cartilages that are connected in the midline by a transcolumellar skin incision 5–7mm long (Fig 10); it does not include Joseph’s large skin incision. The main difference between the external and internal approach is that the external approach allows exposure of the lobule complex without disturbing intercrural and alar–septal attachments.

![Fig 10. Incisions used in the external approach to rhinoplasty.](image)

Adams et al reviewed nasal tip support in open and closed rhinoplasty. The mean loss of tip projection with the open approach was 3.43mm versus 1.98mm for the closed approach. The difference was attributed to greater ligamentous disruption and skin undermining with the open approach. Septal manipulation was associated with decreased tip support regardless of approach.

Rethi used a partial, high-transverse columellar incision that failed to uncover the entire nasal skeleton. Sercer extended Rethi’s incision to expose the entire ossecartilaginous framework of the nose. Padovan further expanded the open rhinoplasty concept and incorporated his treatment of the nasal septum. Goodman described his technique of external rhinoplasty and reported an experience with 74 patients. We endorse Goodman’s method and listed the following advantages to the external rhinoplasty procedure:

- better binocular visualization for teaching and studying deformed anatomy
- control of bleeding by electrocautery
- more accurate diagnosis
- more precise correction of deformities

The external approach enjoys all the advantages of the cartilage-delivery technique plus simultaneous bilateral visualization of the lower lateral cartilages in their resting state without retraction. This additional exposure can be of benefit when dealing with an asymmetric tip or when correcting tip projection, where it is desirable to maintain the soft-tissue attachments while simultaneously evaluating the unloaded support to the tip complex.

On the other hand, the external approach implies unnecessary degloving of the tip–lobule complex when tip projection is normal. In this case, the increased exposure gained by the open approach must be balanced against the risk of altering tip support or tip definition while dissecting the dome. Goodman notes the following limitations and potential complications of the open approach:

- separation and secondary healing of the transverse columellar incision
- additional edema of the nasal tip persisting for several months
- increased operative time for incision closure

The indications for the external approach remain arguable even among current masters of rhinoplasty.
Anderson expressed some concern about the resulting scar and suggested that the external rhinoplasty technique may be most applicable in long-standing, severe, posttraumatic nasal deformities. Friedman and Gruber adopted the open rhinoplasty technique because of the increased exposure it affords, but conclude that it is probably not necessary if the cartilaginous vault or tip do not need to be modified much.

Constantian reviewed 100 consecutive patients who underwent secondary rhinoplasty and report 36% had open rhinoplasty at the previous surgery. These patients' symptoms related to an overresected dorsum or tip and internal nasal valve collapse. Excessive columellar length, hard columellar struts, alar/nostril distortion, narrow nose, and external valvular obstruction were more common in this group.

**Surgical Approaches to the Tip**

Most surgical approaches to the nasal tip are variations of (a) the retrograde technique; (b) cartilage-splitting technique; (c) cartilage-delivery technique; or (d) the external approach.

**The Retrograde Technique**

The retrograde or eversion technique of Converse uses a single intercartilaginous incision for access to the nasal dorsum, the cephalic portion of the alar cartilage, and the inferior scroll of the ULC; it also preserves an intact caudal rim of alar cartilage after resection. The retrograde technique is indicated for deformities requiring minimal cephalad resection of the alar cartilages, minimal dome manipulation or modification, and minimal cephalad rotation of the lobule complex. Relative disadvantages of the retrograde technique are a difficult dissection, less visibility, and limited access to the dome–medial crural areas.

**Cartilage-Splitting Technique**

Anderson and Webster and others used intracartilaginous incisions paralleling the caudal border of the alar cartilages. At the lateral aspect of the lateral crura variable amounts of cartilage are resected according to individual anatomy and the degree of tip rotation desired (Fig 11).

are not precisely equal bilaterally; 3) decreased tip projection if the incision at the dome is too far caudal, which alters the pivot point of the lobule (Fig 12); and 4) possible collapse of the lateral crura and alar notching if the caudal rim is weakened by overresection.

Fig 12. Cartilage-splitting incisions have changed the pivot point of tip rotation. A, before and B, after splitting the alar cartilages. (Reprinted with permission from Anderson JR: New approach to rhinoplasty. A five-year appraisal. Arch Otolaryngol 93:284, 1971.)

**Cartilage-Delivery Techniques**

Techniques that deliver the alar cartilages for direct visualization have been described by Sheen, Becker, and Bernstein. Access to the lobule is by combined intercartilaginous and infracartilaginous (alar margin) incisions that offer greater visibility of the alar cartilages; the entire lower lateral cartilage with attached vestibular skin and mucosa is exteriorized as a bipedicled chondrocutaneous flap. It is easier to manipulate the dome areas under direct vision to correct secondary tip deformities and there is better postoperative tip symmetry because the surgeon can see the amount of cartilage remaining and possibly contour the existing cartilage without resection. The cartilage-delivery technique is most appropriate for difficult nasal tip deformities such as asymmetries, twisted, bulbous, box, bifid, or overprojecting tips.

Disadvantages of the cartilage-delivery technique include increased trauma from the dissection; a worse scar from two incisions; and the risk of injury to the caudal strip of the alar cartilage from the marginal incision. One must be careful not to penetrate the soft triangle, for, as Sheen puts it, “any incisions in the soft triangle may cause deformity of the tip.”

**THE OSSEOCARTILAGINOUS VAULT**

**Dorsal Reduction**

The nasal dorsum can be lowered either before or after the tip is modified. Rees, Anderson, and Peck prefer initial tip modification with subsequent lowering of the dorsum to a level appropriate for the revised tip. Safian and Sheen, on the other hand, prefer initial reduction of the dorsum followed by tip modification.

*When tip projection is adequate or excessive* and a small hump removal is anticipated, dorsal reduction might best be done before tip modification. A conservative, controlled dorsal reduction using a sharp rasp is a safe way to avoid overreduction according to Rees, Sheen, and Peck.

*When tip projection is marginal or inadequate,* it seems logical to maneuver the tip first to achieve as much tip projection as possible and then lower the dorsum, instead of first lowering the dorsum, perhaps excessively, in an attempt to achieve a dorsal line below the level of tip projection. Constantian described a notch that tends to appear “at the midpoint of the nasal dorsum when the bridge has been resected beyond the ability of the soft tissues to contract. This notch, commonly seen in secondary rhinoplasty patients, occurs at the cephalic end of the supra-tip convexity and appears whether or not the tip has been overresected.”

Skoog performed composite resection of the bony and cartilaginous dorsum, tailoring the removed unit, and replacing it as a dorsal osseocartilaginous composite graft. The original indications for the operation included severely deviated noses in which extensive dorsal reduction was anticipated; any residual septal deformities could thus be camouflaged by the dorsal autograft.

Regnault and Alfaro further refined the procedure, and Lejour and colleagues used the Skoog technique routinely when dorsal reduction was indicated. Although hump reinsertion may seem overly aggressive by current standards of practice, the technique should be considered in patients with very short nasal bones, in whom lateral osteotomies are risky, and in
select cases of septal deviation where septal modification could lead to total collapse of nasal support. Disadvantage of the Skoog technique in routine rhinoplasty is the potential for displacement and resorption of the dorsal graft.

Often the dorsal hump deformity is more one of cartilage than bone.13,80 The cartilaginous dorsum, including the septum and upper lateral cartilages, can be reduced by composite resection86 or by separating the ULC from their junction with the septum dorsally and resecting each separately.85

With small dorsal humps (most frequent), composite resection maintains mucosal integrity without formal extramucosal tunnel dissection and avoids the risk of narrowing mucosal surfaces at the septal-upper lateral cartilage junction as a result of scar contracture.

In large hump deformities it is necessary to divide the ULC from the septum extramucosally and to resect the attached and potentially redundant mucosa to keep it from heaping over the dorsal profile.

When ULC have to be separated from the dorsal septum to correct a markedly deviated nose or for better septal exposure, submucosal tunnels or extramucosal dissection from the underside of the septal-ULC junction preserves mucosal integrity.

Rohrich and associates118 advocate a gradual approach to dorsal reduction so as to avoid complications such as dorsal irregularities, overresection, inverted-V deformities, and excessive narrowing of the midvault. They list five critical steps: 1) separation of the upper lateral cartilage from the septum; 2) incremental reduction of the cartilaginous septum; 3) dorsal bony reduction with rasps; 4) verification by palpation; and 5) final modification. Bilateral submucoperichondrial tunnels are created before releasing the ULC from the septum to preserve the cartilages and mucosa of the internal nasal valves.

Sheen86 recommends oblique rasping across the bones to minimize pull on the upper lateral cartilages from below. This prevents accidental avulsion of the cephalic portions of the ULC from their junction with the nasal bones during rasping reduction of the bony dorsum. Guyuron119 recommends the use of a guarded power burr for deepening the nasofrontal angle. In substantial reductions of the nasofrontal junction, the burr is more effective than a rasp, electric saw, or osteotome.

Mommaerts and colleagues120 describe a reduction osteotomy in which the osteotome enters the vertical frontonasal suture behind the nasal bones and in front of the nasal spine of the frontal bone. In our view, reduction of the nasofrontal junction presents two problems. One, the soft-tissue response to bony removal is approximately 50%. Two, as the nasofrontal junction deepens, the intercanthal bridge lines visibly widen. Successful bone removal in this area, therefore, may be tempered by a compromise in nasal aesthetics.

Sheen86 recommends spreader grafts for reconstruction of the middle roof in patients who have a narrow nose with visible depression of the lateral walls and abnormal valving on inspiration. Noses predisposed to midvault collapse—eg, noses with short bones, thin skin, weak cartilages, or combinations of these—will be too narrow following resection of the roof and may also benefit from spreader grafts.

Skeletal Manipulation and the Soft Tissues

Guyuron121 studied the reaction of the soft tissues to skeletal reduction over several zones of the nose, as follows:

<table>
<thead>
<tr>
<th>Bony Reduction</th>
<th>Soft-tissue Response (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>nasion and nasal spine</td>
<td>25</td>
</tr>
<tr>
<td>proximal and midnasal bridge</td>
<td>60</td>
</tr>
<tr>
<td>supratip</td>
<td>43</td>
</tr>
<tr>
<td>tip–lobule angle and infratip</td>
<td>40</td>
</tr>
</tbody>
</table>

Guyuron121 combines data on soft-tissue response with preoperative records of the soft-tissue outline to formulate a plan for precise nasal reduction.

Two factors influence the response rate: the thickness of the skin and soft tissues overlying the skeleton, and patient age, which modulates the degree of movement of the soft tissues in several zones. Unfortunately, in the clinical situation the soft-tissue response to skeletal reduction is not linear over the length of the nose; that is, a direct, regularly progressive soft-tissue response does not hold throughout. In fact, as the degree of skeletal reduction increases, the soft-tissue response decreases because of redundancy and “memory” of the soft-tissue envelope. Some studies122,123 even indicate that standard maneuvers in tip modification usually decrease tip projection.
Statistical analysis of these changes led Guyuron\textsuperscript{124,125} to the following conclusions:

- Reduction of the nasion gives the appearance of increased intercanthal distance and a longer nose.
- Reduction of the nasal bridge results in a wider nose on frontal view and a tip rotated upward on profile.
- Augmentation of the bridge makes the nose look narrower.
- Resection of the caudal septum, caudal borders of the medial crura, or cephalic portions of the LLC produces cephalad rotation of the tip, in decreasing order of effectiveness.
- Resection of the alar base not only narrows the nostrils but also moves the alar rims caudally and reduces tip projection when severe enough.
- Resection of the nasal spine increases upper lip length on profile and decreases tip projection by weakening support for the medial crura.

Pessa and colleagues\textsuperscript{126} used 3D CT scans of patients in two age groups to assess skeletal remodeling of the nasal profile after rhinoplasty. The authors report continued, differential growth of the craniofacial skeleton, with the piriform aperture changing the most. This ongoing posterior movement of the maxilla manifested as a retruded nasal profile with age.

Dorsal Augmentation and the Nasofrontal Angle

The higher the nasal dorsum, the smaller the nasal base looks. Constantian\textsuperscript{127} raises the nasal bridge to offset the appearance of an augmented base. This strategy limits the amount of nasal skeletal reduction necessary, decreases the potential for postoperative change and soft tissue distortion, and increases the surgeon’s control over the results.

Ortiz-Monasterio and Michena\textsuperscript{128} review techniques for nasal dorsal augmentation with autogenous cartilage and bone grafts. Their preferred graft material is nasal septum, sometimes stacked two and three layers thick. The longitudinal graft pieces are scored lengthwise on their external surface so they conform to the nasal bridge contour. When the septum is not available in sufficient quantities, the authors use composite cartilage-bone grafts from the rib molded to the appropriate shape.

Gunter and Rohrich\textsuperscript{129} describe U- and A-shaped modifications of septal cartilage grafts for nasal dorsal augmentation to raise the nasofrontal angle. The indications for and surgical technique of these tailored septal grafts are described in the article.

Dorsal surface irregularities can occur following alteration of the osseocartilaginous vault. McKinney, Loomis, and Wiedrich\textsuperscript{130} advocate use of a thin septal graft to reconstruct the nasal dorsum following osteotomy. The authors note that “nasal hump resection converts a smooth, fused nasal ‘cap’ into five separate components. This may unmask a twist in the septum, expose sharp irregular edges, evidence an openroof deformity, and/or develop a pinched middle third as a result of removal of the spreader effect of the hump.”\textsuperscript{130} Their septal graft is durable enough to camouflage contour irregularities yet thin enough not to raise the dorsum. If septum is not available, they opt for a double layer of temporalis fascia rather than synthetic material.

Endo and colleagues\textsuperscript{131} review 1200 cases of augmentation rhinoplasty with ear cartilage grafts, including replacement of silicone prostheses in 40%. Complications developed in 4%, the most common being graft malposition. The infection rate in their series was 0.5%. Crushed cartilage grafts have also been recommended following reduction of the dorsum.

More recently, Gryskiewicz et al\textsuperscript{132} proposed the use of Alloderm for the correction of dorsal contour irregularities and minimal dorsal augmentation. Alloderm was found to be stable (non-shifting), soft, and natural-looking. A 2+ year follow-up of 20 patients disclosed partial graft absorption in 45%; 3 patients required reoperation. The authors recommend slight overcorrection in the nasal dorsum, which exhibits the highest rate of resorption. A subsequent article\textsuperscript{133} looked at secondary rhinoplasty patients and confirmed 20–30% graft resorption over the dorsum and 10–15% resorption over the tip.

Jackson and Yavuzer\textsuperscript{134} note excellent outcomes with Alloderm for camouflage of dorsal nasal irregularities. Alloderm blocks adhesions between the osseocartilaginous vault and overlying skin and helps conceal scars. The authors found no significant absorption or recur-
rence of deformity in 15 patients followed for 6–24 months postoperatively.

Erol\textsuperscript{135} described an adjunctive procedure for dorsal camouflage or augmentation in primary and secondary rhinoplasty. The technique, called “Turkish delight”, involves diced cartilage wrapped in Surgicel and shaped as a tube. The roll is inserted in the nasal dorsum and molded to fit the desired contour after closure of incisions. He reports a 0.7% complication rate in 2365 rhinoplasties, with overcorrection and partial resorption in 0.5%.

Elahi, Jackson, and others\textsuperscript{136} used a modified Erol technique for augmentation rhinoplasty in 67 patients and report good retention of the graft material for up to 24 months.

Subsequent studies by other authors using Erol’s technique have yielded variable results. Daniel and Calvert\textsuperscript{137} examined the use of diced cartilage wrapped in Surgicel (group 1), wrapped in fascia (group 2), and with no wrapping (group 3). There was complete resorption of the cartilage in the Surgicel group and good survival of the cartilage grafts in the other two groups. The authors believe the Turkish delight technique may be useful in minor camouflaging but question its utility in significant dorsal augmentation.

Brenner et al\textsuperscript{138} studied the survival of four kinds of diced cartilage grafts implanted in dorsal skin pockets of rats: cartilage and Surgicel, cartilage and fascia, fascia alone, and Surgicel alone. The lowest cartilage viability was seen in the group wrapped with Surgicel, probably due to the inflammatory response elicited by Surgicel.

**Nasal Osteotomies**

*Outfracture* involves levering the nasal bones laterally through a medial osteotomy to complete the cephalad portion of the fracture of the nasal bones. The current trend in rhinoplasty is away from this maneuver, as it can produce a “rocker” deformity.

The indications for nasal bone *infracture* continue to be debated. Infracture is useful in accomplishing either of two goals: closure of an open roof following hump removal to narrow the apex or roof of the nose, and narrowing the base of the bony-cartilaginous pyramid. Depending on the thickness of the septum and the dorsal angle of the ULC–septal junction, a certain amount of the nasal dorsum may be removed without creating a space between the septum and nasal bones or septum and upper laterals—an open roof. Removal of a small dorsal hump deformity does not necessarily produce an open roof, and infracture of the nasal bones only narrows the base of the bony-cartilaginous pyramid, not its apex or roof.

Two questions should be asked before undertaking an osteotomy: (1) Is there an open roof giving a flat appearance to the nasal dorsum? And, (2) Is the base of the bony pyramid excessively wide on frontal view such that the aesthetic lines at the base of the pyramid do not parallel the aesthetic lines from superciliary ridge to nasal tip along the dorsum of the pyramid? Routine or unnecessary nasal bone infracture in the absence of a significant open roof or when the nasal bones are not divergent may produce a pinched appearance to the upper and middle third of the nose.

Osteotomies of the nasal bones are classified as follows:

- low-to-low lateral osteotomy with greenstick fracture of the cephalic portion of the nasal bones at their junction with the frontal bones\textsuperscript{85}
- low-to-low osteotomy along the frontal process of the maxilla and extending to connect the cephalic portion of the lateral osteotomy with the nasal dorsum at the radix\textsuperscript{85}
- low-to-high osteotomy beginning low at the frontal process of the maxilla caudally and curving upward to pass lateral to the dorsum at the radix\textsuperscript{86}
- high lateral osteotomy\textsuperscript{81} beginning along the base of the nasal bones at the frontal process of the maxilla caudally and curving toward the dorsum at the radix (Hilger\textsuperscript{139})
- medial osteotomies passing vertically between the septum and the nasal bones and extending cephalad to the nasal process of the frontal bone

Sheen\textsuperscript{86} lists advantages of the low-to-high osteotomy as follows: (a) the residual cephalic nasal bone bridge is narrow and can be fractured with minimal digital pressure; (b) bony continuity is maintained when the remaining cephalic segment is greensticked; and (c) outfracture, infracture, and disarticulation of the nasal bones are unnecessary.
In cases where the bony pyramid has an excessively wide base and bony apex but dorsal projection is normal, a lateral osteotomy is indicated, taking care to circumscibe the abnormally wide portion of the skeleton with the osteotomy. Laterally, periosteal elevation and soft-tissue undermining should be kept to a minimum to maintain soft-tissue attachments to the lateral portion of the nasal bones. These soft-tissue attachments keep the bones from collapsing into the piriform aperture when mobilized.\textsuperscript{36,38} Infracture alone will not succeed in narrowing the apex, however, so that a medial osteotomy and frequently a medial ostectomy are necessary to displace the osteotomized segment medially.

Rees\textsuperscript{85} and Sheen\textsuperscript{86} caution that an excessively high osteotomy laterally along the nasal bone can produce a visible ridge or stair-step deformity at the base of the bony pyramid. To avoid this problem the authors propose their technical modifications, which leave a narrow residual cephalic segment that is reportedly easier to greenstick without direct or medial osteotomy.

Wright\textsuperscript{140} in 1961 and later Daniel and Lessard\textsuperscript{13} evaluated the effects of various types of hump removal, osteotomy, and nasal dorsal dissection using cadavers. The authors conclude that

- saw cuts produce less comminution than chisel cuts (but this seems to be more of a disadvantage than an advantage)
- rasping is safest and simplest for hump reduction
- closure of an open roof necessitates medial movement of the bony vault that is greater at its caudal end
- the length of the hump, especially its cephalic extent, determines how medial movement will occur
- following excision of a hump that extends above the intercanthal line, medial fracture or osteotomy may be required
- in smaller humps that end below the intercanthal line, a transverse fracture is required
- the most satisfactory infracture method is that of Becker\textsuperscript{109} (lateral osteotomy with greenstick fracture at the cephalad portion of the bones); the small spur on the residual superior portion of the nasal bone at the nasofrontal junction can be rasped
- the bony triangle above the intercanthal line is virtually impregnable, and narrowing it requires rongeuring of the bony web
- medial osteotomy with outfracture of the superior attachment of the nasal bones is not desirable, for it produces an unintended angling of the open dorsum and curved fracture lines following a curved osteotomy. If the fracture line at its cephalad end does not reach the nasal dorsum, a bony bridge may persist to cause a rocker effect, levering outward after the nasal bones are moved inward
- with infracture of the nasal bones after lateral osteotomy without medial osteotomy, the bones do not spring back into their original position so long as the site of greenstick fracture is the thin upper portion of the nasal bones and not the upper heavier portion. Transverse fractures pass through the body of the nasal bones and not through the nasofrontal suture line
- potential problems of the low-to-low osteotomy with greenstick fracture are incomplete fracture or spicule formation in the cephalad portion. If this does not fracture readily, a 2mm osteotome may be inserted through a stab incision in the glabellar or canthal area to complete the fracture line
- should the low-to-low osteotomy leave a wide cephalic portion of nasal bone, direct transverse osteotomy with a small osteotome through a stab incision is more precise than medial osteotomy and outfracture or greenstick fracture

Rohrich and coworkers\textsuperscript{141} found the external perforated osteotomy technique produced consistent results in rhinoplasty with minimal postoperative complications. The osteotomies should be designed to cut through intermediate or transitional zones of bony thickness, such as along the lateral nasal wall. A comparative, endoscopic study in cadavers\textsuperscript{142} confirmed the superiority of external osteotomies in minimizing intranasal trauma: mucosal tears were seen in 11% of external perforated osteotomies versus 74% of internal continuous osteotomies.

Harshbarger and Sullivan\textsuperscript{144} studied the bony thickness and fracture patterns of the medial nasal osteotomy. They drilled 1mm holes along the left nasal bones in 17 cadavers and found bone thickness gradually increased from caudal to cephalic and from lateral to medial, leaving a natural cleavage plane. The right hemi-noses had medial osteotomies at 0° or 15° from the midline and
were combined with low-to-low lateral osteotomies followed by digital greenstick infracture. The 0° osteotomies produced contour irregularities and rocker-like deformities. The 15° medial osteotomy produced reliable, controlled infracture with adequate narrowing.

Gryskiewicz and Gryskiewicz\textsuperscript{145} studied 75 rhinoplasty patients who required nasal osteotomy and compared the perforating method of nasal osteotomy with a 2mm straight osteotome versus the continuous technique with a 4mm curved, guarded osteotome. Each patient received one technique on one side of the nose and the other technique on the opposite side. The osteotomies were performed through an internal transnasal or an external percutaneous approach. On evaluation at 3, 7, and 21 days, ecchymosis and edema were less on the side with perforating lateral osteotomies with the 2mm straight osteotome than on the side with the continuous osteotomy with the curved osteotome.

Gryskiewicz\textsuperscript{146} also found that scars resulting from external percutaneous osteotomies were imperceptible in 94% of patients, but on a few occasions a small visible scar may be apparent. He stresses the importance of thorough cleaning of the chisel between cases to avoid traumatic tattooing.

Castro and associates\textsuperscript{147} recommend a modified Joseph saw on a reciprocating handpiece for basal and superior nasal osteotomies. A fixator anchors the saw on a single axis that allows sawing without resistance and averts multiple bone cuts. Giampapa and DiBernardo\textsuperscript{148} prefer a dual-plane, curved reciprocating saw for low-to-high osteotomies, believing they can make precise lateral transverse osteotomies and avoid a medial osteotomy when using this instrument. Kim and Kim\textsuperscript{149} describe their technique for endoscopically-assisted osteotomies with a reciprocating saw through bilateral intraoral incisions in the gingival sulcus. Despite these advances in instrumentation, most rhinoplastic surgeons still prefer to use osteotomes in the nose.

THE TIP-LOBULE COMPLEX

The size, shape and position of the alar cartilages relative to the upper lateral cartilages, septum, and soft-tissue envelope determine the conformation of the tip-lobule complex. When the tip-defining points of the dome fall at or below the profile line of the nasal dorsum, analysis of the facial and nasal measurements is needed to determine the status of the tip. When tip projection is adequate, reduction of the dorsum satisfies the aesthetic requirements. When tip projection is inadequate, attempts to increase tip projection are appropriate.

The most difficult aspect of rhinoplasty is to surgically manipulate the tip-lobule complex so as to achieve predictable results. Primary deformities of the tip and supratip area are formidable problems initially, and secondary deformities resulting from inappropriate surgical manipulations are even more difficult to correct.\textsuperscript{11}

A carefully planned and executed operation preserves the normal anatomy of the nose as much as possible. Techniques for the correction of various tip deformities are detailed by Rees,\textsuperscript{85} Sheen,\textsuperscript{86} Janeke and Wright,\textsuperscript{101} Peck,\textsuperscript{111} Petroff and colleagues,\textsuperscript{122} and Rich et al.\textsuperscript{123} Janeke and Wright\textsuperscript{101} stress the importance of preserving tip support during rhinoplasty by safekeeping

- the dense connective tissue between the lateral crura and the sesamoid cartilages
- the junction of the medial crura with the caudal septum
- the aponeurosis between the upper and lower lateral cartilages
- the interdomal ligament formed by a congregation of dense connective tissue between the domes of the lower laterals

A minimum 5mm of intact lateral crural cartilage must be left in place at the caudal margin to support the weight of the soft tissues and maintain tip projection.\textsuperscript{150}

The most important elements of nasal tip projection are the medial crura, their attachments to the caudal septum, and the presence of additional cartilage grafts between the medial crura themselves or beneath the crural feet. Petroff and colleagues\textsuperscript{122} evaluated 51 patients who underwent primary rhinoplasty. Tip projection was measured preoperatively, intraoperatively, and 6 months postoperatively. Nasal tip projection increased an average 1.5mm following injection of local anesthetic solution. When either a cartilage-delivery or cartilage-splitting approach was used, most of the support mechanism of the nasal tip was weakened or totally disrupted. Lowering the cartilaginous dorsum and shortening the caudal septum also had a profound
effect on the postoperative position of the nasal tip. Regardless of the preoperative goal, actual nasal tip projection decreased postoperatively in most patients unless steps were taken to increase the length and strength of the medial crural segment. Of these, 70% had full transfixion with excision of various amounts of caudal septum. Disruption of the caudal septal attachments not only correlated with a higher incidence of decreased tip projection, but the quantitative loss was 2.8mm, compared with an overall average of 1.8mm. When the preoperative goal was to maintain nasal tip projection, the success rate was 28%. When the preoperative goal was to increase nasal tip projection, the overall success rate was 57%, but most had procedures that increased the strength of the medial crural segment. When the preoperative goal was to decrease tip projection, the success rate was 87%.

Rich and others reviewed 100 cases of non-augmenting rhinoplasty to measure the effect of lower lateral cartilage excision on nasal tip projection. Three technique variants were used: cephalic artery resection with and without vertical dome division +/- suture approximation of the medial crura (modified Goldman tip) when the cartilage was sectioned. Despite overall good to excellent results, the authors noted a measurable loss of tip projection in all but one patient.

Byrd and coworkers reported on a subset of patients who were retrospectively identified as being at high risk of losing tip projection, shape, and rotation during rhinoplasty. Their noses were characterized by a weak midvault, a plunging tip with polly beak, retracted alae, and weak lower lateral cartilages. These patients had been treated with a floating columellar strut, yet all but one (of 20) lost nasal tip projection. Armed with this information, a second group of 20 patients who had similar features were treated prospectively with septal extension grafts, and nasal tip projection was either maintained or increased in all but one. The authors recommend anterior septal extension grafts for controlling projection, shape, and rotation of the nasal tip during open rhinoplasty in these high-risk patients.

Hubbard reported similar techniques using direct fixation of the medial crura to the septum or septal extension grafts to secure the nasal tip, and noted minimal variance postoperatively.

Rohrich and Griffin present a classification of asymmetric deformities of the columella and nasal tip and their recommended methods of surgical correction (Fig 13).

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**Fig 13.** Algorithm for surgery of the asymmetric nasal tip. (Reprinted with permission from Rohrich R, Griffin JR: Correction of intrinsic nasal tip asymmetries in primary rhinoplasty. Plast Reconstr Surg 112(6):1699, 2003.)
These reports prompt the following questions: Does the loss of nasal tip projection during rhinoplasty account for the poor correlation between dorsal resection and overlying soft-tissue response? Can we create the appearance of tip projection after rhinoplasty by lowering the dorsum and rotating the tip (Rich) despite a measured reduction of true projection? Are we really achieving the desired nasal tip projection or are we modifying the dorsum simply to create the desired tip-dorsal profile line?

Suturing Techniques

Many of the supporting structures to the tip are interrupted during standard rhinoplasty and it is frequently necessary to increase tip definition at the time of the surgery.\[^{150}\] Kridel\[^{154}\] reports a tongue-in-groove technique in which the medial crura are advanced upward and back and the denuded caudal septum is placed into a surgically created space between them. This method corrects excessive columellar show and maintains correction after straightening a caudally deviated septum. It is also indicated for controlling nasal tip rotation and projection while preserving the integrity of the lobular cartilaginous complex. The technique may be combined with either the external or endonasal rhinoplasty approach.

Kridel and colleagues\[^{150}\] show the value of sutures in enhancing nasal tip rotation and projection and illustrate the correction of wide, bulbous, amorphous tips in 50 patients using a suture technique they call “lateral crural steal” (LCS) through an open rhinoplasty approach. The concept behind LCS is to increase the length of the medial crura at the expense of the lateral crura. The suture technique depends on a stable nasal base, which is created by securing the medial crura to each other, proceeding from the base of the columella to the nasal tip. If the medial crura are buckled or weak, a strut of septal cartilage is placed in the columella for additional strength. Plumping grafts are inserted to achieve the desired nasolabial angle. Once the middle crural complex is stabilized, the lateral crura are advanced medially and each is sutured first to its medial crus and then to its counterpart on the opposite side with a mattress suture across the tip complex (Fig 14). As the lateral crura are shortened, the tip is relocated superiorly and anteriorly. If tip rotation is not desired, the lateral crus can be freed from its lateral fibrous attachments and vestibular skin so that it can move independently.

Foda and Kridel\[^{155}\] evaluated the effect of two cartilage-modifying techniques on their effects on nasal tip projection and rotation. In the lateral crural steal technique, the lateral crura are advanced onto the medial crura, resulting in an increase in length of the medial crura and shorter lateral crura. In the lateral crural overlay (LCO) technique, the lateral crura are shortened by vertically transecting them and overlapping the cut edges. Computer imaging was performed on 30 patients seeking primary rhinoplasty mainly for nasal tip reposi-tioning. The external approach was used in all cases. LCS resulted in an increase in both nasal tip projection and rotation. LCO resulted in significantly greater tip rotation but decreased tip projection. The authors conclude that LCS is indicated when a moderate increase in nasal tip projection and rotation is desired, and LCO is reserved for patients with severe tip underrotation associated with overprojection.

Tardy and coworkers\[^{156}\] review long-term outcomes of transdomal suture techniques on the nasal tip. These techniques preserve the integrity of the nasal tip—eg, an intact caudal segment or complete strip of alar cartilage—while reorienting its elements. The transdomal...
suture is indicated in broad, trapezoidal nasal tips where the alar cartilages are typically firm and strong, with a broader than normal arch to the dome segment connecting the intermediate and lateral crura. The triad of anatomic findings—firm, broad, divergent alar cartilages; thin skin; and delicate alar sidewalls—should suggest the option of transdomal suture for nasal tip sculpturing.

Tebbetts\textsuperscript{157,158} places sutures to shape and stabilize the tip by controlling the multiple “force vectors” that influence the tip complex. He believes in maintaining the structural integrity of the alar rim strips; shaping and positioning the lateral and medial crura in a reversible, nondestructive manner; minimizing variables by decreasing the need for a visible graft to shape the tip complex; applying sutures judiciously and precisely; and following specific sequences for every maneuver.

Regalado-Briz\textsuperscript{159} studied 52 patients who underwent open rhinoplasty by a modification of Tebbetts’ suture technique. The cephalic portion of the lateral crus was preserved and lateral crural resection was limited to the most medial aspect. Suture shaping was used to stabilize and control tip morphology. Byrd’s\textsuperscript{160} discussion stresses the importance of controlling the projection and rotation of the domes so as to establish an aesthetic tip-dorsum relationship.

Daniel\textsuperscript{161,162} presents a two-part review of a simplified 3-stitch, open-tip suture technique for primary and secondary rhinoplasty. The technique consists of 1) a strut suture to affix the columellar strut between the crura, 2) bilateral dome-creation sutures to create tip definition, and 3) a dome equalization suture to narrow and align the domes.

Hugo\textsuperscript{163} uses a suture technique for replanting the medial crura in the hooked nose. The medial crura are detached from the septum and each other, the tip is elevated and rotated to increase projection, and the medial crura are reattached to the septum.

Behmand, Ghavami and Guyuron\textsuperscript{164} track the evolution of the major tip suture techniques. Guyuron and Behmand\textsuperscript{165} discuss the sequencing and multiplanar effects of several suture techniques for the tip.

Daniel\textsuperscript{166} analyzes the large-nostril-to-small-tip disproportion “deformity”. He argues against the traditional basal view and the “ideal” ratio of 2/3 to 1/3, proposing instead a lateral view analysis and a nostril–tip length ratio of 55:45 or 60:40. Daniel recommends a 3-suture tip technique with columellar strut graft and alar base resections to restore this relationship. In his discussion of this paper, Sheen\textsuperscript{167} prefers tip augmentation with cartilage grafts to achieve the same end.

**Scoring or Crushing Techniques**

McCollough and English\textsuperscript{168} discuss various modifications of the alar cartilages designed to increase tip projection, all of which involve weakening by scoring or crushing the portion of the lateral crus immediately lateral to the dome as well as the middle or intermediate crus immediately below the dome. A horizontal mattress suture is used to pull the tip-defining points centrally and to carry the alar cartilages medially, narrowing the lobule and increasing the vertical height of the tip-defining points. These maneuvers are most applicable when the tip-lobule complex is broad and the excess width can be aesthetically converted into vertical projection.

**Resection Techniques**

Goldman\textsuperscript{169} divides the lateral crus lateral to the dome to narrow the lobule and add projection to the tip. The method borrows from the lateral crus to augment the height of the medial crus (Fig 15).

**RESECTION LATERAL CRUS**

**MAY:**
1. Allow medial advancement of dome.
   a. Increases tip projection
   b. Centralizes dome projection points.
2. Cause pinched tip.
3. Cause collapse of nostril arch.

**MAY:**
1. Increase cephalad rotation of tip.
2. Weaken support of nostril arch.
3. Allow lateral advancement of lateral crus.
   a. When domal segment morselized or scored, eliminates wide or boxed tip.
   b. Decreases tip projection.

Fig 15. Effect on tip projection from resection of the lateral crura at two points.
In McLure’s\textsuperscript{170} modification, no vestibular skin is included with the segment of the lateral crus that is rolled medially and a septal cartilage strut is added between the medial crura for support. A small separation is maintained between the repositioned lateral crura to simulate a double nasal dome.

The effects on the nasal tip of resecting the alar cartilages in the dome, intermediate crus, and medial crus are illustrated in Figure 16. These are radical solutions to the problem of the drooping nasal tip, and in thin-skinned individuals they are apt to leave visible irregularities.

Kamer and Cohen\textsuperscript{171} excise a central horizontal strip of alar cartilage to elevate the tip, increase tip projection, and rotate the tip superiorly while preserving structural integrity of the arch. The defect created during the resection is closed by rotating the caudal segment of the lateral crus cephalad and affixing it to the still-stable cephalic margin. They recommend the technique for noses that have a wide dome and a drooping tip.

Massih\textsuperscript{172} describes elliptical horizontal excision and repair of the alar cartilage in open rhinoplasty to correct cartilaginous tip deformities. An elliptical excision is made in the central segment of the lower lateral cartilage and the upper and lower edges of the remaining cartilage are repaired with 5-0 nylon sutures. This technique appears identical to Kamer and Cohen’s.

Figure 17 illustrates the potential effects on the nasal tip of resecting the cephalic border of the alar cartilages and caudal septum.

Adamson and associates\textsuperscript{173} report on 116 consecutive patients who had open rhinoplasty and vertical dome division. Patients operated on early in the series had cartilage resection and suture reapproximation, while those operated later had dome division, overlap, and suturing technique. Vertical dome division is recommended for the correction of lobule asymmetry, retrodisplacement, wide domal arch, and a hanging infratip lobule. An important consideration in the cartilage-overlap technique is a reduction in nasal tip projection. If a loss of tip projection is not desired, tip grafts or other methods to enhance tip projection are needed.

\textbf{Grafts to the Tip}

Grafts to the lobule complex can improve tip projection when manipulation of the existing cartilage alone fails. A cartilage graft is inserted within a limited soft-tissue pocket under some degree of tension to produce angulation at the columella-lobule junction (Sheen), projection...
Sheen reviewed his 20-year experience with grafts to the nasal tip, which he feels are best suited for primary rhinoplasties. Sheen divides his experience into three parts, paralleling the evolution of nasal tip grafting to current standards. Over the years, sources of graft materials have included the septum, ear, rib, vomer, and ethmoid. Septal cartilage grafts have evolved from a single columella-lobule contour graft to multiple small septal cartilage fill grafts, sometimes crushed or bruised to avoid angularities and to improve definition. Ear cartilage is a distant second choice to septal cartilage because of its tendency to shatter when manipulated. Sheen reserves rib cartilage grafts for cases involving complex reconstruction of the entire nasal skeleton. (A 5-year review shows good take with rib grafts and no change in tip contour.) Because of progressive resorption of vomer and ethmoid bone grafts for the tip, Sheen now uses them only as buttresses to hold overlying septal cartilage grafts.

The most persistent complications of tip grafts in Sheen’s series were malposition and undesirable angularities. Tip grafts can shift their position and cause a number of problems. Grafts that are displaced laterally cause asymmetry; those that migrate upward cause tip blanching or overprojection; and if displaced downward they protrude from the columella. Oversized grafts can also compromise the vascular supply to the skin of the lobule. Sheen stresses the need for thorough prep and precise wound closure to keep infections to a minimum.

Cardenas-Camarena and Guerrero report an 8-year experience with cartilage grafts in nasal surgery, encompassing 83% from the nasal septum, 12% from the ear, 3% from the alar cartilages, and 2% from rib. Grafts were placed between the medial crura in 64%; as Sheen tip grafts in 28%; in the nasal dorsum in 19%; as spreader grafts in 8%; as Peck grafts in 8%; and in the rim in 3%. Reoperation was required in 8% to achieve the desired result.

Bateman and Jones reviewed the outcome of augmentation rhinoplasty using autologous cartilage grafts in 103 patients followed for an average 3 years. The revision rate over the follow-up period was 15.5%. The same surgeons’ revision rate in 311 rhinoplasties without grafts over the same period was 4%. The authors conclude that rhinoplasty with cartilage graft is associated with a significantly higher revision rate than when no graft is required.

Constantian notes that 77% of primary rhinoplasty patients and 80% of secondary rhinoplasty patients in his practice required grafting mainly to improve lobular contour, not tip projection. He describes the distant effects of dorsal grafts and tip grafts in rhinoplasty and outlines his techniques for achieving these effects. Grafts affect nasal length, symmetry, ethnicity, and dorsum–tip relations. Constantian subsequently elaborated an alternative cartilage-bearing tip graft technique in which small amounts of autologous donor material are used to augment only those lobular segments that require increased contour or support. The technique evolved in response to the high number of patients with inadequate donor cartilage for traditional shield type grafts and the observation that, by enlarging the lobule, tip grafts can create undesirable postoperative disproportions in some patients. The revision rate in 405 rhinoplasties (40% primary, 60% secondary) was 14%.

Peck uses rectangular onlay grafts of septal or auricular cartilage that are placed overlying the domes. A tight pocket helps keep the graft in position, but if necessary it can be stabilized with a pullout suture.
Much like Sheen’s tip grafts, Peck’s onlay grafts can displace, distort, or partially resorb, and it is difficult to judge intraoperatively the appropriate degree of projection desired, with the result that the tip is often over- or undercorrected.

Peck and colleagues describe an 18-year experience with the umbrella graft in rhinoplasty. The graft consists of a vertical cartilaginous strut between the medial crura and a horizontal onlay graft overlying the alar domes. The umbrella graft was used in 22% of 1252 mostly secondary rhinoplasties. The revision rate for the umbrella graft was 5%, and the most common complication was visible cartilage. In his discussion of this paper, Rohrich states that nasal tip support usually depends equally on the length and strength of the paired lower lateral cartilages, which in turn are supported by the suspensory ligaments connecting the domes and the fibers that connect them with the upper lateral cartilages.

Baker and Courtiss note that parchment-thin skin is a common problem associated with secondary rhinoplasty, and believe that an onlay graft of temporalis fascia is the most satisfactory method to cover the underlying osseocartilaginous framework or cartilage grafts in patients who exhibit this condition. The surgical results in 6 patients with temporalis fascia grafts are reviewed. A biopsy of the temporalis fascia and cartilage graft confirmed the long term viability of the fascia and its underlying cartilage.

Anderson prefers a strut of cartilage from the septum placed between the medial crura, from the level of the upper border of the nostrils downward almost to the premaxilla. Millard recommends anterior septum-columellar struts extending from the premaxillary area to the nasal tip. Dibbell describes the use of a Bowie-knife-shaped strut to increase tip angularity and projection, particularly in cleft lip noses. The potential disadvantages of strut grafts are a widened columella, a tent-pole effect with blanching at the nasal tip, leaning of the tent pole, and visibility of the graft through the skin.

Arden and Crumley review their clinical experience with and indications for combined placement of columellar struts, shield grafting, and caudal septal grafts. Patients most likely to require combination grafts are those with lobular hypoplasia or tip underprojection. The authors advocate a columellar strut sutured to the medial crura and septal midline when a transfixion incision is required. They find shield grafts particularly useful in highlighting tip architecture in the Asian, Hispanic, Mestizo, or African nose, as well as in revision rhinoplasties where tip scarring or existing alar cartilage structures prohibit natural skin redraping. For lengthening the nose, caudal septal grafts are used, but the limiting factor is the amount of available lining. Porter, Tardy, and Cheng advocate a contoured auricular projection graft for nasal tip projection in Asian and African noses.

Orak and colleagues report an extrasupported tip graft for the treatment of bulbous nasal tips. The technique involves an A-shaped tip graft supported with a columellar strut, both inserted into small separate pockets (Fig 18).
Gunter and Rohrich introduced alar spreader grafts for correction of the pinched nasal tip. The grafts are shaped like bars or flat triangles and are carved from autogenous septal or auricular cartilage. The spreader graft is inserted between and deep into the remaining lateral crus to force them apart, propping up the caved-in segment of the pinched tip.

De Carolis reports using an infradome graft to improve dome reshaping in rhinoplasty. The technique places under the domes two parallel strips prepared from the resected alar cartilages. The grafted cartilages block the plication suture, which averts excessive pinching of the domes and enhances stability.

McCollough and Fedok describe the technique of lateral crural turnover graft for correction of the concave lateral crus. Adham and Teimourian mobilize and advance the lateral crus toward the alar rim; the alar cartilages are reshaped and the domes are grafted with stacked disks of cartilage—individual dome-projecting grafts. Adham later modified the procedure by camouflaging the stacked disk grafts with LLC trimmings (from the cephalic edge) to avoid a boxy look.

Hamra prefers crushed cartilage grafts over the alar domes following reduction rhinoplasty via the open approach. The tip is reduced through dome division and suture reconstruction. Contour deformities are avoided by overgrafting the divided domal segments with a crushed onlay graft.

Guyuron, Poggi and Michelow introduced a subdomal graft for management of the pinched nasal tip. The graft is placed into a subdomal pocket extending from one dome to another (8–10mm long x 1.5mm wide x 1.5mm thick). The technique was successfully in 53 primary rhinoplasties and 8 secondary cases of pinched nasal deformity or asymmetric domes.

Hamra opts for dome excision, side-to-side cartilage repair, and crushed cartilage overlay graft to improve tip contour. This is a simple method to treat tip deformities and reduce tip projection when the angle of divergence is normal.

Bujia studied the viability of chondrocytes in crushed, uncrushed, and cut cartilage grafts. More cartilage cells (70–90%) are damaged by crushing than by cutting, which leaves most cells viable and able to proliferate.

Pereira and colleagues assessed the availability of block conchal cartilage for total reconstruction of the ala in a cadaver model. “From the lamina tragi, isthmus, and cavum conchae, en bloc resection is possible with characteristics of form and dimension similar to those of the homolateral alar cartilage” (Fig 19).

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**Fig 19.** The ear is incised and a segment is removed from the intermediate part of the lamina tragi, isthmus, and cavum conchae. The incised piece corresponds to the medial crus (A), the junction of the medial and lateral crura (B), and the lateral crus (C). (Reprinted with permission from Pereira MD, Marques AF, Ishida LC, et al: Total reconstruction of the alar cartilage en bloc using the ear cartilage: a study in cadavers. Plast Reconstr Surg 96:1045, 1995.)
Fanous and Webster\textsuperscript{198} recount their experience with Mersilene tip implants for the correction of tip deformities in 98 patients. Indications were recession, boxiness, asymmetry, thick or thin skin, upward or downward turn, and a bifid tip. Mersilene mesh is soft, pliable, and easily shaped, and can be invaded by surrounding connective tissue, which affixes the implant firmly in place and prevents displacement.\textsuperscript{199}

Despite this favorable report, readers should exercise caution when using alloplastic materials in the nasal tip.Aside from the potential for tissue ingrowth and scar, an alloplast rejection reaction would have catastrophic consequences in this critical area of the nose. Autogenous sources of tip grafts, such as nasal septum and ear cartilage, are undeniably superior in nasal reshaping.

**Broad or Boxy Tip**

A nasal tip that looks boxy or bulbous rather than triangular from the basal view is the product of either an increased angle of divergence of the medial crura or a wide arc in the dome segment of the lateral crura. Tasman and Helleig\textsuperscript{200} measured the distance between the domes and the skin thickness over the LLC before and after transdomal suture tip-plasty. The distance between the cartilaginous domes correlated with tip width before surgery. After surgery, the degree of tip refinement correlated with preoperative skin thickness but not with interdomal distance. These data are further evidence that tip definition surgery is limited by thick soft tissues.

Rohrich and Adams\textsuperscript{201} propose an algorithm for the management of nasal tips where the angle of divergence is $>30^\circ$ (type I); the domal arc (between the tip-defining points) is $>4\text{mm}$ (type II); or both conditions are present (type III) (Fig 20). Their technique involves limited domal and cephalic trimming followed by transdomal and/or interdomal suturing. The endpoint is reached when the distance between tip defining points is 5–6\text{mm}.

Gruber and Friedman\textsuperscript{202} discuss the rationale for their use of sutures in the correction of broad or bulbous tips: the transdomal suture (to narrow the individual domes); the interdomal suture (to bring symmetry, add tip strength, and sometimes to narrow the tip complex); the lateral crural mattress suture (to reduce lateral crural convexity); and the columella-septal suture (to prevent tip droop and adjust tip projection).

**Division Techniques**

Goldman\textsuperscript{169} narrowed the square tip by completely transecting the lateral crura and vestibular skin. A modification of this approach divides the lateral crura outside the dome area with or without division of vestibular skin.\textsuperscript{203} The medial crura can then be sutured near the dome or the lateral crura, rotated medially, and sutured to gain further projection anteriorly. McKinney and Stalnecker\textsuperscript{204} describe their modification of the Goldman technique for bulbous tips in thick-skinned individuals with both normal and overly projecting dome points.

Unless the skin of the nose is very thick, transection techniques produce a more triangular tip at the expense of a single dome point, the distinct possibility of pinching or kinking of the alar rim, and visible asymmetries.

**Scoring Techniques**

Unlike transection, scoring usually maintains the integrity of the cartilage and hence support of the tip, with less visibility of the cut cartilage edges. McCollough and English\textsuperscript{168} discuss an alternative to the Goldman technique that consists of scoring the cartilage medial and lateral to the dome and bringing the lateral crus medially with horizontal mattress sutures. This centralizes the dome segment while avoiding the break or step-off that typifies the Goldman tip. The technique is recommended for use in wide, bulbous, or underprojecting tips.

Peck\textsuperscript{111} achieves a triangular tip through wide mobilization of the lateral crura with resection of their distalmost segment and scoring of the dome area. Sheen\textsuperscript{86} narrows the broad or boxy tip by interdigitating partial scoring cuts in the dome and medial crura. Hamra\textsuperscript{205} modifies Sheen’s technique for repositioning the lateral crus by creating a subcutaneous pocket and suturing the medial crura together. The dissection is simpler, undermining is easier, and the procedure can be done through an open or closed approach. The technique is indicated for patients who have cephalically positioned lateral crura showing the “parentheses” deformity on frontal view. In these cases the tip is frequently flat and broad, the alar rim is notched, and the basilar view shows a square perimeter.
The Overprojecting Tip

Overprojection of the nasal tip—the “Pinocchio nose”—results from excessive length of the medial and lateral crura. Procedures designed to reduce the overprojecting tip involve full-thickness resection of either the medial\(^{206,207}\) or lateral\(^{8,6,111}\) crura or scoring of the dome–medial crura junction with or without resection of the lateral crura.\(^{8,6,111}\) Tardy and others\(^{208,169}\) analyzed the overprojecting tip and find that overdevelopment of the caudal quadrangular cartilage “tends to ‘tent’ the tip away from the face and may tether the upper lip, producing an indefinite nasolabial angle and, on occasion, creating abnormal exposure of the maxillary gingiva, particularly upon smiling.” Correction begins by lowering the cartilaginous profile, releasing the tip from this abnormal influence. Almost every case required weakening tip support and overall reduction of the overdeveloped components. Following complete transfixing incision, the tip immediately settled back.

Any procedure that transects the rim of the alar cartilage can alter the smooth arch of the nostril and produce sharp edges, a notch or step deformity. To minimize this potential complication, it is essential to precisely realign and suture the transected cartilage ends and to keep intact as much of the nasal lining as possible.
Neu\textsuperscript{209} addresses the Pinocchio tip by rolling the lateral crura medially and creating new, less prominent domes while preserving the natural bowing of the alar arch. If necessary, any extra length can be excised at the footplates, which causes caudal rotation of the tip.

Smith\textsuperscript{210} reduces the overprojecting tip through an open rhinoplasty technique that transects and raises a columellar flap which carries the crura of the alar cartilage within. Tip sculpting is limited to cephalic trimming of the lateral crura.

Gryskiewicz\textsuperscript{211} resects columellar skin to avert an iatrogenic hanging columella after reducing an overprojected tip. The optimal indication for this technique is when tip setback is >3mm.

**Surgery on the Columella, Nasal Spine, and Lip**

The columella–lip angle is critical to the aesthetic appearance of the nose. According to Aston and Guy,\textsuperscript{212} the desired septolabial angle is 90–95° in men and 100° in women. Lewis,\textsuperscript{213} on the other hand, proposes that the ideal uptilt of the columella should be 5–15° (or 95–105°) in men and 12–25° (102–115°) in women. He suggests that tall patients, patients with long faces, and those with receding foreheads or chins should have less of a “tilt-up,” while patients with straight foreheads or prominent chins should have even wider columella–lip angles. We disagree. In our opinion, tilting-up of the nasal tip creates a shorter nose that becomes further disproportionate with a prominent chin. Instead, nasal length should vary directly with chin vertical length.

The nasolabial angle is directly influenced by the configuration of the nasal spine and caudal septum. On smiling, the upper lip pulls back and the caudal border of the septum and nasal spine appear to protrude downward, sharpening the columella–lip angle. Aston and Guy\textsuperscript{212} review techniques for resection of the caudal border of the septum and the nasal spine. Figure 21 illustrates the effects of these maneuvers on the columella–lip angle.

Overresection of the caudal septum or nasal spine may produce an excessively obtuse septolabial angle (“pig nose”), an acute septolabial angle with a plunging tip (“witch’s nose”), a retracted columella, or a flat upper lip that seems excessively long (“ape lip”). Webster and associates\textsuperscript{214,215} discuss the anatomy of the columella and analyze the aesthetics of the nose with respect to surgical techniques for correcting deformities of the lip-columella junction, including tissue subtraction, tissue addition, and sliding procedures.

Cachay-Velasquez\textsuperscript{216} advocates a Rowen-Boyd resection of the depressor septi nasi muscles to correct the rhinogingivolabial syndrome: drooping nasal tip, short upper lip, and increased exposure of the maxillary gums, particularly when smiling. Resection is carried out through an extension of the transfixion incision and is
frequently accompanied by partial resection of the caudal septum and nasal spine. The postoperative results reflect the change induced in the columella–lip angle and between the tip and upper lip.

Rohrich et al\textsuperscript{217} studied the role of the depressor septi nasi muscle in rhinoplasty and describe three anatomic variations. An active depressor septi muscle can accentuate a drooping nasal tip by shortening the upper lip on animation. They recommend muscle release and transposition through a sublabial intraoral incision during rhinoplasty to improve the tip–upper lip relationship.

De Benito and Fernandez Sanza\textsuperscript{218} resect the columella and nasal depressor muscles to improve the nose–lip relationship and the smile. The resection eliminates the downward movement of the nasal tip with smiling.

Lawson and Reino\textsuperscript{219} describe reduction columella-plasty, which involves full-thickness excision of a diamond shaped piece of tissue from between the feet of the medial crura. The incision is carried down through the skin, depressor septi muscle, and adjacent soft tissue. When the defect is closed, the splayed medial crura are brought together, increasing the nasolabial angle, modifying the shape of the nares, and increasing projection of the nasal tip.

Pessa\textsuperscript{220} suggested selective resection of the levator alae (levator labii superioris alaqui nasi) muscle to correct the acute nasolabial angle and prominent nasolabial folds and to improve asymmetries in nasal base position. Cadaver studies illustrate the origins of the levator alae muscles at the frontal process of the maxilla and their insertions into the lateral alae and orbicularis oris muscles. The angular artery and vein lie medial and superficial to the muscle and serve as a reliable guide to its position. The infraorbital nerve is lateral to the levator alae muscle and lies beneath the levator labii superioris muscle, approximately 7mm below the orbital rim. The principal action of the levator alae muscle is to elevate the alar base, producing a sneer or snarl. As the alar base is elevated, the nasolabial angle becomes acute and the medial nasolabial fold becomes accentuated. The muscle is approached through a subciliary incision, a skin-muscle flap is elevated, the orbicularis oculi muscle is dissected inferiorly to free it from the orbital rim, and dissection proceeds medially to the groove between the maxilla and nasal bones where the levator alae muscle is located and identified. A 0.5–1cm-long segment of muscle is resected. Alternatively, muscle resection may be accomplished through a buccal sulcus incision.

Foda\textsuperscript{221} reviewed his results after a minimum of 1 year in 360 consecutive “droopy tip” rhinoplasties using three alar cartilage modification techniques. He found lateral crural steal to be most effective for underprojected tips; lateral crural overlay worked best in cases of overprojected tips; and the tongue-in-groove technique was best suited for tips with adequate projection.

Guyuron\textsuperscript{222} studied abnormalities of the footplate of the medial crura and how their surgical correction influences the outcome of rhinoplasty. In a prospective series of 20 consecutive primary rhinoplasties, the author found the distance between the medial footplates to be 7.5–15mm (avg 11.4mm). The length of the footplates was 4–7.5mm (avg 5.8mm). In a retrospective review of 295 consecutive rhinoplasties, footplates were altered in 76. In cases of overprojecting tip and divergent footplates, the lateral portion of the footplates was partially resected and then approximated. If the tip was underprojecting or had normal projection, the divergent footplates were approximated without resection. When the subnasale and the base of the columella protruded, the soft tissue between the footplates was removed. When the footplates diverged, the columellar base and nasal spines were retracted but the soft tissues left undisturbed so as to narrow the columella and advance it caudally.

Lengthening the Short Nose

The short nose is characterized by lower-than-normal distance from the nasofrontal angle to the tip-defining points and an overly wide nasolabial angle with increased nostril show\textsuperscript{223}. Gunter and Rohrich\textsuperscript{223} describe a technique that lowers the tip-defining points by detaching the lateral crura from their attachments to the ULC, suspensory ligament, and septum (Fig 22). This release effectively rotates the alar cartilages caudally, lowers the dome, decreases projection of the tip, and lengthens the distance between the nasofrontal angle and the tip-defining points. As tip projection decreases, the illusion of nasal length increases. The technique is best suited for patients who have a short nose with an overprojecting tip.
Fig 22. Technique for lengthening the nose by rotating the tip downward. (Reprinted with permission from Gunter JP, Rohrich RJ: Lengthening the aesthetically short nose. Plast Reconstr Surg 83:793, 1989.)

Lee et al224 lengthen the postoperative short nose with a combination gull-wing conchal composite graft and rib costochondral dorsal onlay graft as a replacement for the missing nasal lining and cartilage and to reinforce the framework, respectively. Wide degloving of the outer skin envelope is recommended to cover the entire nasal length without tension.

The problem with this method of reconstruction is the failure to differentially project the nasal tip above the plane of the reconstructed dorsum. The outcome of this technique is a somewhat underprojecting tip with “Polly beak” fullness. A more aesthetic result can be obtained by incorporating columellar support to raise the nasal tip above the plane of the dorsum.

Naficy and Baker225 illustrate five techniques for lengthening the short nose:

- the flying buttress graft—a single or paired spreader graft(s) secured to the columellar strut
- caudal septal grafts
- tip grafts of various shapes
- radix grafts to elevate the nasion
- interposition grafts between the upper and lower lateral cartilages

Ha and Byrd226 revisit their experience with septal extension grafts: extended spreader grafts, paired batten grafts (below the junction of the septum and ULC), and direct extension grafts (directly affixed to the anterior septal angle when cartilage supply is limited). Despite the grafts’ tremendous versatility in primary and secondary rhinoplasty, the authors caution against supratip/midvault widening or excessive lengthening from “over-extension.”

Guyuron227 lengthens the nose with a tongue-and-groove technique and three pieces of appropriately shaped septal cartilage. The technique combines bilateral spreader grafts beyond the septal angle with a columellar strut, and yet avoids rigidity of the tip. The author reports 20 of 23 patients enjoying good to excellent results over 12.5 years, but warns that the technique is labor-intensive and requires sufficient cartilage.

Juri228 recommends conchal cartilage grafts in the nasal tip in conjunction with wide undermining of skin and mucosa for the treatment of the iatrogenically retracted tip and short nose. The precise method of shaping the cartilage grafts is detailed in this paper.

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Hamra229 treated 15 patients with surgically shortened noses by means of infratip cartilage grafts. A two- or three-tier cartilage graft from septal or conchal donor site is sutured to the caudal edge of the medial crura. According to the author, the success of this operation is partly due to lack of skin elasticity among the older patients in this series.

To lengthen the nose, Gruber230 releases the septal mucoperichondrial lining and ULC from the LLC. A batten graft is attached to the septum, which in turn holds the tip cartilages in a more caudal position. The most common complication is inadequate lengthening.

Wolfe231 uses a nasofrontal osteotomy with mobilization of previous fractures for lengthening posttraumatic foreshortened noses. To lengthen congenitally short noses, Wolfe prefers a perinasal osteotomy. His experience with 9 cases is presented.

The Tension Nose

Excessive growth of the quadrilateral cartilage results in a high nasal dorsum with anterior and sometimes inferior displacement of the nasal tip cartilages—a tension nose.232 Johnson and Godin232 reviewed 50 con-
secutive primary rhinoplasty candidates and note 46% had some manifestation of tension deformity. They recommend an open approach to reduce the excessive elements of septal cartilage and anterior nasal spine. Cartilage grafts and sutures are then used to reproject the domes. Tardy offers a different perspective on the same anatomical deformity.

THE PHYSIOLOGIC AIRWAY

Howard and Rohrich summarize the nasal anatomy and physiology in nasal airway obstruction. Primary airflow is through the middle meatus (Fig 23). Resistance to airflow is structurally related to hypertrophic turbinates, valvular incompetence, septal deviation, or intranasal masses. Constricted points along the way increase the velocity of air flow and may generate negative pressures that collapse the internal and external nasal valves. The appropriate treatment of the obstructed nasal airway depends on its etiology. Medical management is often recommended for nonstructural rhinitis. Surgical treatment is required when the airway obstruction is due to turbinate disorders, a deviated septum, or incompetent internal or external nasal valves.

Fig 23. The primary inspiratory current is an arched pathway through the middle meatus. (Reprinted with permission from Howard BK, Rohrich RJ: Understanding the nasal airway: principles and practice. Plast Reconstr Surg 112(4):1071. 2002.)

THE TURBINATES

Jackson and Koch review controversies in the management of hypertrophic inferior turbinates, with emphasis on surgical treatment.

Ophir analyzed the results of total inferior turbinectomy in 38 patients after 1–7 years: 84% reported subjective relief of nasal obstruction and 92% had wide, clean nasal airways on rhinoscopy. Objective airflow measurements in 32 patients showed increased patency in all, including 3 patients who still complained of nasal obstruction. There was no atrophy of the nasal mucosa or chronic infection. The author recommends total inferior turbinectomy for patients with obstructing inferior turbinates.

Courtiss and Goldwyn looked for undesirable long-term sequelae in 25 patients who had resection of obstructing inferior nasal turbinates at least 10 years earlier. They found no incidence of dry nose syndrome and conclude that bilateral subtotal resection of the inferior turbinates is the treatment of choice for nasal obstruction due to hypertrophied turbinates.

Surgery on the inferior turbinates should be considered along with septal straightening when attempting to relieve nasal obstruction. Pollock and Rohrich report an experience in 408 patients with obstructed airways who were successfully treated with adjunctive inferior turbinate resection. Their favorite procedure is full-thickness excision of the anterior one-third to one-half of the inferior turbinate. Long-term follow-up revealed no evidence of atrophic rhinitis or untoward sequelae.

Rohrich and colleagues now prefer submucous resection (SMR) of hypertrophic inferior turbinates, which in their series was associated with fewer complications of bleeding, mucosal crusting or desiccation, or recurrent obstruction. The anterior one-third to one-half of the bony segment is resected with this technique. No atrophic rhinitis was reported.

THE NASAL VALVES

Constantian analyzed the functional effects of alar cartilage malposition. Rhinoplasty with resection of the cartilaginous dorsal roof or alar cartilages is the most common cause of acquired incompetence at the internal and external valves. The external nasal valve is presumed to be the mobile nasal ala at the introitus of the vestibule that is normally supported by the lateral crus; external valvular incompetence ensues from malposition of the alar cartilage. Graft support to the lateral
The wall of the nostril is recommended to minimize this complication.

Teichgraeber and Wainwright\textsuperscript{240} report on 27 patients with nasal obstruction who were treated over a 3-year period. Of these, 14 had involvement of the internal valve only; 2 had involvement of the external valve alone; and 11 had involvement of both valves. The cause of the obstruction was previous surgery in 13 patients, trauma in 8, and a congenitally narrow nose in 4. Surgery consisted of nasal valve repositioning and cartilage grafting through an open approach. The valves were reconstructed with spreader grafts, lateral crural spanning grafts, crural onlay and sidewall grafts, and columellar struts used singly or in combination (Fig 24). Treatment was successful in 24 of 27 patients. The authors suggest strategies to prevent nasal valve collapse during rhinoplasty.

Fig 24. Site and number of cartilage grafts used in reconstructing the nasal valve area. (Reprinted with permission from Teichgraeber JF, Wainwright DJ: The treatment of nasal valve obstruction. Plast Reconstr Surg 93:1174, 1994.)

Stucker and Hoasjoe\textsuperscript{241} review the treatment of 56 patients who had nasal valve obstruction. Follow-up ranged from 18 months to 13 years. Treatment consisted of open rhinoplasty with valve and sidewall stabilization with a dorsal conchal cartilage graft bridging the ULC and alar cartilage (Fig 25). Rhinomanometry in 24 patients showed objective improvement postoperatively.


Sheen\textsuperscript{242} notes that internal valvular incompetence is seen when the angle between the caudal edge of the ULC and the septum is <15°, such as following resection of the midvault roof. Sheen recommends the use of spreader grafts placed submucosally between the dorsum and ULC to widen the ULC–septal angle.

Schlosser and Park\textsuperscript{243} quantified changes in cross sectional area of the nasal valve after placement of spreader grafts and flaring sutures in 6 cadaver heads. The average minimal area increased by 5.4% with spreader grafts, by 9.1% with flaring sutures, and by 18.7% with combined spreader grafts and flaring sutures. On a scale of 1 (complete obstruction) to 10 (complete patency), the mean nasal patency scores improved from 3.4 to 6.5 with the combination of spreader grafts and flaring sutures. A follow-up article by Park\textsuperscript{244} emphasized the clinical application of flaring sutures to enhance the repair of dysfunctional nasal valves.

Guyuron and associates\textsuperscript{245} introduced the upper lateral splay graft to widen a narrow internal valve. The splay graft spans the dorsal septum but is deep to the left and right upper lateral cartilages. Excessive widening of the caudal portion of the dorsum is possible with imprudent use of the technique.
Al-Qattan and Robertson\textsuperscript{246} review acquired nostril stenosis with related airway obstruction secondary to a shortage of vestibular lining and discuss techniques designed to replace the vestibular lining and widen the introitus.

**THE NASAL SEPTUM**

Deformities of the nasal septum may produce internal nasal obstruction without external deformity; external deformity without airway obstruction; or internal airway obstruction and external deformity. The surgical correction of internal or external septal deformities must strike a balance between preserving dorsal support of the nose on the one hand and obliterating the visible or functional abnormality on the other. The correction of complex deformities often necessitates both submucous resection and some form of septoplasty.

Episodes of staphylococcal bacteremia resulting in metastatic infection have occurred in association with nasal septoplasty, suggesting the possible need for antimicrobial prophylaxis. Silk and others\textsuperscript{247} reviewed the records of 50 healthy patients who had blood cultures drawn before and during the procedure. Although 50\% had colonization of the nasal mucosa by *Staphylococcus aureus*, none of the blood cultures showed bacterial growth. The authors conclude that staphylococcal bacteremia during nasal septoplasty is a rare occurrence that does not warrant antimicrobial prophylaxis.

Yoder and Weimert\textsuperscript{248} analyzed the infection rate in 1040 patients who underwent septal surgery without prophylactic antibiotics. Minor nasal infections developed postoperatively in 5 patients (0.48\%), and all responded to oral antibiotic therapy. The authors conclude that the risk of infection after nasal surgery without antibiotic coverage is minimal.

**Submucous Resection (SMR)**

Submucous resection of an obstructive septal deformity was first described by Killian\textsuperscript{249} in 1905. Currently the basic principles of subperichondrial dissection and resection of the obstructing cartilage remain largely unchanged, but “the Killian submucous resection is seldom indicated. If done, it should preserve at least 1cm of the dorsal margin and 1cm of the caudal portion of the septal cartilage.”\textsuperscript{250}

Bernstein\textsuperscript{251} lists indications for SMR, including midseptal obstructive deformities. After conservative excision of the most severely obstructing portions of the septum by SMR, the remaining cartilage is usually realigned by septoplasty techniques.

**Septoplasty**

Edwards\textsuperscript{252} reviews the rationale for septoplasty. Simple midseptal deflections (which can be successfully managed by SMR) comprise only 25\% of cases, while caudal dislocations account for about 65\%. Complicated deformities make up the rest. According to Edwards, SMR results in inadequate correction of these more complicated deformities, three-fourths of which are best treated by septoplasty.

In 1950 Converse\textsuperscript{253} recommended vertical scoring of the residual dorsal strut of the septum to correct persistent deviations of the dorsum. Fry\textsuperscript{254} later described “interlocking stresses” in nasal septal cartilage that could be relaxed by scoring the cartilage. Numerous modifications of scoring techniques have since evolved, along with procedures combining resection and scoring.

Gruber and Lesavoy\textsuperscript{255} advocate closed septal osteotomy to realign the bony septum (perpendicular plate of the ethmoid, vomer, and vomerine ridge). An intranasal fracture is carried out with a long nasal speculum. All 32 patients in their series had fracture of the vomer and perpendicular plate of the ethmoid. The vomerine ridge (premaxilla area) was fractured in 69\%. This resulted in dramatic straightening of the bony septum in 82\% of patients.

**Combined SMR and Septoplasty**

Noting that a timid surgical attack of the deviated septum may result in persistent deformity, Johnson and Anderson\textsuperscript{256} recommend a more aggressive approach consisting of resection of an inferior strip of septum next to the nasal spine so that the septum can swing freely toward the midline. The authors advocate total or near-total transection of the dorsal strut to correct a deviation while preserving intact mucoperichondrium on the convex side. The septal strut is stabilized with transseptal mat-
tress sutures to prevent collapse after division. Medial and lateral osteotomies to reposition the nasal bones complete the procedure. Any residual deformities of the dorsum can be camouflaged with morcelized autogenous cartilage grafts.

Byrd et al\textsuperscript{257} proposed an algorithm for correction of the crooked nose through an open approach. Anatomic correction consists of total release of the cartilaginous septum from the LLC and ULC as well as cartilaginous and bony septal resection to free the dorsal and caudal septum. Scoring is avoided and the curvature is corrected by repositioning the septum and control sutures aided by batten and extended spreader grafts. The nasal tip is routinely secured with a combination of batten and spreader grafts to preserve tip projection. Osteotomies are modified to deal with specific deformities in the bony skeleton.

De la Fuente and Martin del Yerro\textsuperscript{258} prefer “bilateral mucoperichondrial–mucoperiosteal dissection of the septum from its caudal edge to the most posterior deviated part, because it provides easy septal resection in a good surgical field.” A dorsocaudal L strut is preserved when possible, but if involved in the deviation, it can be resected and reconstructed with dorsal and columellar grafts.

Cannistrá and coworkers\textsuperscript{259} advocate an endonasal technique with full release of the septum from the upper lateral cartilages.

Rees\textsuperscript{260} notes that when a high bony deviation is associated with marked distortion of the cartilaginous septum, the surgeon is hard-pressed to completely alleviate the septal deformity and simultaneously correct the external bony vault deflection without totally excising the septum. For severely deviated noses he recommends \textit{total removal of the entire bony and cartilaginous septum extramucosally} and replacement as a free graft. This is a risky procedure if the lateral osteotomy and infracture should turn out to be less than perfect.

More recently Gubisch\textsuperscript{261} described complete removal of the septum with subsequent replantation after correction of deformity in 1012 patients. All septal replants healed primarily. The complication rate was 2.2%. The main problem with the technique was difficulty in reconstructing the dorsum and stabilizing the replant.

Sheen\textsuperscript{86} notes that a midline septum may be totally irrelevant to the objectives of septal surgery—ie, patent airways and a nose that appears straight. Sheen opts for a conservative approach involving careful resection of portions of the obstructing septum, which are subsequently crushed and replaced as camouflage grafts to mask the deviations. Constantian\textsuperscript{262} resects the dorsum in the area of deviation until the dorsal edge is close enough to the midline to disguise the remaining asymmetry. The author suggests the following steps for surgical correction of the asymmetrical nose:

1. Determine preoperative nasal balance: Is the dorsum high or too low relative to nasal base size?
2. Resect the dorsum in the area of the external deviation until the dorsal septum edge is sufficiently close to the midline to allow camouflage of the remaining asymmetry.
3. Perform the septal resection necessary for the airway, preserving a continuous dorsal strut.
4. Augment according to (a) the support needed for the dorsum, middle vault, columella, and tip and (b) the aesthetic balance that must be restored.

Constantian

Jugo\textsuperscript{263} advocates total septal reconstruction through an external approach. He gains access to the septum between the alar cartilages along the nasal dorsum. Following removal of the entire septum, the straight cartilage from the center is used to reconstruct the ventral–caudal and ventral–cranial septum, while the deformed cartilage is straightened by crushing and replaced in the posterior septal space. Five girls and 19 boys aged 5 to 14 years were treated this way, and the author reports no alterations of growth necessitating reoperation.

Gunter and Rohrich\textsuperscript{264} review the management of the deviated nose and advocate simultaneous correction of the septum and bony pyramid when both structures are involved. The authors propose extensive alteration of the septum but a conservative approach to the external nasal framework. Total septal reconstruction entails mobilization of all deviated structures, including the ULC, and reconstruction of the deviated L strut along the dorsum if necessary. The mucoperichondrial attachments should be disturbed as little as possible to preserve dorsal support to the nose. Planned, precise osteotomies are used on the nasal bones.

Rohrich et al\textsuperscript{265} group nasal deviations into three basic types: caudal septal deviations, concave dorsal deformities, and S-shaped dorsal deformities with deviation of the bony pyramid. Management includes open exposure
of all deviated structures, release of all involved attachments, straightening the framework while maintaining a sturdy L-strut, restoring long-term support with buttressing septal batten or spreader grafts, turbinate reduction if necessary, and precise osteotomies (Fig 26).

Guyuron and Behmand\textsuperscript{266} discuss the diagnosis and management of caudal nasal deviation by independently assessing the components of the caudal nasal structures: septal deviations, asymmetric growth of the lower lateral cartilages, anterior nasal spine tilting, and medial crural footplate asymmetry. The authors recommend specific techniques to address each of these potential sources of deviation.

Boccieri and Pascali\textsuperscript{267} address the crooked nose with septoplasty, full thickness incisions, and a unilateral cartilage spreader graft referred to as a “crossbar graft” that splints the concave surface of the deviated septum. The surgeon must avoid degloving the contralateral surface or interrupting the anatomic continuity of the L-shaped septal strut.

Conservative approaches to septal deviation use onlay grafts to mask the deformity, but subsequent

resorption or displacement of the grafts may produce dorsal irregularities. In turn, radical procedures for septal straightening risk losing dorsal support to the nose, with subsequent collapse of the nasal bridge and saddle deformity. A thorough knowledge of nasal anatomy and physiology is the key to proper correction.

**Septal Perforations**

Teichgraeber and Russo describe the management of septal perforations in 25 patients, 22 of whom were treated surgically. The perforations ranged from 1.5–2.5 cm and were located on the posterior border of the quadrilateral cartilage near the vomer–ethmoid junction. Operative correction included external rhinoplasty with septal and intranasal mucosal flaps and an autograft of mastoid periosteum or temporalis fascia, and was successful in 19/22 (86%).

Kridel used acellular human dermal allograft in the repair of septal perforations in 12 patients; 11 had complete closure of the perforation. The repair was considered successful if on examination 3 months later the right and left mucoperichondrial flaps were entirely healed. The authors felt this technique yields satisfactory results similar to those obtained with temporalis fascia, mastoid periosteum, or pericranium.

Schultz-Coulon reports bilateral closure using bridge flap techniques in 54 patients, with an overall success rate of 93.7%. Closure was supplemented with autologous cartilage from residual septum, rib, or auricle. Morre et al report a similar technique with equally good results. A “cross-stealing” technique for closure of septal perforations is reported by Mladina and Heinzel. The surgery consists of turn-in flaps based on the margins of the septal perforation from either side of the septum.

Romo and colleagues propose a graduated approach to the repair of nasal septal perforations tailored to the size and location of the perforation:

- Perforations up to 2 cm diameter were closed in 93% of patients by an extended external rhinoplasty and bilateral posteriorly based mucosal flaps.
- Larger perforations (2–4.5 cm) were closed in 82% of patients by a two-stage technique and midfacial degloving to immediately advance posteriorly based, expanded mucosal flaps. A 1 x 3 cm tissue expander was first inserted in a submucoperiosteal pocket on the nasal floor.

Foda reports a one-stage repair of septal perforations up to 4 cm diameter which he used in 20 patients. The repair consisted of bilateral intranasal mucosal advancement flaps bridged by a connective tissue interposition graft through an external rhinoplasty approach. There was complete closure of the perforation in 90% and 80% had resolution of preoperative symptoms.

Guyuron and Michelow propose an algorithm for the management of intraoperative nasal septal tears and perforations based on an experience with 98 patients. Small, nonopposing perforations are allowed to heal spontaneously. Opposing tears ranging from 1–2 cm are repaired on one side by inserting a straight piece of septal cartilage and then repairing the mucoperichondrium on the other side.

**THE ALAR RIM**

The alar rim is a common site of patient dissatisfaction, either because of preoperative deformity or postoperative complication. Gunter, Rohrich, and Friedman describe the ideal alar–columellar relationship and classify discrepancies in these proportions. In aesthetically pleasing noses the highest point of the alar rim is located midway between the transverse levels of the columella–lobule angle and the tip-defining points. On lateral view the nostril is oval; the alar rim forms the superior nostril border and the roll of the columella forms the inferior border (Fig 27). Abnormal variants can have a hanging or retracted columella, a hanging or retracted ala, or a combination of these.

In profile the nostril rim should be cephalad and parallel to the columella. When this balance is disturbed, or if raising the columella will shorten the nose excessively, the alar rim(s) may have to be raised too. Matarasso, Greer, and Longaker diagnose a hanging columella when the septal mucosa is visible on profile, with or without a retracted caudal alar rim and regardless of the nasolabial angle. When unusually wide medial crural cartilages contribute to the deformity—as was the case in 15% of their series—balance can be restored by excising a C-shaped crescent of cartilage from the cranial border of the medial crura through a direct approach.
McKinney and Stalnecker discuss three techniques for achieving a proper columella-alar relationship: (1) excising the skin of the nose; (2) trimming the lateral crura along the cephalic or caudal border; and (3) resecting nasal lining. Decisions relating to these choices are discussed in the article.

Ellenbogen and Blome advocate raising the high point of the alar rim by 3–5mm from the caudal margin of the columella. Indications for raising the alar rim are a cleft nose with anterior webbing, asymmetric nostrils, and a hanging sigmoid ala. In the event of a hanging columella, the alar rim may have to be lowered to correct the high-arched nostril. Ellenbogen reintroduced the concept of lowering the alar rim by incising the alar margin along its free length and unfurling vestibular mucosa caudally. A graft of septal or auricular cartilage is placed between the two layers of mucosa at the proposed new alar height and held in place with through-and-through sutures.

Gunter and Friedman describe the lateral crural strut graft for use in patients with alar rim retraction, alar malposition, alar collapse, concave lateral crura, and/or boxy tip. This versatile cartilage graft is typically placed in anatomic position between the lateral crura and the vestibular lining (Fig 28). The authors describe their technique and provide illustrative examples of these clinical indications.

Rohrich, Raniere, and Ha review alar rim deformities and the surgical options for their correction (Table 1). The authors advocate the use of alar contour grafts or nonanatomic alar rim grafts (septal cartilage) for patients with mild to moderate congenital alar retraction; primary rhinoplasty patients with a propensity for alar notching; secondary rhinoplasty patients with minimal or no vestibular lining loss; and patients with malposition of the lower lateral cartilages. Details of the surgical technique are presented (Fig 29).

Guyuron discusses his approach to various alar rim abnormalities such as convexity, concavity, retraction, and hanging ala. He utilizes lateral crural spanning sutures, posterior transection of the lateral crura, or transdomal sutures to correct convexity. Concavities are corrected with lateral crural strut or alar rim grafts. Mild alar retraction is also corrected with alar rim grafts. Guyuron proposes an internal V-Y advancement flap for severe retraction and gives technical details in the
For hanging alar deformity, the author prefers vestibular lining excisions. Other authors suggest different methods for correction of alar retraction. Tardy and Toriumi propose composite grafting of the alar rim. Constantian also advocates liberal use of composite auricular cartilage grafting for alar rim deformities in secondary and tertiary rhinoplasty patients based on his experience in 100 consecutive patients. In the same paper Constantian describes an “axially oriented” auricular cartilage graft spanning the alar base and sill for the correction of vestibular stenosis with alar collapse. Gruber describes the use of an intercrural batten graft that extends from the caudal edge of the ULC to the cephalic margin of the LLC to push the lateral crus and alar rim caudally. Tardy and colleagues describe a technique for alar reduction and sculpture that is based on a detailed analysis of the anatomy of the alae and nostril floor. Alar modifications are indicated when there is flaring, bulbosity, or excessive width of the nasal base or when tip reposition at surgery produces excessive alar flare. Of importance is the site and angle of insertion of the alae into the face. A cephalic location of the alar–facial junction may create a high arched appearance to the alae, exposing an excessive amount of columella. In extreme cases this variant produces a snarl-like appearance. Caudal insertions of the alae into the face create the appearance of a disproportionately large and bulbous lobule and sometimes alar hooding. The authors give indications for internal nasal floor reduction, alar wedge excision, alar flap, and sliding alar flap.

Table 1

<table>
<thead>
<tr>
<th>Technique</th>
<th>Degree of Alar Retraction Corrected</th>
<th>Graft Location</th>
<th>Efficacy for Lining Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alar contour graft</td>
<td>≤2mm</td>
<td>Alar rim</td>
<td>+</td>
</tr>
<tr>
<td>Alar contour graft</td>
<td>&gt;2mm</td>
<td>Between the lower lateral cartilage domes</td>
<td>+</td>
</tr>
<tr>
<td>Alar contour graft</td>
<td>≤4mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral crural strut graft</td>
<td>&lt;4mm</td>
<td>Beneath the lower lateral cartilage medially</td>
<td>++</td>
</tr>
<tr>
<td>Composite graft</td>
<td>&gt;4mm</td>
<td>Variable (alar rim area)</td>
<td>+++</td>
</tr>
</tbody>
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Fig. 29. Gunter graphics demonstrating the operative procedure. (Reprinted with permission from Rohrich RJ, Raniere J, Ha RY: The alar contour graft: correction and prevention of alar rim deformities in rhinoplasty. Plast Reconstr Surg 109(7):2495, 2002.)

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Millard discusses alar margin sculpturing techniques through external incisions. Planas and Planas review the use of external excisions for correcting variations in the shape of the nostrils in rhinoplasty. Matarasso approaches alar rim excision through an “internal technique” to core out excess alar tissue through an alar base incision. Subsequently the author
limited the indications for this approach to deformities of the lower third of the rim.

SECONDARY RHINOPLASTY

The incidence of postsurgical nasal deformities requiring secondary correction varies from 5% (the best that experienced surgeons achieve, according to Rees) to 12% (Smith, reporting on 221 patients). Rogers offers a comprehensive discussion of postrhinoplasty deformities and the procedures for their correction. The reader is also referred to Webster’s review of techniques, Peck’s retrospective, and Sheen’s chapter on secondary rhinoplasty. Sheen believes that the key to an effective secondary rhinoplasty is accurate diagnosis of the deformity and lists five “ground rules” for the management of postsurgical nasal anomalies, as follows:

- defer surgery until there is final resolution of tissue edema (at least 1 year)
- have a well-defined aesthetic concept
- make a proper diagnosis
- limit the dissection
- use only autogenous material

In general, surgical correction of secondary deformities must be more conservative than the primary operation. The surgeon should resist the temptation to repeat errors of overreduction. In Millard’s words, “once the nose goes wrong, too often an irreversible chain reaction is set in motion, as the surgeon frantically excises again and again.”

Sheen discusses the secondary correction of supratip fullness, total disharmony of all nasal parts, a dorsum that is too low after grafting, a snub nasal tip from overresection of the dorsum and underresection of the caudal septum, and residual high septal deviation. Sheen’s technique for grafting the nasal tip is also helpful in secondary rhinoplasty. When the middle vault has been narrowed excessively and the caudal borders of the nasal bones are visible through the skin, Sheen recommends spreader grafts to reestablish an open angle between the ULC and the dorsal septum. The author correlates reconstruction of the middle nasal vault with improvement in nasal physiology and enhanced airway capacity.

Peck discusses some common deformities in secondary rhinoplasty, as follows:

- lack of tip projection from lack of alar cartilage–dome projection
- lack of tip projection from lack of septal support of the nasal tip–pyramid complex
- saddle deformity
- supra-tip deformity
- alar deformities
- deformities of the upper lateral cartilages and nasal bones
- deformities of the columella and short nose
- deformities of the nasolabial angle
- a thick, rigid tip
- persistent Pinocchio tip

Peck uses a conchal cartilage tip graft when there is lack of tip projection from inadequate dome projection and a conchal cartilage intercrural graft when the lack of tip projection is due to insufficient dorsal support. Peck’s choices for reconstructing the septum in saddle nose deformity are first, a layered septal cartilage graft, and, second, a bone graft harvested from the ilium, rib, or calvarium.

In Peck’s experience the supratip deformity is most commonly caused by a high supratip septal cartilage, and for correction he recommends lowering the dorsum as a unit to include the septum and the left and right ULC. The second most common cause of supratip deformity is inadequate removal of the fibrofatty tissues. The third most common cause is inadequate sculpting of the alar cartilages. A supratip deformity can also result from overzealous lowering of the nasal pyramid in the presence of thick, rigid skin, in which case a columellar strut or dome–tip graft may be indicated.

Guyuron and associates noted supratip fullness in 9% of primary rhinoplasty patients and in 36% of secondary rhinoplasty patients. In primary rhinoplasty the deformity was due to inadequate tip projection (pseudodeformity), an overprojecting caudal dorsum, a combination of both, or cephalically oriented LLC. In secondary rhinoplasty the deformity was caused by underresection or overresection of the caudal dorsum, overresected midvault, underprojected tip (pseudo-
deformity), or any combination of these. The authors conclude that it may be possible to prevent supratip deformity by properly resecting the caudal dorsum, avoiding dead space, restoring adequate projection to the nasal tip, and approximating the supratip subcutaneous tissues to the underlying cartilage with a supratip suture.

Alar notch deformities are most often secondary to resection of vestibular lining or transection of the alar cartilages. Deformities of the upper lateral cartilages and bone are generally corrected by onlay grafts of septum or conchal cartilage.296

According to Peck,297 the most common cause of a crowded lip is a septum that is too long and has literally grown onto the upper lip. Resection of the caudal end of the septum is usually all that is needed for correction.

The recessed nasolabial angle is corrected by insertion of a septal or conchal cartilage graft to build up the base and open the angle. A tight frenulum can be corrected by V-Y advancement of the frenulum.297

The thick, rigid tip is generally associated with sebaceous skin that will not drape over the skeletal framework. In these instances Peck297 recommends augmentation of the tip. He corrects the persistent Pinocchio tip by amputation of the cartilages and reconstruction with onlay graft from the concha.

Parkes and others300 analyzed their experience with 1221 consecutive rhinoplasties, of which 170 (13.9%) were revision procedures. Most secondary problems occurred in the lower third of the nose: Polly beak (33%), bossa (26%), and excessive dorsal resection (24%).

On the basis of his experience with 56 cases of secondary deformity following primary open rhinoplasty, Daniel301 recommends a closed technique when augmentation is the solution and an open approach when structural correction is required. The risks of skin necrosis and poor scarring are similar with either technique. The stigmata of open primary rhinoplasty include 1) a depressed and visible scar; 2) destruction of the soft-tissue facets in the nostril apices; 3) columellar deformities with associated nostril asymmetry; and 4) excessive tip or supratip defatting. These can and should be avoided, and Daniel offers suggestions for eliminating them.

Neu302 describes a “segmental” approach to secondary rhinoplasty for mild to complete loss of alar cartilages and a treatment algorithm based on the severity of the deformity. His technique of cartilage grafting in these difficult patients is detailed and illustrated in the article.

SADDLE NOSE DEFORMITY

Stuzin and Kawamoto303 use cranial bone grafts to correct the postrhinoplasty saddle nose deformity. The subperiosteal pocket extends well into the piriform aperture and along the lateral nasal walls and nasal floor. Mucosal advancement is sometimes indicated. In addition, patients with nasal foreshortening often require a strong cantilever bone graft to augment the dorsum, lengthen the nose, increase tip projection, and support the columella.

Erol304 elevates the nasal dorsum with a pliable graft of diced cartilage wrapped in Surgicel. Although the graft seems more suitable for fill than for structural support, the author reports good results in 2365 patients over 10 years.

In the event of end-stage deficiency of the nasal skeleton, Posnick and colleagues305 recommend full-thickness cranial bone grafts and rigid internal fixation through a coronal incision. The dorsal graft often must extend down to the tip for a well-chiseled contour and good tip definition. The authors warn against grafts that are too wide and that excessively broaden the nasal dorsum, and urge care in sculpting the nasofrontal junction.

Powell and Riley306 analyzed the 4-year results of 850 calvarial bone grafts to the nose in 170 patients. Most graft sites showed partial resorption ranging from insignificant to 30%. Areas of maximum resorption and contour change were at the nasal dorsum and lateral posterior mandible. Excellent contour was achieved and maintained in all but a few cases. Although the authors endorse the use of calvarial bone grafts in facial skeletal reconstruction and in the nasal dorsum, their study shows the nose to be a site of potentially greater bone resorption than other areas of the face.

Jackson307 reviews the long-term outcome of 363 cranial bone grafts used in nasal reconstruction. Split-thickness grafts were used in 85% and full-thickness grafts in the remainder. Jackson reports satisfactory results in the vast majority of cases. Hodgkinson308 argues that bone grafts should not extend to the nasal tip but stop at the septal angle; augmentation of the nasal tip...
should be accomplished with cartilage grafts from other sites. We agree with this view, as differential support of the tip produces aesthetic projection of the tip above the dorsal plane.

Kridel and Konior \(^{30}\) reviewed the fate of 306 irradiated costal cartilage homografts to the nose of which 122 were used on the nasal dorsum, 40 for primary rhinoplasty (PR) and 82 for revision (SR). Complications included infection around the graft in 3–4%, graft resorption in 3–4%, graft mobility in 4%, and cartilage warping in 2.7%. The overall complication rate was approximately 10%. Four patients in the PR group eventually needed revisional nasal surgery for additional augmentation. To date, this is the largest published series of irradiated costal cartilage homografts specifically used for nasal reconstruction.

Daniel \(^{31}\) describes the use of an osseocartilaginous autologous rib graft for dorsal contour in combination with a rigid cartilaginous strut to support the tip and reinforce the columella. The methods of harvest and reconstruction are well illustrated. In a discussion of Daniel’s article, Byrd \(^{311}\) describes his technique for carving portions of the 10th and 11th ribs as nasal grafts (Fig 30).

![Fig 30. Technique for harvesting a portion of the 10th and 11th ribs to serve as columellar and dorsal grafts in rhinoplasty. (Reprinted with permission from Byrd HS: Discussion of "Rhinoplasty and rib grafts: evolving a flexible operative technique" by RK Daniel. Plast Reconstr Surg 94:610, 1994.)](image)

Waldman \(^{312}\) reports his experience with Gore-Tex for augmentation of the nasal dorsum in 17 patients when autogenous sources were not available. The Gore-Tex grafts were inserted during open rhinoplasty, and all patients received some type of columellar support. On follow-ups of 12–36 months, Waldman notes no operative or postoperative complications. One implant was removed 5 months after insertion because of excessive augmentation.

Godin, Waldman, and Johnson \(^{313}\) analyzed the postoperative course of 137 patients—69 primary rhinoplasties, 68 revisions—who had augmentation with Gore-Tex patches. Follow-up was 6–80 months (avg 25mo). They state: “Three (2.2%) of 137 grafts became infected and were removed. One graft was removed 5 months postoperatively because of excessive augmentation. None of the patients who underwent implant removal required subsequent augmentation. All 137 patients [were] pleased with their results.” Several technical points were felt to be important to the success of the procedure, as follows:

- For dorsal grafts, boat-shaped implants are preferable.
- All implant edges must be carefully beveled and the graft cut to the width of the nasal bones at the nasion, gradually widened toward the rhinion, and tapered to a sharp point at its caudal end.
- The dissected pocket should easily accept the graft without rolling or bunching.
- The graft should run the entire length of the dorsum to avoid steps or notches in profile.
- The graft is soaked in saline containing a broad spectrum antibiotic and secured with 5-0 polypropylene suture.
- Overcorrection is not necessary, as resorption of Gore-Tex implants has never been observed.

An update of Godin’s series of nasal dorsal augmentation with Gore-Tex comprised 309 consecutive patients, 52% primary rhinoplasty (PR) and 48% secondary rhinoplasty (SR) cases. \(^{314}\) In follow-up of 5mo to 10y, the graft infection rate was 3.2% overall: 1.2% PR, 5.4% SR. The grafts became infected in 3 patients with perforated nasal septums and had to be removed. The authors consider septal perforation a contraindication to Gore-Tex implantation.

Owsley and Taylor \(^{315}\) reviewed their use of Gore-Tex for nasal augmentation in 106 patients (87 on the dorsum), and state that “postoperative follow-up has
revealed a stable implant material with no complications relating to the graft material.” In his discussion of this paper, however, Daniel316 cautions against the use of Gore-Tex for soft-tissue augmentation on the basis that it is not approved by the FDA for this purpose and the manufacturer itself does not recommend it.

Straith317 reviewed the long-term (average 15y) outcome of Silastic implants for the correction of saddle-nose deformity in 5 patients. A careful dissection, watertight closure, antibiotic irrigation, and implant design that avoids pressure on thin vestibular membranes are credited for the good results.

The forgotten element in successful correction of post-traumatic saddle nose is nasal lining. For an in-depth discussion of this topic, the reader is referred to SRPS volume 10, number 12.318

ADJUNCTIVE PROCEDURES

Resection of the Alar Base
Sheen86 classifies alar bases according to relative proportions of vestibular and external skin. Weir319 in 1892 corrected excessively flaring or wide nostrils by resecting the alar bases. Sheen86 later modified Weir’s technique by retaining a medial flap on the wedge excision. This refinement provides for a more natural, continuous nostril sill and reduces the alar notching produced by the scar of the Weir procedure.

Paranasal Augmentation
Guerrerosantos320 reviewed augmentation of the paranasal and anterior maxillary area with autogenous fascia and cartilage. Graft designs and positions were detailed. The procedure is recommended as an adjunct to orthognathic surgery as well as in primary and secondary rhinoplasties.

Mentoplasty
In 1965 Millard183 discussed adjunctive procedures in corrective rhinoplasty, including wedge excision of the alar bases and resection of the alar margins to narrow the width of the nose and correct alar flare; insertion of a columellar strut graft of septal cartilage to elevate the tip; and introduction of a chin implant through an intraoral approach. According to Millard, augmentation mentoplasty is indicated in approximately 15% of rhinoplasty patients.

Rish321 proposed a simple and effective method for determining who would benefit from chin augmentation. Using photographs of the patient in profile with the Frankfort line parallel to the floor, a vertical line is dropped perpendicular to the Frankfort horizontal and through the lower lip. If the chin does not reach this line, the patient is probably a candidate for augmentation mentoplasty.

Davis322 classified chin deformities as macrognathic, retrognathic, and microgenetic. Microgenia and occasionally retrognathia are the only conditions in which chin augmentation is appropriate. He uses primarily Silastic chin implants and stresses proper placement over the pogonion, as low as possible over the point of the chin, where the bone is dense and less likely to resorb than if the implant is placed higher on the mandible. If augmentation >8mm is required, a simple chin implant is unlikely to give satisfactory results, in which case a mandibular osteotomy or sliding genioplasty is indicated.

Two studies323,324 document resorption of the mandibular cortical surface after placement of solid chin implants. Although essentially a radiographic finding and usually self limiting, this cortical resorption nevertheless has prompted the development of softer prostheses.

Simons325 reviews the history of mentoplasty, describes an extraoral surgical approach, and discusses other adjuncts to rhinoplasty including chin reduction, orthodontia, makeup, and hair styling.

COMPLICATIONS
In 1964 Klabunde and Falces326 surveyed 300 unselected cases of cosmetic rhinoplasty and noted an overall complication rate of 18.3%, although 95% of patients were satisfied with the results. Intraoperative or early postoperative complications in their series included the following:

• operative hemorrhage
• septal perforation
• anesthesia-related problems
• postoperative hemorrhage
• postoperative infection

Late complications consisted of the following:
• persistence of edema or ecchymosis
• excessive scar
• vestibular webbing
• hypesthesia

A later retrospective study of 200 rhinoplasties by McKinney and Cook disclosed considerably lower incidence of infection, hemorrhage, and secondary revisions in the intervening 17 years. The overall complication rate was approximately 6% (4% if chin complications were excluded), and 12% of patients required revisions. Despite the improved surgical outcome, patient satisfaction declined to 90%. Dissatisfied patients were more likely to be female, in their 40s, and not physician referrals.

Teichgraeber, Riley, and Parks reviewed 259 consecutive rhinoplasties and noted a 5% incidence of serious complications, defined as hemorrhage (5), perforation (4), infection (3), and pneumocephalus (1). All these patients had concomitant septal or turbinate surgery.

Padovan and Jugo reviewed the complications of external rhinoplasty in their practice over a 14-year period. Intraoperative complications included excessive bleeding (>250mL) in 1.3%, and cuts on the caudal border of the LLC and tears of the columellar skin, which occurred rarely but were annoying. The most common early postoperative complication was transient epiphora occurring in 12.7%. Transient anosmia occurred in 4.6% and prolonged edema in 3%. The most common late postoperative complication was failure to achieve the desired aesthetic or functional goal in 5% of patients. Approximately half of these requested secondary correction. The authors recommend the following measures to avoid complications in open rhinoplasty:
• meticulous surgical technique
• proper set of instruments
• hypotensive anesthesia
• careful screening for coagulation disorders
• no surgery during the menstrual period or during times of aspirin intake

• careful patient selection and increased caution in hypertensive patients
• routine use of broad-spectrum antibiotics and steroids
• careful placement of nasal packs only in the anterior half of the nasal cavity
• no narrow, straight osteotomes

Corticosteroids

Hoffman and associates note certain advantages to the use of steroids during rhinoplasty. In a randomized, double-blind study of 29 patients, they documented less postoperative edema of the eyelids and nose and fewer ecchymoses when steroids were administered. Patients who received steroids also had less discomfort postoperatively.

In a randomized, double blind prospective study of 20 male patients, all of whom had osteotomies as part of their rhinoplasty, Berinstein and coworkers measured the effect of a single preoperative dose of 10mg dexamethasone on postoperative edema. Contrary to expectations, these patients showed more edema than those who did not receive the corticosteroid.

Shafir et al report the case of a 37-year-old woman who underwent rhinoplasty, including septal correction, with injection of small amounts of long-acting Depo-Medrol to either side of the nasal bridge. Within seconds of the last injection, the patient lost vision in the ipsilateral eye and had no pupillary reflex. A diagnosis of central retinal embolus and choroidal occlusion was made and routine treatment for vascular occlusion of the bulb was immediately given. Despite these measures, the patient remained blind in that eye.

In a review of the literature in 1981, Mabry found 10 cases of blindness following steroid injections, but in 1994 reported zero visual complications in his own series of 13,000+ intranasal steroid injections. The pathomechanism is believed to be microemboli occluding one or more of the retinal or choroidal vessels.

Nasal Packing, Stents, Splints, and Dressings

Guyuron assessed the role of nasal packing in septorhinoplasty and concluded that patients who had packing were less likely to develop recurrent septal deviation and synechiae and more likely to have an
improved nasal airway postoperatively. Significant improvement in airflow was documented in 96% of patients who had nasal packing compared with 64% of those who did not have nasal packing.

Reiter and colleagues\textsuperscript{336} disagree. On the basis of their analysis of 75 consecutive nasal procedures completed without packing, they recommend through-and-through suturing of the entire septal flap, small caliber osteotomy, meticulous closure of all intranasal incisions, and proper application of conforming dressings as alternatives to packing.

Camirand and colleagues\textsuperscript{337} reviewed the course of 812 patients who had neither internal packing nor external immobilization following rhinoplasty. None showed early bone or septal displacement and there was no increased swelling, bruising, pain, epistaxis, or synchiae over patients who had packing. [It is not clear from their report whether any patient in this series had turbinate surgery, which will increase the risk of synchiae.] Submucosal hematoma and septal necrosis were nonexistent. Nevertheless, most rhinoplasty surgeons feel that external conforming dressings are of benefit in controlling postoperative edema.

A randomized, prospective trial by Lubianca-Neto and associates\textsuperscript{338} evaluated the time of nasal packing in relation to hemorrhagic complications after nasal surgery. Of 104 patients in the study, half had packing for 24 hours and the other half for 48 hours. No statistical difference was observed between the two groups in terms of hemorrhagic complications. Hypertension was the only prognostic factor for postoperative bleeding.

Guyuron and Vaughan\textsuperscript{339} evaluated the efficacy of septal stents for maintaining patency of the airway after septorhinoplasty. Subjective ratings of airway improvement were very similar whether patients had received stents or not. The number of patients in this small sample who complained about discomfort was higher in the nasal stent group, as well as the rate of partial, residual, or recurring septal deviation.

Airway Changes
Constantinides and colleagues\textsuperscript{340} studied the long-term outcome of open cosmetic septorhinoplasty and its effect on nasal airflow in 27 patients. Plethysmographic findings showed improvement in 23 and worsening in 4. Subjective impressions of nasal patency did not correlate well with objective measurements. The authors conclude: “Patients with normal nasal resistance values may suffer long term asymptomatic increase in nasal resistance values after cosmetic open septorhinoplasty.”

Risk of Nasal Fracture
Guyuron and Zarandy\textsuperscript{341} note an incidence of nasal bone fracture after rhinoplasty of 0.624/y (24/1121 over 8 years). In contrast, the National Center for Health Statistics cites a 0.021% annual incidence of nasal bone fracture. Clearly, “the incidence of nasal bone fracture following rhinoplasty … is higher than that of fracture in the general population.”

Sense of Smell
Kimmelman\textsuperscript{342} evaluated the olfactory capacity of 93 patients before and after nasal surgery—including ethmoidectomy, polypectomy, Caldwell-Luc, reduction of nasal fracture, and septorhinoplasty—and report improvement in 61 and decline in 32. There was no correlation with age, gender, type of operation, or anesthetic.

Toxic Shock Syndrome
Reports of toxic shock syndrome (TSS) after nasal surgery\textsuperscript{343–345} deserve special attention. Between 1980 and 1983 the incidence of TSS after nasal surgery was 16.5/100,000 patients, which is proportionately higher than for the general population of menstruating women. In all cases the onset of symptoms was rapid and consisted of fever, nausea, vomiting, diarrhea, erythroderma, and hypotension; the wound did not appear grossly infected. The causative organism was a species of \textit{Staphylococcus} capable of producing a potent exoprotein, toxic shock syndrome toxin-1 (TSST-1). Topical and systemic antibiotics did not seem to offer any protection against the disease.\textsuperscript{345} No predisposing factors have been identified and there is only a weak correlation with surgical technique.\textsuperscript{343–345} Patients who develop TSS tend to receive splints more often and all have nasal packing, but so do 98% of all patients. In short, to this day we do not know why a few patients contract TSS after rhinoplasty and most do not.
THE NONCAUCASIAN NOSE

The basic approach to the noncaucasian nose involves elevation (augmentation) and narrowing of the dorsum, increasing tip projection and definition, and narrowing of the wide nasal base and alae.

Hoefflin reports his experience with geometric sculpting of the thick and poorly defined nasal tip common to black, Hispanic, and Asian patients. Tip definition and refinement to create the illusion of a thinner nose can be accomplished through 1) geometric tip defatting on the central and lateral areas; 2) triangular alar cartilage reduction; 3) placement of an ultra-supportive, peapod-shaped graft in the nasal tip; and 4) alar base reduction.

The Asian Nose

Most rhinoplasty surgeons find that their Asian and Western patients share similar concepts of the ideal nose. Asian noses frequently lack adequate tip projection, nasal length, and dorsal height/projection. Widened alar bases, caudal tip rotation, short columella, and thickened alae are also common findings. The following points should be considered when contemplating rhinoplasty on an Asian patient:

- Thick, sebaceous nasal tip and columellar skin may limit the amount of lobule refinement that can be achieved.
- Patients tend to prefer intranasal or closed approaches.
- The scars of transcolumellar incisions may remain visible, with notching or hypertrophy.
- Patients generally opt for procedures without grafts because of their aversion to external scars.
- Septal cartilage availability is questionable.
- Flat or absent nasal dorsums may require extensive dorsal augmentation.

Alloplastic augmentation through closed techniques has been advocated over more traditional open rhinoplasty techniques with autogenous materials. The safety and efficacy of alloplastic materials remains controversial. Falces and coauthors review specific techniques designed to create Western features in Asian and black noses. Flowers addresses rhinoplasty in Asian noses and lists indications and limitations of alloplastic materials for dorsal augmentation.

Parsa uses autogenous split calvarial grafts for nasal augmentation in Asian noses based on his experience with 62 patients followed for up to 8 years. Most noses could be satisfactorily augmented with a single-layer split calvarial graft, but some required multiple layers. The complication rate was 8%, including 3 minor seroma-hematomas at the graft donor site, one complete bone resorption, and one overcorrection that necessitated secondary revision.

Endo and colleagues used ear cartilage grafts for augmentation of the nasal dorsum in 1263 Japanese patients. Follow-up ranged from 6–20 months. Complications occurred in 4% of patients, and the most frequent and significant problem was graft malposition. Local infection developed in 6 patients but was controlled with antibiotics. The authors conclude that ear cartilage graft is the best alternative for dorsal nasal augmentation in Japanese patients.

Deva, Merten, and Chang reported a 10-year experience with silicone augmentation rhinoplasty. A dorsal-columellar strut prosthesis was most used commonly. Of 422 patients (412 of Asian ethnicity), 5.5% had major complications requiring the removal of the implant within the first 30 days. The causes of implant removal were displacement, hemorrhage, prominence, and supratip deformity. An additional 4.3% of patients required later removal of the silicone implant, mainly for excessive prominence or displacement. Only 2 patients (0.5%) had implants removed because of extrusion. There were no infections. The satisfaction rate was 84%, and those who were dissatisfied wanted further augmentation of the nose. The authors believe the main cause of extrusion is overaugmentation; there is an augmentation threshold beyond which the complication rate will rise dramatically. They discuss implant selection in relation to nasal morphology and desired augmentation, and maintain that silicone nasal rhinoplasty is safe in selected patients.

Zeng et al report 406 cases of silicone augmentation rhinoplasty. Complications were related to depth of implantation and character of overlying tissue. The authors conclude that subperiosteal implantation is superior to subfascial. The published complication rates in other series of dorsal nasal augmentation with silicone implants vary.
Clark and Cook describe their technique of immediate nasal reconstruction with irradiated homograft costal cartilage after extrusion of alloplastic nasal implants in 18 patients. One complication (warping) required graft removal. The authors state that this procedure may be a reasonable alternative to staged reconstruction because it avoids soft-tissue scarring and contracture. The typical site of extrusion for Silastic (nasal tip), Supramid, and Gore-Tex (nasal valves, nasal sidewall, rhinion) implants is discussed.

Jung and colleagues recommend autogenous cartilage grafts from the seventh rib over alloplastic materials for dorsal augmentation >8mm. Other autogenous and alloplastic materials for dorsal augmentation are discussed in the “Saddle Nose Deformity” and “Dorsal Augmentation” sections above.

The Black Nose

Ofodile, Bokhari, and Ellis analyzed 201 black American noses and noted three distinct groups on the basis of anatomic features: the African (44%), the Afro-Caucasian (37%), and the Afro-Indian (19%). The nasal dorsal contour went from mostly concave in the African group to predominantly convex in the Afro-Caucasian and Afro-Indian groups. African noses were shortest and widest, Afro-Caucasian narrowest, and Afro-Indian longest. The alar cartilages tended to be small and thin in the African group and large and thick in Afro-Indian noses.

Rees, Bernstein, Kamer and Parkes, Santana, and Song and others review techniques of rhinoplasty in blacks. Santana advocates correction of alar base flaring without alar base excision. Through a Caldwell-Luc incision, the soft tissues in the middle one-third of the face are undermined subperiosteally and sutures are placed across the alar line and tightened in the midline. This narrows the alar bases somewhat and elevates the columella. The authors report no recurrence of flaring. Song and coworkers discuss the use of cantilevered costal cartilage grafts for nasal dorsal augmentation in 19 black patients. They detail the techniques for graft harvest, design, and placement.

Rohrich and Muzaffar discuss the classic anatomic features of African-American noses (Table 2). They reject the notion that the alar cartilages are smaller or weaker than in caucasians, and attribute the lack of tip projection to the relatively obtuse angle between the medial and lateral crura with underdevelopment of the nasal spine. The many techniques for increasing tip projection, increasing tip definition, dorsal augmentation, and correction of alar base abnormalities are reviewed. The authors recommend liberal use of tip grafts, alar base excision, and dorsal augmentation, with cautious use of nasal osteotomies.

<table>
<thead>
<tr>
<th>Skin</th>
<th>Caucasian</th>
<th>Black</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibrofatty layer</td>
<td>Thin</td>
<td>Thick</td>
</tr>
<tr>
<td>Alar cartilage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>Large</td>
<td>Large</td>
</tr>
<tr>
<td>Support</td>
<td>Strong</td>
<td>Strong</td>
</tr>
<tr>
<td>Alar base</td>
<td>Slight alar flaring</td>
<td>Excess alar flaring; increased interalar distance</td>
</tr>
<tr>
<td>Nasal pyramid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal bones</td>
<td>Long</td>
<td>Long but flattened</td>
</tr>
<tr>
<td>Base</td>
<td>Narrower</td>
<td>Wide</td>
</tr>
<tr>
<td>Dorsum</td>
<td>Thin</td>
<td>Broad/depressed</td>
</tr>
</tbody>
</table>


Porter and Olson offer an anthropometric analysis of the African-American female nose, with a classification of nostril morphology and norms. For example, the columella-to-lobule ratio is 1.5:1, the nasolabial angle is 86°, and the alar width-to-intercanthal distance ratio is 5:4.

The Hispanic Nose

Ortiz-Monasterio described his approach to rhinoplasty in Mestizo noses, and later reviewed the use of augmentation techniques in noncaucasian noses. His preferred source of graft material for augmenting the dorsum is septal cartilage; rib cartilage is only a second choice.Septal cartilage is also favored over auricular concha for grafts to the nasal tip. Most patients require augmentation of the dorsum, columella, and tip, as well as alar base resection.

Daniel proposed a classification system for Hispanic nasal morphology, as follows:
Type I (Castilian) — high radix and dorsum and relatively normal tip projection
Type II (Mexican–American) — low radix and bony dorsum, normal cartilaginous dorsum, and depressed tip
Type III (Mestizo) — low radix, normal dorsum, decreased tip projection, and thickened nasal ala/tip

Daniel’s surgical approach to rhinoplasty varies with the type of deformity: a functional reduction rhinoplasty for Type I noses; a “finesse” rhinoplasty for Type II; and a “balanced” rhinoplasty for Type III noses (Table 3). The author also stresses conservative dorsal reduction for Type II and III noses, radix grafting for Type II, and lobular soft-tissue reduction with alar base/sill excisions for Type III.

THE COCAINE NOSE

Slavin and Goldwyn noted the potential problem of cocaine users presenting for rhinoplasty. In their series of 13 patients who had used cocaine, fewer than half were properly identified as cocaine users during the initial consultation. The preoperative rhinoscopic findings that should alert a physician to cocaine use are: visible perforation, microscopic evidence of granulomas, inflammation, and necrosis. Surgical complications related to cocaine use include localized septal collapse, delayed mucosal healing, and inadequate correction of septal deflection. The authors conclude that submucous resection and septoplasty should be avoided in patients with a known history of intranasal cocaine use.

Millard and Mejia discussed their approach to reconstruction of cocaine-damaged noses. Cocaine causes vasoconstrictor of the intranasal mucosal blood vessels and, with continuing ischemia, mucosal necrosis ensues. The exposed cartilage can succumb to chondritis and septal perforation to varying degrees. The authors support the use of local mucosal flaps for smaller perforations. For more severe deformities, including complete midvault/tip collapse, staged reconstruction is required. They recommended the use of bilateral nasolabial flaps for soft-tissue reconstruction followed by staged rib cartilage grafting of the tip and dorsum 3 months later.

<table>
<thead>
<tr>
<th>TABLE 3</th>
<th>Anatomic Characteristics andRecommended Surgical Procedures for Hispanic Noses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radix</td>
<td>High to normal</td>
</tr>
<tr>
<td>Type I</td>
<td>Low</td>
</tr>
<tr>
<td>Type II</td>
<td>Low</td>
</tr>
<tr>
<td>Type III</td>
<td>Normal</td>
</tr>
<tr>
<td>Dorsum</td>
<td>Low</td>
</tr>
<tr>
<td>Bony</td>
<td>Low</td>
</tr>
<tr>
<td>Type I</td>
<td>Normal</td>
</tr>
<tr>
<td>Type II</td>
<td>Normal</td>
</tr>
<tr>
<td>Cartilaginous</td>
<td>Low</td>
</tr>
<tr>
<td>Type I</td>
<td>Normal</td>
</tr>
<tr>
<td>Type II</td>
<td>Normal</td>
</tr>
<tr>
<td>Tip</td>
<td>Normal</td>
</tr>
<tr>
<td>Type I</td>
<td>Decreased (−1)</td>
</tr>
<tr>
<td>Type II</td>
<td>Decreased (−1)</td>
</tr>
<tr>
<td>Projection</td>
<td>High</td>
</tr>
<tr>
<td>Type I</td>
<td>Decreased (−1)</td>
</tr>
<tr>
<td>Type II</td>
<td>Decreased (−1)</td>
</tr>
<tr>
<td>Volume</td>
<td>Increased (+1)</td>
</tr>
<tr>
<td>Type I</td>
<td>Decreased (−1)</td>
</tr>
<tr>
<td>Type II</td>
<td>Decreased (−1)</td>
</tr>
<tr>
<td>Width</td>
<td>Normal</td>
</tr>
<tr>
<td>Type I</td>
<td>Increased (+3)</td>
</tr>
<tr>
<td>Type II</td>
<td>Increased (+3)</td>
</tr>
<tr>
<td>Skin</td>
<td>Variable (+1/−1)</td>
</tr>
<tr>
<td>Type I</td>
<td>Normal</td>
</tr>
<tr>
<td>Type II</td>
<td>Variable (+1/−1)</td>
</tr>
<tr>
<td>Base</td>
<td>Variable</td>
</tr>
<tr>
<td>Type I</td>
<td>Normal</td>
</tr>
<tr>
<td>Type II</td>
<td>Thick (+3)</td>
</tr>
<tr>
<td>Operation</td>
<td>Functional reduction rhinoplasty</td>
</tr>
<tr>
<td>Type I</td>
<td>Finesse rhinoplasty</td>
</tr>
<tr>
<td>Type II</td>
<td>Balanced rhinoplasty</td>
</tr>
</tbody>
</table>

(Reprinted with permission from Daniel RK: Hispanic rhinoplasty in the United States, with emphasis on the Mexican American nose. Plast Reconstr Surg 112:244, 2003.)
BIBLIOGRAPHY


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<table>
<thead>
<tr>
<th>Change from Baseline at 6 Months (LRS)</th>
<th>RADIÉSSE</th>
<th>COSMOPLAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved</td>
<td>82.1%</td>
<td>37.6%</td>
</tr>
<tr>
<td>No Change</td>
<td>17.1%</td>
<td>35.0%</td>
</tr>
<tr>
<td>Worse</td>
<td>0.8%</td>
<td>27.4%</td>
</tr>
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</table>