Considerations in the etiology, treatment, and repair of septal perforations

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Nasal septal perforations present a distinct challenge to the facial plastic surgeon, and a problem to the patient. A clear-cut causal factor must be established from a long, diverse list of potential causes, some of which can be life-threatening. Surgical repair presents a complex technical challenge, because a septal perforation is a hole in three distinct contiguous layers composed of both right and left septal mucoperichondral flaps and the intervening cartilage, all three of which must be separated from each other and repaired individually. Many procedures to repair septal perforations have been described. Those techniques that have the best physiologic result, the highest success rate, and the best long-term patient acceptance and comfort require the use of bilateral intranasal mucosal advancement flaps with the interposition of a connective tissue graft. This article describes presenting symptoms and findings for septal perforations, the history and physical examination, causes, helpful hints for prevention of perforations, and surgical and nonsurgical treatment options and outcomes.

Presentation

Facial plastic surgeons usually discover septal perforations during their examinations of the nose as an incidental finding in a patient without symptoms, or they are presented with a patient complaining of symptoms whose cause they find to be a perforation.

There may be a history of prior nasal surgery. A number of septal perforations are asymptomatic if they are located posteriorly within the nose where there is good humidification. The more anterior the perforation, the more likely the patient is to seek evaluation and treatment of symptoms. The major symptoms of septal perforation are crusting, bleeding, whistling, nasal obstruction, and, sometimes, pain or rhinorrhea.

Crusting and bleeding usually occur with septal perforations at the edge of the circumference of the perforation, because of the inability of the mucosa to heal well over the exposed cartilage. If there is no exposed circumferential cartilage at the edge of the perforation and there are just two adherent mucoperichondral flaps, the perforation is less likely to crust or bleed (Fig. 1). When there is septal cartilage right up to the edge of the perforations, however, the mucosa has a more difficult time healing, and there is usually a low-grade chondritis present that creates an inflammatory response, leading to crusting and bleeding in this nonhealing area. Some patients present with increasing frequency of epistaxis, and, on examination, one finds huge amounts of crusts and dried blood, which are extremely difficult to remove from the perforation without causing further bleeding. These patients need to be put on emollients and irrigations and then brought back into the office after a week of such treatment for improved evaluation.

Presence of dried blood and crusts certainly can lead to airway obstruction, which may improve when the crusts are removed. Obstruction can be a major presenting symptom, however, even in a clean nasal perforation. The septum divides the nasal cavity into two distinct chambers through which normal lamellar airflow takes place [1]. When a perforation is present,
the lamellar airflow is disturbed and turbulence occurs, decreasing the flow of air and producing a definite sense of nasal obstruction [2]. Whistling in the nose is a common nuisance noted usually in the smaller perforations because of the noise created secondary to the aerodynamics of flow through a small opening. Whistling usually is noted during sleep by a partner, but can also be embarrassing and troublesome to the patient during the day. Pain may be noted in conjunction with bleeding and crusting associated with chondritis; in severe cases, especially in the cocaine abuser, pain is caused by the cellulitis and inflammation. The larger the perforation, the more turbulent the airflow, the greater the incidence of rhinorrhea. A dried nose attempts to rehydrate itself through increased secretions. However, long-term septal perforations with turbulent airflow result in further destruction of respiratory epithelium within the nose, with loss of cilia and loss of function. Normal respiratory epithelium changes into dry mucosa, so that eventually most of the internal structure of the nose is extremely dry.

On physical examination of the nose, a full diagnosis cannot be made until all crusts have been removed and decongestion of the turbinates has taken place, making it possible to visualize the entire nasal septum. Examination of some patients with a bend in the septum and enlarged turbinates is difficult, and a posterior perforation may be missed. When a perforation is noted, its circumferential size and relative position should be documented. An ominous sign is crusting that is observed not only around the edge of the perforation but all over the nasal septal and turbinate mucosa. Such a finding occurs more often in patients with causes suggestive of a granulomatous or vasculitis process. Findings of overall crusting in a cocaine user or in a patient with a granulomatous process make the prognosis for long-term operative success more guarded.

The septum should be palpated with a cotton-tip applicator to discern persistent cartilage between the mucosal flaps and to determine whether cartilage extends close to the edges of the perforation. In perforations that have occurred after septoplasty, there is usually very little cartilage left, and this makes dissection of the flaps more difficult. If one finds extensive membrane swelling and inflammation or sees synchiae or collapse of the nose internally as well as externally, one should consider the possibility of an ongoing disease process or the active use of cocaine. Previous cocaine use usually results in a clean-edged perforation with cartilage present almost all the way to the edges of the mucosal perforation. A thorough head and neck and generalized examination is necessary to rule out any other system involvement.

Patients often have very little understanding of the internal nasal anatomy, do not know what the septum is, and know little about the complexity of septal perforation repair. Most patients, moreover, have no idea that they have a septal perforation when presenting their symptoms and are understandably unsettled to learn that operative attempts to repair this perforation are not always successful. It is often helpful to use an in-office endoscope attached to a monitor or to a color printer to educate the patient as to the extent of the problem (Fig. 2). Anatomic models or diagrams are especially useful in helping the patient understand what may need to be done [3]. An even more difficult situation occurs when the patient presents to the facial plastic surgeon for revision rhinoplasty after unsuccessful cosmetic surgery elsewhere and learns that the external deformity is accompanied by a crippling internal airway defect.
Box 1. Septal perforation causes

**Trauma**

External

Fracture  
Septal hematoma  
Piercing injuries

Self-inflicted

Nose picking  
Foreign bodies

Iatrogenic

Nasal surgery  
Septoplasty  
Sinus surgery  
Turbinate surgery  
Rhinoplasty  
Septal cauterization  
Septal packing  
Septal splinting  
Cryosurgery  
Trans-sphenoidal hypophysectomy  
Postoperative suctioning  
Nasotracheal intubation

Drugs—legal and otherwise

Vasoconstrictive nasal sprays  
Steroid nasal sprays  
Cocaine  
Smoking

Chemical irritants

Chromic, sulfuric, and hydrochloric acids  
Chlorines and bromines  
Agricultural aerosolized dust  
Rice and grain elevator dust  
Chemical and industrial dusts  
Lime  
Cement  
Glass  
Salt  
Dust  
Heavy metal  
Cyanide, arsenicals

**Neoplastic causes**

Adenocarcinoma  
Squamous cell carcinoma  
Metastatic carcinoma  
Midline destructive granuloma

**Inflammatory causes**

Vasculitides  
Collagen vascular diseases  
Sarcoidosis  
Wegener’s granulomatosis

**Infections**

Tuberculosis  
Syphilis  
Rhinoscleroma  
Lepromatous leprosy  
Rhinosporidiosis  
Multiple fungal species  
Mucor  
Typhoid  
Diphtheria

**History and causes**

There are many causes for septal perforations, and a very thorough history is necessary in all patients (Box 1). A history of acute, chronic, or previous systemic disease must be determined. A history of any previous nasal surgery or instrumentation, of any previously treated epistaxis, of nose picking, of internal and external nasal trauma, of use of over-the-counter or prescription nasal sprays, of illicit drug abuse, and of smoking or other hazardous aerosol exposures should be established.

**External nasal trauma**

A blow to the external nose can cause fracturing of the septum with the possibility of disruption of the mucoperichondrium with cartilaginous fractures, especially in someone who already has a deviated septum. If fractures with tears are left untreated, infection and perforations can result. An undiagnosed and untreated septal hematoma from trauma can go on to develop fibrosis and loss of the intervening cartilage or can get infected and develop an abscess leading to a perforation. Nasal trauma in a postoperative septoplasty patient is more likely to lead toward
a perforation than in a nonoperated individual. Direct piercing injuries are rare, yet the author has treated one individual whose face was impaled by a motorcycle’s gearshift that went straight across the face and right through the septum. This injury resulted in a septal perforation that later required repair.

**Self-inflicted trauma**

Nose picking is more of a problem than some individuals believe. It is amazing to see how often people insert not only their fingers but also other objects into their noses, either as a nervous habit or in an attempt to clean the nose. Some people cause severe damage to the septum and epistaxis from their nose picking. Children quite commonly insert foreign bodies into the nose, and those with hearing aids have been known to put hearing aid batteries in their noses. Battery injury can cause chemical burns to the septum, resulting in perforation.

**Surgically induced trauma and previously treated epistaxis**

The most common cause of recognized septal perforations is seen in patients who have been treated for epistaxis and in those who have had previous nasal procedures. Nasal septal epistaxis often is treated initially by simple vasoconstriction and application of silver nitrate. Tight nasal packs are sometimes placed to prevent rebleeding, or in cases where bleeding simply cannot be controlled with cautery. Tight nasal packs, especially in patients who have had previous septoplasty, may compress the vascular supply to the septum and if left in place long enough can lead to septal perforation, secondary to interruption of mucoperichondral blood supply. Sometimes electrocautery is used on the septum, and it is quite easy to cause damage to both membranes. If septoplasty has been performed and there is no intervening protective cartilage, the risk of perforation is even greater. Some physicians sew hard intranasal septal splints into place after septoplasty. If the septal splints are sewed too tightly, they too can compromise the blood supply to the septum.

The classic cause of septal perforations is a previous septoplasty, in which there have been tears in both septal membranes in a contiguous area where intervening septal cartilage or bone has been removed. When such tears do occur, it is wise to repair them immediately and to insert an intervening cartilage or a connective tissue or acellular dermal graft to act as a barrier to perforation. In postoperative care after a septoplasty one must be quite careful, in suctioning out the nose, not to push the suction through a thin septal membrane.

Other nasal surgeries and procedures that are not performed directly on the septum can cause inadvertent damage to and subsequent perforations of it. Cautery and cryotherapy of the turbinates with an unprotected septum may cause burns and loss of septal integrity. Endoscopic sinus surgery and nasal antral window surgery have also been implicated in perforations. Trans-septal approaches to the sphenoid are causes of perforations. In certain individuals who have a large septal deviation or spur and require nasotracheal intubation, an endotracheal tube placed through that obstructed side can cause total denuding of the septum, leading to perforation. Discussions with the patient before any nasal procedure should encompass the potential for the complication of a septal perforation, and when one occurs, the physician should disclose this information to the patient postoperatively. Some perforations so caused may be tiny and asymptomatic and require no repair. The unrecognized perforation may approach enormous dimensions and significance, however, before it is brought to the patient’s attention by another physician [3].

**Prevention**

The mucoperichondral flaps overlying the septal cartilage provide its blood supply. When there has been a tear in one side of the membrane alone, the cartilage usually can get its blood supply from the opposite, still-intact membrane and thus survive. The problem occurs when the mucoperichondrium has been disrupted on both sides of the cartilage in corresponding areas, leading to cartilage necrosis and later perforation. In a septoplasty, if corresponding tears have occurred with removal of the intervening cartilage, a perforation will be evident at the end of the procedure. As Fairbanks [4] has pointed out, nasal septal perforations need to be repaired immediately at the end of the nasal operation, no matter how small they may appear, especially when the intervening cartilage has been removed. It is foolhardy to believe that a perforation will heal on its own. It is more likely that the perforation will enlarge postoperatively with the contraction of healing.

Mucosal lacerations are common in septoplasty, especially when one encounters a very crooked septum or a septal spur posteriorly. The secret to preventing corresponding tears in both mucoperichondral flaps is to be sure that one has undermined broadly and elevated the mucoperichondrium away from the deviated cartilage or septal spur area before attempting to remove the spur or the deviation. Even
in the case of a spur, where penetrating the overlying membrane is quite common, the opposite mucoperichondrium usually can be elevated easily and carefully. If one membrane remains intact, the chance of a through-and-through perforation is decreased. Elevation of the mucoperichondral flap must be in the correct plane, and often the novice surgeon will not adequately access this flap and will leave mucoperichondrium on the septum itself. Using the sharp portion of the Cotlee elevator, the surgeon can assure an appropriately elevated mucoperichondral flap more accurately. Often the maxillary crest is also deviated, and perforations can quite easily occur along the crest. In these cases not only the mucoperichondrium of the septum but also the mucoperiosteum on the floor of the nose are elevated and joined. These flaps are retracted away from the cartilage and bone before excision of the obstructing cartilage or bone. When a large spur is encountered, the cartilage is separated from the bony septum and the mucoperichondrium is elevated over the bony portion of the spur on its opposite side. Becker scissors are used to cut above and below the deviation, and then the tip of the nasal speculum is used to push the spur closer to the midline as one teases the mucoperichondrium off the protruding portion of the spur.

In some cases, however, because of the inexperience of the surgeon or the difficulty of the case, corresponding tears do occur. In such cases, it is important to perform separate closure of the perforation in each membrane, followed by the placement of crushed cartilage that is reimplanted between the flaps in the area of these perforations (Fig. 3). Trenite et al [5] have shown that there is a decreased rate of perforation when autologous cartilage is used for reskeletization. It is this author's strong opinion that reskeletization should occur when possible in septoplasty, especially when contiguous tears occur, even if the tears are sewn closed. The obstructing cartilage that has been removed, and which normally would be discarded or sent to pathology for identification, can either be crushed or placed between the mucoperichondral flaps, which are mattressed together at the end of the case. Even if the crushed cartilage does not survive postoperatively, at least it serves as a barrier against through-and-through perforation. If the cartilage used for reskeletization purposes does not survive, it may add to fibrosis and strengthen the septal flaps that have been weakened by removal of the cartilage. If no septal cartilage is available for reskeletization, as in the case of revision septoplasty or in cases where all available cartilage has been used for grafting purposes, acellular dermis or a connective tissue graft may be used.

Septal perforations are potential unwanted complications in any nasal procedure, and the patient should be warned of them preoperatively. Postoperatively, patients must be informed of the presence of a perforation so they can make decisions about how to proceed for relief of any symptoms.

Nasal sprays, smoking, and cocaine usage

Shoelzel and Menzel [6] have noted that chronic use of nasal sprays may lead to septal perforations. Patients themselves can abuse some of the vasoconstrictive sprays [7], which cause intense vasoconstriction of the mucoperichondrium and can lead to perforations, especially when combined with cigarette smoking or very dry climates. The advent of the steroid nasal sprays and the rise of their long-term use in individuals have been greeted with very little heed to the potential for septal perforation. Patients on these medications should be monitored periodically to check for any septal irritation, which could later proceed to perforation.

Cocaine use is particularly damaging to the septum because the drug itself causes intense vasoconstriction, which is worsened by the fact that most street cocaine is not pure but rather adulterated with very irritating substances, such as borax or talc [4]. One-time use of intranasal street cocaine has been known to cause a septal perforation. Chronic cocaine abusers often destroy their noses because infection complicates the inflammation, irritation, and lack of blood supply. The condition worsens to such an extent that membrane, bone, and cartilage necrosis takes place and leads not only to perforation, but also to nasal collapse, intranasal stenosis, and saddling. Chronic cocaine abusers usually are easy to detect in the office, based on their jittery habits, their wired,

Fig. 3. A piece of septal cartilage is crushed in a cartilage crusher and then placed back between the mucoperichondral flaps to reskeletize the septum and help prevent a perforation.
intense appearance, and their chronic nasal snif ting. It is useless to repair a septal perforation in a patient who is still using cocaine, because the perforation is certain to recur.

Unfortunately, cocaine patients have a difficult time curing their addiction and often are less than truthful in their history with the physician. Operating on patients who are still using cocaine is to be avoided. Obtaining preoperative cocaine levels on such patients may be warranted. Talking with the individual’s counselor may also help with operative planning, because most cocaine addicts are unable to quit without counseling. Additionally, cocaine patients need anesthetic and medical clearance because of their susceptibility to more anesthetic complications than nonusers.

Chemical irritants

In addition to cocaine, nasal sprays, and smoking, industrial irritants are common causes of perforations [1]. Individuals who work in chrome plating factories or in chemical plants and are exposed to chronic, sulfuric, and hydrochloric acids are at high risk for severe nasal airway irritation. Industrial and agricultural aerosolized dust, such as is found in grain and rice elevators and cement, glass, and lime factories, can cause perforations. Individuals working with swimming pool chemicals or in chemical factories are also at high risk. Prevention of nasal injury in these working situations would entail wearing proper filter masks during the irritant exposure. Any such irritant can cause more damage if the nose is further dried by the environment or by smoking.

Pathologic processes

Serious systemic diseases, including neoplastic, inflammatory, and infectious conditions, are causes of septal perforation. When none of the previously listed causes has been determined, the physician must look elsewhere and rule out potential serious causes. Vasculitides and collagen vascular disorders, such as lupus, rheumatoid arthritis, and polychondritis, can lead to septal perforations as well as dorsal cartilaginous saddling. The problem with such conditions is that they can go into remission and then recur. Before repairing perforations in these patients, it is wise to touch base with the primary physician, rheumatologist, or infectious disease physician handling the patient. These patients must be told that even though a repair can be successful, another perforation may occur if their disease flares up again at a later time because of the process of vascular destruction—an event that this author has noted, especially in patients with renal and small vessel disease. Granulomatous diseases, such as Wegener’s granulomatosis and sarcoidosis, are less common causes. A CT scan of the nose and paranasal sinuses is helpful when granulomatous disease is suspected.

Neoplastic disorders, such as metastatic carcinoma and squamous and adenoid carcinomas and melanomas, must be ruled out. Midline lethal granuloma is another serious destructive process for which one must evaluate when there is no clear-cut cause for the septal perforation. If the head and neck examination has not revealed any other pathology, laboratory batteries for collagen vascular and kidney disease, fluorescent treponemal antibody-absorption, and Epstein-Barr virus titers should be drawn, and the venereal disease research laboratory test, antineutrophil cytoplasmatic antibody test, and angiotensin converting enzyme test should be performed. Nasal cultures for fungal and bacterial species may be necessary in the presence of an inflammatory process. Skin testing for anergy, tuberculosis, and fungal infections also may need to be performed. When no clear cause has been discovered, a biopsy of the perforation may be indicated before reparative surgery, although Murray and McGarry [8] would disagree. The biopsy specimen of the septum should be taken from the posterior edge of the perforation, making sure to include enough tissue so that the pathologist has a specimen away from the perforation edge from which he or she can get a definitive diagnosis. A small biopsy specimen taken from the edge of the perforation is often reported as merely chronic inflammation. It is important not to perform the biopsy at the superior edge of the perforation where one would increase the vertical perforation height, which is more difficult to close. Similarly, biopsies at the anterior portion should be avoided, because that area needs to be closed to decrease symptoms.

Nonsurgical treatment

An asymptomatic perforation, such as those that are located posteriorly and have well-healed edges, rarely requires any treatment at all. Mild symptoms, with the exception of obstruction, usually can be managed by medical therapy. Often just keeping the nose moist is enough, and the daily application of petroleum jelly on a cotton-tipped applicator to the inside of the nose may be satisfactory. Topical nasal estrogen spray may be added to help reduce squamous metaplasia and subsequent dryness; Chmiel [9]
suggests 25 mg of conjugated estrogen solution mixed to one 30 cc bottle of nasal saline spray, with two puffs each side three times a day.

Patients who have a great deal of intranasal crusting need more frequent therapy with nasal irrigations, as well as ointments and emollients. Fairbanks [4] suggests an antiseptic wash of one teaspoon of table salt dissolved in a quart of warm water to be used to irrigate the nose. A rubber bulb syringe or a nasal adapter for the Water Pik are good delivery systems. Adding a moisturizing and coating substance, such as a cup of corn syrup (Karo) or glycerin (which is readily available at the drugstore) further serves to reduce nasal crusting. Adding a teaspoon of vinegar or 1 to 3 tablespoons of boric acid powder is effective in decreasing Staphylococcus areas and Pseudomonas aeruginosa growth. These irrigations can be followed in particularly dry noses with bacitracin or Bactroban, especially if there is a chronic infection.

If these treatments are unsuccessful, if the patient is unwilling to care consistently for the nose, if the sensation of nasal obstruction is dominant, or if the patient declines surgery or is not a surgical candidate, a silicone grommet prosthesis may be helpful (Fig. 4). Unfortunately, the prostheses that are available commercially are generally of one size and do not adequately fit larger perforations [10]. In these cases, a custom-made silicone button easily can be made by the local prosthodontist if the facial plastic surgeon provides the dimensions of the perforation. Price et al [11] use reformatted CT images to obtain measurements. Alternatively, it is usually quite simple to insert a piece of paper against the perforation after topically anesthetizing the nose; then, through the opposite nostril, one may use a marking pen to outline the perforation itself. Usually the standard or custom-made septal buttons can be inserted in the office under local anesthesia. When the perforation is especially large, sedation may be necessary. When buttons are in place, occasional nasal irrigations are still suggested to keep the obturator clean. If there is a chondritis or low-grade infection present, the button will not cure this problem, and continued observation and treatment by the physician are necessary. Silicone septal buttons should also be used in patients who, for other medical reasons, are not good surgical candidates. They should certainly be considered in patients with chronic or recurrent disease processes, as well as patients with continued cocaine use.

Surgical goals

The primary goal of surgery should be not only to repair the perforation but also to restore normal function and physiology to the nose. Many different techniques have been described for closure, but only those that use intranasal advancement flaps are able to achieve normal physiology, because they use the normal respiratory epithelium for closure. However, in the long-term septal perforation patient, squamous metaplasia may have replaced the normal respiratory mucosa of the advanced flaps, and dryness may persist despite closure. Other methods that use skin grafts or buccal mucosal grafts may be effective in closing the perforation, but these leave the patient with a dry nose that continues to crust because skin normally sheds, and normal respiratory epithelium is not present. From experience, one readily knows that when one goes to the dentist and has air blown by the mucosa, an uncomfortable dry feeling ensues. When buccal mucosa grafts are used in the nose for perforation repair, the normal flow of air through the nose dries these grafts and does not solve the problem.

A second goal of surgery should be a tension-free closure so that the repair will not break down postoperatively with healing scar contraction. Because there is no elastic tissue in septal mucosa, adequate mobilization of septal flaps must be performed [4]. The open external rhinoplasty approach affords necessary access and exposure for repairing the perforation and for the development of these mucosal flaps [12,13]. By using sliding bipedicled or unipedicled flaps taken from the floor of the nose extending laterally under the inferior turbinate, one can close the mucosal portion of the perforation with normal nasal mucosa. It is absolutely crucial that in addition to both mucoperichondral flaps being closed, a connective tissue interposition graft be placed between the corresponding perforations to act as a template on which the edges of the sewn perforation can migrate and mucosalize closed. Fairbanks [4,13], Gollom [14], Kriedel et al [15,16], Goodman and Strelzow [17], and others have described using this method with over 90% success rates in perforations of up.

Fig. 4. A silicone grommet button prosthesis can be placed in the perforation in a nonoperative candidate.
to 2 cm to 3 cm. As perforations increase in size, the chances of success decrease proportionally. The anterior to posterior length of the perforation is not critical in closure because the tension of closure is from the floor of the nose to the dorsum, which is perpendicular to this axis.

In evaluation of a septal perforation for surgery, the height of the perforation is a helpful determinant of the potential for successful repair. The absolute size of the perforation is not as important as the proportion of septal membrane remaining. For example, a 1-cm perforation in a young child with a small nose could be much more difficult to repair than a 2-cm perforation in an adult patient with a very large nose and septum. Perforations that extend all the way to the nasal dorsum are almost impossible to repair, unless there is some small cuff of membrane to which the inferior advanced flap can be sewn. Similarly, perforations that extend all the way down onto the floor are technically difficult. If multiple adhesions between the remaining septal membranes and turbinates or lateral nasal wall are present, the surgeon may wish to lyse these adhesions in a separate preceding procedure and place Silastic sheeting on the septum for several weeks to prevent reformation, then go back into the nose for the definitive perforation repair. In addition to the height of the perforation, another prognostic indicator is the amount of cartilage remaining in the rest of the septum. When a fairly aggressive septoplasty has been performed previously, the dissection of the adherent mucosal flaps is extremely difficult and can lead to worsening of the perforation during mucoperichondral envelope separation.

Finally, one of the most important determinants of success is quite simply the experience and skill of the operative surgeon. Because septal perforations commonly are caused by novice nasal surgeons, it follows that a gentle and experienced touch is the key to their repair. The separation of the mucoperichondral flaps can be tedious and must be done quite carefully, so as not to cause an increase in the size of the perforation or another perforation elsewhere along the septum. When septal flaps are sewn together, the use of a cutting needle facilitates closure, but if used with any amount of force the suture needle can easily tear the residual membranes, making the closure much more difficult. Operative time decreases as the surgeon becomes more agile with the operation. Hemostasis can be the determining factor in early operative success and can be a problem in prolonged surgery. Effective hemostasis can be assured by injecting vasoconstrictors periodically during a technically more difficult perforation repair.

Surgical options

David Fairbanks [4,13] uses the endonasal or closed approach with a full transfixion incision in his repairs. Although his method is highly successful, it is extremely difficult, especially in large perforations or in patients with small nostrils. Fairbanks at times will do a lateral alotomy to gain better access and visualization, but this leaves the patient with the potential for a more visible incision.

The open-external approach has multiple advantages in that it allows access to the anterior, superior, and posterior aspects of the perforation and not only increases surgical exposure but also provides a field without the distortion that normal intranasal retraction causes. The external approach gives the surgeon excellent binocular vision and furthermore allows the assistant to retract so that the surgeon can use both of his hands simultaneously. By avoiding a transfixion or hemitransfixion incision intranasally in the anterior portion of the septal membrane, the open technique preserves the anterior septal blood and lymphatic supply and may even improve nasal advancement flap viability. The small transverse columellar skin incision is a small price to pay for the improved access to the perforation. This incision and its minimal scar are much less noticeable than the scar from analar crease incision, and, if the principles of scar camouflage and layered closure are followed, the scar will fade quickly and become imperceptible with time. The most noticeable scars from transcolumellar incisions are from those that are not closed in layers and those in which the surgeon may not have meticulously closed the skin incision.

One of the decided disadvantages of the open approach is that the medial crura are totally dissected away from themselves and from the septum. The fibrous connections between the medial crura and the septum and the overlying skin are supporting attachments that normally help preserve tip projection. It is incumbent upon the surgeon to reconstitute this support mechanism after the perforation is repaired. The medial crura and tip cartilages should be sewn back together with interrupted permanent or semipermanent sutures, and sometimes a columellar strut should be placed between the medial crura to support the nasal tip further. Tip-drop otherwise will almost invariably result, creating a cosmetic deformity that was not present before the perforation.

Bilateral bipedicled floor and dorsum mucosal advancement flaps require mobilization and borrowing of septal mucosa in vertical dimensions. The upper lateral cartilages are separated from the septum, and, as the membrane that is still attached to the
upper lateral cartilages is pulled down for a closure attempt, the upper lateral cartilages themselves will have a tendency to be pulled inferiorly. A pinched appearance to the middle third of the nose may result. Sometimes grafting materials must be placed over these upper laterals so as to maintain the contour of the nasal dorsum. Likewise, as the mucosal defect is closed and the bipedicled flaps are pulled into place, a certain amount of tension is placed on the caudal septal mucosa and the medial crura, producing a definite cephalad rotation of the nasal tip. If the patient has a ptotic tip, these maneuvers actually will help improve the aesthetic result. If a nose is already over-rotated or foreshortened, however, the problem may be worsened by repair, and corrective methods will have to be added to the procedure to counteract these effects. For example, through-and-through sutures placed between the dissected septal flaps anterior to the caudal septum and the medial crura may help prevent columnellar retraction.

Other authors use advancement flaps with a connective tissue interposition graft, as advocated here, but use a different approach. Romo et al [18] have described a midfaced degloving technique. Karlan et al [19] used a sublabial incision, and Kurloff [1] described a modification of the open technique to further increase exposure. This author prefers the external approach whose description follows, because it gives the surgeon the opportunity to perform rhinoplasty or revision rhinoplasty procedures at the same time. Friedman et al [20], Murakami et al [21], and Ayshford et al [22] have advocated inferior turbinate flap repairs for mid- and anterior perforations, especially in cases where previous septal flaps have been unsuccessful. Readers are encouraged to review these articles for alternative surgical approaches.

Surgical methods

Selecting a connective tissue graft

Connective tissue autografts are commonly used to interpose between the repaired septal flaps. Commonly used materials are temporalis fascia and pericranium, both of which require a separate donor site (Fig. 5). Pericranium, fascia, and temporalis are extremely thin grafts with very low metabolic requirements that act as templates for overlying mucosal tissue migration and vascularization. Additionally, the graft maintains a barrier between the corresponding repaired flaps during the healing process and decreases any risk of incisional breakdown and reperforation. If temporalis fascia is harvested, and if the surgeon is right-handed, the right temporal scalp is generally the donor site. A horizontal incision is made with care to bevel the incision site, so as to remain parallel to the hair follicles and thus protect them. The scalp is retracted, and dissection is carried down to the deep temporalis fascia with wide undermining. The dimensions of the harvested graft must be significantly larger than the perforation, because the graft must have a large enough diameter so that its edges go far beyond the perimeter of the original

Fig. 5. (A) The temporalis fascia as it is being harvested. (B) A 4 cm × 4 cm piece of temporalis fascia spread out to dry prior to insertion between the mucoperichondral flaps.
perforation. The surgeon should take into account the possibility of enlargement of the perforation through manipulation and dissection of the flaps. A large circular piece of temporalis fascia is harvested and hemostasis is maintained with a cautery. The wide undermining and the size of the graft, which is usually about 5 cm in diameter, warrant simple passive drainage with the incision closed in layers. A pressure dressing of the mastoid type is used.

Because there is some donor site morbidity to obtaining temporalis fascia or pericranium, and because these grafts are exceedingly thin and difficult to manage when they are wet, human acellular dermal grafts (AlloDerm, Life-Cell Corp., Branchburg, New Jersey) [23] can be used as the connective tissue interpositional graft, with similar success rates to those of temporalis fascia or pericranium [21]. Acellular dermal grafts are thicker and easier to place and suture, and they may give more substance to the repaired septum (Fig. 6). Readers are directed to the paper by Kridel et al [24] for a more in-depth discussion of the use of acellular human dermal allografts. Alternatively, Ambro et al [25] describe using porcine small intestinal mucosa as an interpositional graft, but there is a potential for porcine allergy.

Surgical procedure

The patient is placed on perioperative antibiotics, which should be started before and continued for up to 1 week after surgery. General oral tracheal anesthesia is preferred, because the operation is lengthy, requires meticulous and tedious dissections, and may require two different operative sites, the nose and the temporal scalp (if the graft is so harvested). An oral pharyngeal throat pack is placed before localization to prevent any blood from entering the esophagus and stomach, thereby helping prevent postoperative nausea. Infiltrative anesthesia with 1% lidocaine (Xylocaine) with 1:100,000 epinephrine is used more for hemostasis. Endoscopic photographic documentation of the perforation is usually performed, and diagnostic endoscopy is performed to examine the nose fully.

A low transeptal incision with an inverted V configuration is outlined on the columella. Incisions for the standard open septorhinoplasty approach are performed (Fig. 7). The reader can refer to the author’s description in his previous article [26]. The nasal skin then is elevated sharply off the underlying medial crura and dome cartilages, and dissection continues back in an avascular plane directly on and over the upper lateral cartilages and dorsum. The dome cartilages are separated and the medial crura are retracted laterally to gain access to the caudal end of the septum. Elevation of each mucoperichondral flap is performed as one would for a septoplasty, staying directly on the cartilage and carrying out the elevation posteriorly toward the perforation. Superior mucoperichondral pockets are developed along with the flap elevation just beneath the junction of the upper lateral cartilages and the septum. The upper lateral cartilages then are cut sharply away from the septum, using a knife blade that leaves the mucoperichondral flap still attached to the now laterally retracted upper lateral cartilage (Fig. 8). At this point, one can see the definite advantage of using the open approach, because of the superb visualization of the septum superiorly. The open approach also affords the surgeon the ability to go back behind the perforation with ease. One needs to note that the upper lateral
cartilage release is accomplished through an incision that is usually straight and parallel to the septum, but closer to the rhinion the incision fades approximately 15° off the midline. Elevation also is performed along the inferior portion of the perforation and extended onto the nasal floor and under the inferior turbinate. When connecting the mucoperiosteal floor flaps with the mucoperichondral flap over the septum, the surgeon frequently needs to incise fibrous bands at the premaxilla. The surgeon should be aware that there are sometimes penetrating vessels here at the junction of the floor of the nose and the maxillary crest, which must be cauterized. The perforation now is opened from the front, using a broad exposure technique and careful dissection. Avoiding enlargement of the perforation is important with this maneuver. Dissection must proceed posteriorly for at least a centimeter back behind the perforation. A very comforting event when dissecting between the septal flaps, especially if they are adherent and there is no septal cartilage around them, is finally to reach normal septal bone or cartilage posteriorly. Dissection then is done in exactly the same manner on the other side of the septum until the surgeon has three different structures with perforations, the totally free mucoperichondral flaps on each side and the intervening septum with its cartilaginous defect (Fig. 9).

At times, a septralplasty may also be necessary if deviation of the residual septum is noted or a septral spur exists posteriorly. It is incumbent upon the surgeon to attempt this correction during perforation closure, because after septal perforation repair, entering the septum again for any reason other than to repair a reperforation is discouraged. If any cartilage needs to be removed for the septralplasty, it is best to do so conservatively and avoid compromising the structural support that the nonperforated portion of the septum provides.

Once adequate mucosa has been freed for planned advancement flaps, an anterior to posterior incision is made underneath the inferior turbinate at the lateral nasal wall. Care is taken not to perforate the very thin lateral bony wall and enter the maxillary sinus. The flaps should be checked to ensure thorough elevation off the nasal floor and wall (Fig. 10 [27]). At times the size of the inferior turbinate makes visualization difficult, and an infracture or limited partial resection will be necessary. If partial resection is performed, the surgeon should avoid inferior turbinate mucosal incisions that may, when combined with nasal floor flap mobilization incisions, lead to postoperative scar band formation and closure of the inferior meatus. The surgeon should check to see that the advancement flap is totally mobilized off the septral cartilage, off the nasal floor, and from beneath the inferior turbinate. Gentle manipulation of the edge of the perforation and advancement superiorly along the septum will demonstrate the degree of extra laxity that flap creation has obtained. The flap attached anteriorly and posteriorly is now a bipedicled flap that has a blood supply from both of these directions (Fig. 11). Because the inferior turbinate position is posterior relative to the anterior caudal septum where most perforations occur, however, floor flaps may seem limited for very anterior perforations. If more mobility is necessary, back cuts may be made from the anterior and posterior ends of the incision under the inferior turbinate, going from lateral to medial onto the bony nasal floor, with the surgeon taking care to maintain adequate pedicle width. In some cases, that incision alone is not adequate for mobilization and an unipedicled flap is needed. The incision

Fig. 9. Both upper laterals with mucoperichondral flaps are laterally retracted, revealing the bare cartilage of the septum, which in this case has a caudal deflection to the right.
along the nasal floor can then be angled medially and joined with the perforation at its most anterior aspect (Fig. 12). A bipedicled flap is preferable because of increased vascular supply.

For larger perforations, the inferior advancement floor flaps alone are not adequate for closure, and a superiorly based bipedicled flap may be necessary. This flap can be developed in one of two ways. The mucoperichondral flap can be dissected from the undersurface of the now lateralized upper lateral cartilage; the surgeon does not make an actual incision in the mucosa, thereby preserving even more blood supply. The surgeon can release the mucosa from the upper lateral cartilage without fear of endangering the viability of the dorsal septum and its cartilage. Occasionally even this method does not provide enough mucosa, and a through-and-through superior incision in the mucoperichondral flap at the junction of the upper lateral cartilages and septum is necessary. The incision may be extended posteriorly if needed. The surgeon needs to be aware that the blood supply from the ethmoid vessels comes into the mucosa in this area, and often there is brisk bleeding that must be cauterized. If a bipedicled superior flap is created through this superior mucosal incision, it should be performed only on one side to avoid exposing the dorsal cartilaginous septum bilaterally. Loss of cartilaginous viability in the cartilaginous

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Fig. 10. The effect of making a floor/inferior turbinate flap with advancement of the mucosal floor flap toward the septum to close the perforation. (From Kridel R. The open approach for repair of septal perforations. In: Daniel RK, editor. Aesthetic plastic surgery: rhinoplasty. Boston: Little Brown and Co.; 1993. p. 561; with permission.)

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Fig. 11. A bipedicled floor flap has been advanced toward the wall of the septum, and the perforation has been closed. Note the effect the tension of closure has in rotating the tip cephalad. A bipedicled flap has excellent blood supply.

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Fig. 12. When the bipedicled floor flap cannot be adequately mobilized, especially if the perforation is quite anterior, a unipedicled flap may be necessary.
dorsal area may result in dorsal saddling or a high perforation. Whichever technique is used, a few millimeters of mucosa generally are mobilized (Fig. 13). Furthermore, if the patient has a large dorsal hump and desires simultaneous refinement of this feature, more mucosa can be provided by taking the bony and cartilaginous dorsum after separation of the upper lateral cartilages. The upper lateral cartilages can be resewn later in closure at a lower level, providing more lax tissue. The readers are encouraged to read the article by this author [3] entitled “Combined septal perforation repair with revision rhinoplasty” if they plan to combine septal perforation repair with rhinoplasty, as this can be a very challenging combination of procedures.

Once enough mucosal laxity has been provided by these advancement flaps, the perforation in each mucoperichondral flap is closed using interrupted sutures of either 4-0 or 5-0 chromic or plain gut (Fig. 14). Any granulation tissue or scarring that is present at the periphery of the perforation should be removed before suturing to provide fresh edges that are more likely to heal. At this point, the graft from the temporalis fascia or pericranium or the human acellular dermal graft is used. The interposition graft is placed between the mucoperichondral flaps and brought back posteriorly at least 1 cm beyond the closed perforation. The graft may extend from within a millimeter or two of the caudal edge of the septum to 1 cm posterior to the perforation, depending on the quantity of grafting material available. The graft then should be stabilized to prevent postoperative movement by using a few individual sutures to sew it directly to the septal cartilage remnant. After fixation, the graft should be inspected to ensure that it effectively covers the center of the closed perforation.

The upper lateral cartilages then must be resutured to the septum. If the perforation was large and required superior advancement flaps, it may be difficult to reattach the upper lateral cartilages to the septum at their original height and at the same time avoid tension on the newly closed perforation site. The surgeon may be forced to resecure the upper lateral cartilages to the septum at a lower level, with the potential cosmetic outcome being a pinched appearance of the nasal dorsum. The pinched appearance results from the upper laterals being lower than the central septal dorsum. Recognition of this potential problem could occasion cartilaginous onlay grafts.

Fig. 14. (A) The separated mucoperichondral flaps; the perforation in each flap is readily seen. (B) The perforation is sutured closed on one side. The dark marks identify the interrupted sutures.
Over the reset upper lateral cartilages to provide better dorsal symmetry. When a reduction rhinoplasty is performed at the same time, this pinched appearance is less of an issue.

The intranasal septal flaps must then be mattress-tied together, reapproximating both flaps and sandwiching the interposition graft. Mattressing the septum aids in the healing of the perforation and speeds the revascularization of the graft. It further helps to prevent the occurrence of a postoperative hematoma. The mattress stitch is usually a 4-0 chromic suture, and a continuous suture technique is used (Fig. 15). The needle must be extremely sharp so that it passes freely through not only the flaps, but also the graft, and causes little displacement of the interposition graft. If an acellular human dermal graft is used, the graft is relatively thick and can make passage of the needle more difficult. Mattress sutures must be used above and below the repaired perforation so that the sutures are placed in a plane perpendicular to that of the perforation repair. This suture technique strengthens and reinforces closure.

As noted previously, resupport of the nasal tip support mechanisms is crucial. The medial crura and domes must be resewn together with or without a columellar strut. The nose also should be evaluated at this time to see if there has been any unwanted rotation of the tip because of tension of the closure and continuity of the septal flaps with the mucosa of the medial crura. If unwanted rotation and shortening of the nose have occurred, the surgeon may use a caudal septal replacement graft [22,28] to lengthen the nose or place a large cartilaginous batten in front of the medial crura to camouflage the rotation. A tip graft can also be added that does not extend above the dorsum and thus provides extra length to the tip without increased rotation or projection. The dome cartilages then must be sewn together with permanent sutures, reconstructing the dome complex and preventing postoperative bossae. Routine open external rhinoplasty closure is performed after returning the nasal skin to its normal anatomic position.

The repaired septal flaps now must be protected during their healing phase. Soft pliable 0.02-in thick polymeric silicone sheeting (Silastic, Dow Corning, Midland, Michigan) is placed on both sides of the septal flaps, covering almost all of the septum on each side, and is secured in place by approximately three 5-0 nonabsorbable sutures (Fig. 16). These
sutures should not be overly tight, so as not to constrict the blood supply to the septum. Because the polymeric silicone sheets are transparent, the repair site can be visualized postoperatively with monitoring of the progress of the healing mucosa. Monitoring of the protected repaired site is especially helpful if the surgeon is unable to close the perforation fully. The surgeon can assess the mucosal migration over time and keep the Silastic sheets in place until full healing has taken place. The sheeting protects the graft site from airflow drying and allows safe postoperative suctioning. Keeping the area moist and preventing it from drying out accelerates the healing process. Usually, three mattress sutures are necessary to hold the sheeting in place. If one suture comes out, the others still allow fixation without rotation. The use of hard, thick septal splints, such as the Doyle splint (Xomed, Jacksonville, Florida), is not advocated because they are too firm, are not easy to see through, and hurt the patient on removal.

The nose is packed very lightly with Gelfoam strips (Pharmacia and Upjohn Co., Kalamazoo, Michigan) underneath the inferior turbinates, followed by a small Telfa pack (Kendall Co., Mansfield, Massachusetts) impregnated with antibiotic cream. If too much packing is placed, vascular compromise of the repair site could ensue as nasal swelling develops. The Gelfoam is also helpful because it absorbs any bleeding that results from the development of the bipedicled flaps. The nose is externally taped and splinted, whether or not any dorsal modifications, osteotomies, or grafts have been used. Elevation of the open rhinoplasty flap creates a potential space for blood accumulation and fibrosis postoperatively, and a standard external splint must be placed for prevention.

Postoperative care

All patients are told that there will probably be some bloody discharge postoperatively, because of the raw areas underneath the inferior turbinates. The patient is provided with a large number of 4 × 4 gauze drip pads and tape. Major nasal discharge often subsides after the first 24 hours, but it is usually necessary for the patient to wear a drip pad during that time and for a few days more.

On the first postoperative day, the Telfa packs are removed and the Gelfoam usually is left in place. Sometimes, if closure of the perforation has required superior advancement flaps, it has been necessary to place Gelfoam superiorly. Gelfoam underneath the inferior turbinate and higher in the nasal vault may be left in place. The patient is instructed to use saline nose drops three to four times per day, with at least 10 drops in each nostril. This moisture helps to keep the Gelfoam moist and allows easier suctioning over the next 7 to 10 days. The patient is encouraged to place antibacterial ointment in the nose to prevent postoperative crusting, using cotton-tip applicators. The external nasal splint usually is removed at 5 to 7 days, and the nose is retaped for another 5 days. The nonabsorbable columellar sutures are removed at about the fifth day. The plain gut sutures usually have dissolved by themselves by that time; if not, they are removed.

Careful examination of the site of the previous perforation is performed through the clear Silastic sheeting at each visit. In most cases, the sheeting is left in place for 3 weeks, but it may be necessary to prolong that time if the perforation does not appear to be fully healed. If the Silastic sheeting has been removed and there is still a small area that is unhealed, then the patient is instructed to keep this area moist, using antibacterial ointment three to four times per day in addition to a saline mist.

The patient is instructed not to use any vasoconstrictive sprays, to refrain from smoking, and to avoid noxious fumes during the postoperative phase. Blowing the nose also is to be avoided for the first month postoperatively. For patients in dry climates, a cool mist vaporizer and other forms of humidification are extremely helpful. After the Silastic sheeting is removed, the patients are encouraged to avoid smoking and exposure to noxious chemicals and certainly to avoid using cocaine, if that was the cause, for the rest of their lives.

If the patient had a temporalis fascia graft harvested, the drain is removed on the first day, the pressure dressing is maintained for 2 or 3 more days, and the sutures are removed in 7 to 10 days.

If any crustling is noted over the site of the perforation, it must not be removed, because this may be a healing area. Rather, ointment should be applied until healing takes place, which may take several more weeks.

Outcomes

As noted above, the successful outcome of this operation depends on numerous factors, including the cause of the perforation, its size and location, the skill of the surgeon, and the cooperativeness of the patient postoperatively. Even if one has been unsuccessful in fully closing the perforation, this surgery usually makes it smaller. In the event that complete closure is not possible, all perforations should be closed from an anterior to posterior direction, moving the perforation more posteriorly and thereby decreasing pa-
tient symptoms. A repeat operation, if necessary, can be attempted in about 6 months.

After the perforation is thoroughly healed, the patient can feel the same satisfaction as the physician in the successful closure. Photographic documentation once again can assist the patient in understanding this difficult and complex problem and in seeing its successful outcome. It is amazing to see how well the septum heals with no, or almost no, evidence of previous perforation.

References