Septoplasty Complications: Avoidance and Management

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Although complications after septoplasty are rare, conservative approaches with proper preoperative diagnosis minimize such complications even further. The reported incidence of complications from septoplasty can range anywhere from 5% to 60%.[1,2] Experience, meticulous surgical technique, and comprehensive preoperative planning are all necessary to limit complications. Additionally, the septoplasty surgeon must have a comprehensive understanding of the relevant anatomy, with a specific appreciation for high-risk areas.[3] Although research by Bateman and colleagues[4] has shown that no single surgical maneuver could be identified or associated with an increased risk for septoplasty complications, the need for meticulous surgical technique remains evident. Finally, the importance of experience cannot be understated because it combines methodic and systematic procedure with sound surgical judgment.[3,5]

PREOPERATIVE PLANNING AND EVALUATION FOR SEPTOPLASTY

With any surgical procedure, preoperative planning is essential, and septoplasty is no exception. Nasal obstruction from a deviated septum alone is not always an indication for immediate surgical intervention. Conservative medical therapies should always be attempted and documented before moving forward to the operating room. Significant anatomic obstructions, however, most often still require surgical management.

When evaluating a patient for septoplasty, extensive preoperative assessment is necessary, including a thorough documentation of the patient's past medical and surgical history, allergies, and medications. Two of the more common complications

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from any surgery include bleeding and poor healing. Therefore, it is necessary to review all the patient's preoperative medications, such as anticoagulation and herbal medicines, to reduce these risks. It is also critical to assess the patient's history of tobacco use, because smoking cessation is advised for at least 2 to 4 weeks before and after surgery to avoid delayed nasal wound healing.[1,3] Another consideration in the preoperative workup is a history of intranasal cocaine use. Cocaine users often have abnormalities in the mucoperichondrium leading to decreased vascularity of the septal cartilage secondary to the vasoconstrictive actions of the drug and irritative effects of other contaminating agents. Therefore, this puts these patients at risk for complications during septal surgical procedures.[6]

The presence of significant mucosal disease should raise awareness about several comorbid diseases that may compromise the results of a septoplasty. In fact, any pathologic changes to the septal mucosa on physical examination should arouse suspicion and be evaluated with a biopsy or blood serologies for autoimmune diseases and allergies. The most common changes include chronic inflammation, squamoproliferation, nonnecrotizing granulomas, foreign body giant cells, erosion, and ulceration (**Fig. 1**).[6]

An important step in planning for more complex septorhinoplasty cases includes preoperative photographs.[4] It is crucial to have this confirmation for several reasons, including suitable surgical planning and preparedness, accurate postoperative assessment of aesthetic deformity secondary to the procedure, and protection in the event that litigation is brought about from an unhappy patient.

Finally, as with all procedures, proper informed consent and explanation are important, as is the need to have a thorough discussion of potential complications with the patient. All the following complications, including infection, bleeding, hematoma, septal perforation, scarring, sensory impairment, cerebrospinal fluid (CSF) leak, and aesthetic changes, should be specifically noted, in addition to the necessity of correcting them. The possibilities for revision surgery should also be explained at this time.

ANESTHESIA COMPLICATIONS

Studies have shown that local anesthesia with sedation might lead to fewer complications for patients undergoing septoplasty than general anesthesia. General anesthesia was shown by Fedok and colleagues[7] to require an intervention for bleeding or unintended hospital admission after surgery more frequently. In addition, postoperative
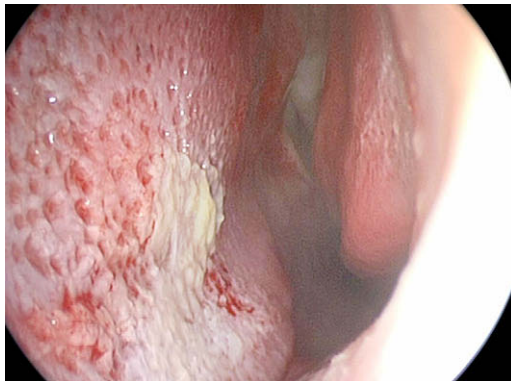

Fig. 1. The anterior septal mucosa reveals chronic inflammation from suspected cocaine use. This inflammation can create a weak or thin mucoperichondrial flap at risk for perforation.

nausea, emesis, and epistaxis rates were higher with general anesthesia, at 36%, 14%, and 3.6%, respectively, compared with local anesthesia with sedation at 8%, 3%, and 0%, respectively. Fedok and colleagues[7] also showed that operating times, in addition to aggregate recovery times, were significantly lower when using local anesthesia with sedation over general anesthesia. When using local or monitored anesthesia care techniques, the authors have found that nasopharyngeal packs are an excellent adjuvant and prevent bleeding into the airway.

The use of topical and injectable anesthetics and vasoconstrictive agents has also been heavily debated, including the use of intraoperative cocaine. Although these drugs have many attractive properties, including rapid onset, prolonged duration of action, vasoconstriction, and decongestant effects, their complications have included mild anxiety, myocardial infarction, cerebral vascular accident, and death. Additionally, there are no present criteria to identify which patients may be at risk for these serious complications.[8] It is important to remember the maximum dosing for each drug. The dose is additive; a 50% toxic dose of two separate drugs may become 100% toxic if they share similar properties. Accordingly, vigilant perioperative patient monitoring with blood pressure, pulse oximetry, and electrocardiography for quick intervention is necessary when using any of these anesthetic medications. Treatment initially includes oxygen, intravenous fluids, and removal of the cocaine-soaked pledgets. If cardiovascular alterations are noted, appropriate anesthesia care is necessary.

FUNCTIONAL COMPLICATIONS

The occurrence of septoplasty complications can be separated temporally. They may be seen at the start of surgery and extend well beyond the completion of the healing phase. Following this time line, the authors review the most common complications.

Hemorrhage: Early

Bleeding or hemorrhage is one of the more common complications of septoplasty, usually occurring during surgery or immediately after surgery. When performing septoplasty surgery, it is important to tell all patients to expect 1 to 2 days of mild oozing after surgery.

True hemorrhage as a result of septoplasty has been reported at a rate of 6% to 13.4%, sometimes requiring admission and overnight observation.[9,10] Acute bleeding during nasal surgery most frequently occurs as a result of poor injection technique or inadvertent mucosal trauma during flap elevation. To prevent bleeding from inadequate injection of local anesthesia, initial topical decongestion with oxymetazoline or cocaine for 5 to 10 minutes before making an incision not only improves visibility but offers the surgeon an opportunity to discern inflammatory mucosal disease from true anatomic septal irregularities. It is beneficial to inject the area in which the incisions are to be made and the important areas of vessel origins (dorsal septum, posterior bony septum, along the nasal floor, and at the anterior nasal spine) adequately. A total of 5 to 6 mL of local anesthesia is typically required for an adequate septal injection when adequate time for vasoconstriction is provided. Proper injections hydrodissect the mucoperichondrium off of the septal cartilage, aiding in flap elevation. In cases of "traumatic" noses or nasal septal fractures, hydrodissection may not work as well and multiple injection sites may help to minimize bleeding.

In terms of traumatic causes of bleeding with septoplasty, in addition to poor technique and accidental mucosal trauma with the septal needle during closure, concomitant intraoperative treatment of turbinate disease is suspected to be the most common cause of postoperative bleeding. The most common source of postoperative

bleeding seems to be from the turbinate incision site for inferior turbinectomies. Given their vascularity, it is important to inject the head of each inferior turbinate with approximately 1 mL of local anesthesia 5 to 10 minutes before turbinectomy. Additionally, submucosal resection of the inferior turbinates with a microdebrider is a nice technique that not only allows for a quicker recovery but minimizes mucosal trauma compared with standard turbinate resection followed by cauterization. After the turbinectomy, oxymetazoline-soaked pledgets can be packed against the head of the turbinate for compression to limit bleeding further. They are then removed after extubation to avoid any bleeding at that time. It is always important to secure the pledget strings to avoid accidental aspiration.

There are many methods to prevent significant hemorrhage from occurring after a septoplasty. Although extensive intranasal cautery often tends to lengthen the healing process and the patient's return to normal function, the use of a fibrin sealant may be an acceptable alternative. Fibrin sealant is a formulation based on a concentrate of human clottable proteins and a highly purified human thrombin. The amount of sealant required truly depends on the area of tissue to be treated. Vaiman and colleagues[11] have shown that fibrin sealant, administered by aerosol spray in endonasal surgery, is more effective and convenient than nasal packing. The sealant facilitates hemostasis and prevents or reduces postoperative bleeding and oozing during surgical procedures. Also, as a human blood product, it stimulates normal wound healing of the operated area. No special treatment is required with the use of fibrin sealant, there is no danger of aspiration, and no antibiotics are necessary because there is no foreign object inserted into the nasal cavity. Vaiman and colleagues[11] have shown that postoperative hemorrhage is 22.9% to 25% when using nasal packing and 3.12% to 4.65% when using a fibrin sealant. In fact, Vaiman and colleagues[12] have shown that when using a fibrin sealant during septoplasties, their patients achieved complete resolution of major symptoms; good tissue approximation; and no hematomas, swelling, synechiae, atrophic changes, or adhesions. In contrast, in their group of patients in whom nasal packing was used, 36.5% of patients incurred some level of bleeding and additional discomfort, including sleep disturbance (93%), lacrimation (26%), and pain (47.2%).[11,12]

Finally, it is important to be aware of unusual causes of bleeding from septoplasty. For example, if heavy intraoperative bleeding occurs, it could be secondary to rare occurrences, such as an internal carotid artery-cavernous sinus fistula causing a hyperemic and reactive nose. Be aware of additional signs and symptoms of this complication, including a developing orbital proptosis, deterioration of visual acuity, and pulsating tinnitus.[1]

Cerebrospinal Fluid Leak: Early

Another complication of septoplasty that is exceedingly rare but deserves discussion is CSF leak. This complication is caused by a tear of the dura mater surrounding the brain and its supporting structures of the skull base, which therefore produces a leak of fluid through the formed connection between the subarachnoid space and the nasal cavity. This problem is extremely unusual after septoplasty, but it can be a serious and life-threatening complication if not managed quickly and appropriately. Nasal surgery is the second most common cause of CSF leakage, second only to traumatic skull base fractures. CSF leakage typically occurs early on in the postoperative period, but it may sometimes be days before symptoms develop. Classic presentations include CSF rhinorrhea, headaches, and a salty or metallic postnasal drip.

The literature reports that CSF leakage can occur when elevating the septal mucoperichondrium with a Cottle elevator and tunneling too superiorly on the septum,

beyond the limits of the ethmoid roof, or by fracturing the perpendicular lamina, which subsequently can fracture the cribriform plate.[13,14] These areas are at risk because of an intimate connection of dura to a weak and thin bone structure.[13] The anterior cranial fossa is the usual site of this complication, with the roof of the ethmoid sinus and the cribriform plate as the most common sites. CSF leaks in the roof of the frontal and sphenoid sinuses are more likely to occur during endoscopic sinus surgery rather than during septoplasty surgery. When performing a septoplasty and a high bony septal deviation needs to be addressed, a controlled break of the perpendicular plate with a 4-mm chisel or Caplan scissors provides safe separation of the perpendicular plate from the skull base (**Fig. 2**). This is particularly important to remember when re-pairing a nasal septal fracture, especially in the case of a "twisted" nasal septum when the dorsal septum is already malpositioned, likely requiring manipulation.

Early recognition of this complication is important. CSF rhinorrhea may be the first sign. In some cases, if a proper diagnosis is not made, there can be enlargement and remodeling of the bone over time and a dural defect, leading to herniation of the meninges and brain tissue through the defect by pulsation of the brain. This type of skull base defect after septoplasty would subsequently put the patient at risk for an ascending infection. The patients can sometimes present late with the symptoms of meningitis.[13] If septoplasty surgery is performed extremely superiorly in the nasal cavity, avoidance of barometric pressure changes is recommended for 4 weeks after surgery.

The best way to minimize CSF leakage complications after septoplasty is through prevention and early diagnosis. Tawadros and Prahlow[15] have shown that the risk for having a CSF leak after nasal surgery is increased in patients with a low-lying crib-riform plate of the ethmoid roof, specifically found at a level inferior to two thirds of the orbit height on the preoperative CT scan. It is also imperative to prevent this compli-cation with good realization and preoperative awareness of anatomic variations and a less aggressive septoplasty method, especially when manipulating the perpendic-ular plate attached to the ethmoid roof.[14]
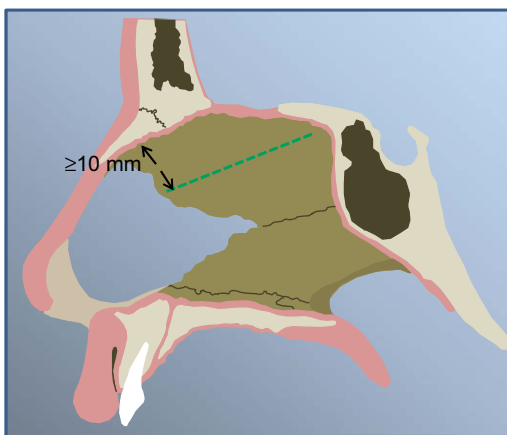

Fig. 2. A controlled cut through the perpendicular plate of the ethmoid reduces torque on the skull base. This should minimize injury to the olfactory groove and cribriform plate. It is important to maintain a 10-mm dorsal strut at the bony cartilaginous junction (seen here). Aiming the chisel or scissors toward the sphenoid sinus should also prevent inadvertent anterior skull base penetration.

If CSF leak has occurred, antibiotics should be given immediately for meningitis prophylaxis. Conservative management of CSF leaks is preferred, with placement of a lumbar drain, reserving surgical repair for patients with a persistent leak despite these therapies. The defect may be approached endoscopically or transcranially to allow for a multilayer repair. If this complication occurs during surgery, it can be repaired endoscopically at that time once informed consent for the additional procedure is obtained.[14] Preoperative informed consent for the septoplasty should include this information, but stopping to inform the patient's family and obtain neurosurgical consultation is recommended. Surgical treatment options for CSF leak repairs include intra- and extracranial approaches, in addition to transcranial approaches, if you need to prevent recurrent meningitis in patients with large defects.[13] Transnasal endoscopic repair is now the standard technique being performed. It is critical to note that meningitis and hydrocephalus can impair the endoscopic correction of a CSF leak and may lead to a poorer surgical outcome.[13]

Infection: Early-Intermediate

As with any surgical procedure, postoperative infection is an important complication to prevent. Overall, there is a 0.48% to 2.5% chance of infection occurring secondary to septoplasty surgery, with infection most likely to occur immediately after surgery.[1,16] Postoperative septoplasty infections are typically localized to the septum and nasal cavity, but they can rarely occur in the form of more dangerous threats, such as meningitis, cerebritis, subdural empyema, brain abscess, and even cavernous sinus thrombosis.[1]

The pathogenesis behind infections after septoplasties stems from the fact that the upper respiratory tract is colonized with many normal bacterial floras. The mucous membranes act as a protective barrier and aid in processing foreign bodies. During septoplasty, those mucous membranes are traumatized and can put the patient at risk for infection and bacteremia by the vascular route within the nasal mucous membranes.[17] There is evidence of transient bacteremia that occurs during open septorhinoplasty. Transient bacteremia is usually harmless in healthy subjects and usually resolves spontaneously without complications; however, the possibility of bacteremia during septoplasty surgery must be kept in mind, and the necessary precautions should be taken before surgery in patients with high risk for cardiovascular infection because this can lead to a dramatic result.[17] Additionally, if septoplasty involves the use of nasal packing for 48 hours after surgery, the risk for bacteremia increases.[18] Even when there is no bony laceration, intracranial infection can occur by direct invasion by way of venous and lymphatic channels of the mucoperiosteal lining of the nasal septum, which is frequently traumatized during septoplasty.[1]

Some patients undergoing septoplasty may be predisposed to infection. It is known that nasal septal deviation impairs mucociliary transport. Septoplasty surgery to fix a deviated septum can significantly improve mucociliary transport; however, the procedure does impair mucociliary transport in the intermediate postoperative stages. Complete recovery of this transport system is established 5 days after surgery if the basal cells and basement membrane of the mucosa remain intact.[19] As noted here, the change in the mucociliary transport system might contribute to an altered nasal mucosal pathogen environment after surgery. Eviatar and colleagues[20] have found that although there is not a major difference in bacterial cultures before and after surgery, as implied by the dominance of *Staphylococcus aureus*, a change in nasal culture results does exist. So, although surgery does not completely disrupt the balance among nasal bacteria, changes in the cultures in the first postoperative month might indicate that the procedure caused mucosal abnormalities secondary to

secretions, stasis, crusting, and packing after surgery. These events and circumstances suggest the importance of local environmental factors, aside from growth of bacteria in blood-absorbent packing matrix, in promoting the growth of S aureus.[21]

Although transient bacteremia may occur and be completely asymptomatic, there have been reported cases in which the dangerous systemic toxic shock syndrome has occurred secondary to septoplasty.[21–23] S aureus, considered an important pathogen in the genesis of nosocomial infections, is a frequent cause of bacteremia in postoperative patients.[17] Most physicians credit the nasal packing as the mechanism behind this severe infection. The mechanism is compared with toxic shock syndrome secondary to tampon use on a large mucosal surface.[21,22] When systemic changes, such as fever, diffuse erythroderma and subsequent peripheral desquamation of the hands, hypotension, vomiting, diarrhea, and multisystem complaints with laboratory abnormalities, take place, the patient should be treated promptly, with removal and culture of the nasal packing and hospitalization for the administration of fluids, empiric antistaphylococcal antibiotics, and possibly vasopressor medications.[21,22] This condition warrants early suspicion, recognition, and initiation of appropriate treatment so as to avert significant morbidity and mortality. Given this potential risk and patient discomfort, it may be beneficial to avoid nasal packing unless it is required for uncontrolled bleeding, which is rare.

Septoplasties are considered potentially contaminated operations, but the proportion of patients developing a postoperative infection is small; therefore, perioperative systemic or postoperative antimicrobial prophylaxis is unnecessary.[16] Caniello and colleagues[18] have found that regardless of whether or not antibiotics are used, there is no concerning difference in terms of pain, fever, nausea, vomiting, bleeding, and purulent secretions. In addition, the downside to the indiscriminant use of antibiotics includes severe complications, such as toxic reactions and reduction of the antibody formation stimuli, in addition to representing high costs and encouraging less strict compliance with good surgical practice.[18] The senior author (SAG) regularly provides preoperative antibiotic prophylaxis before induction for all patients undergoing septoplasty. Postoperative antibiotics are given only to those patients who have structural grafting or some type of splint or packing placed. In this situation, 3 to 5 days of treatment should be sufficient.

Again, as with any surgical procedure, there are some circumstances in which antibiotics are necessary. Patients with significant comorbid immune-related conditions, such as diabetes or compromised immunity, may receive prophylactic antibiotics. After surgery, in cases of acute or chronic infection of the operative site, use of cartilage grafts, implantation of allogenic materials, presence of a hematoma, mechanical blockage attributable to nasal packing, or postoperative nasal obstruction producing rhinosinusitis, antibiotics should be administered.[1,16]

Septal Hematoma or Abscess: Intermediate

If unrecognized and not treated, septal hematoma is a significant complication of septoplasty. A septal hematoma may arise in the dead space created between the mucoperichondrial flaps when the cartilage or bony septum is removed during septoplasty. This space is susceptible to accumulation of blood products and the formation of a septal hematoma.[24] The hematoma that forms after surgery can itself lead to several other complications, including ischemia and necrosis of the septal cartilage, decreased septal support, and impaired nasal function. A septal hematoma may also subsequently lead to the formation of a septal abscess, with Staphylococcus, Haemophilus influenza, and, rarely, Pseudomonas being the most common pathogens (**Fig. 3**).[1]
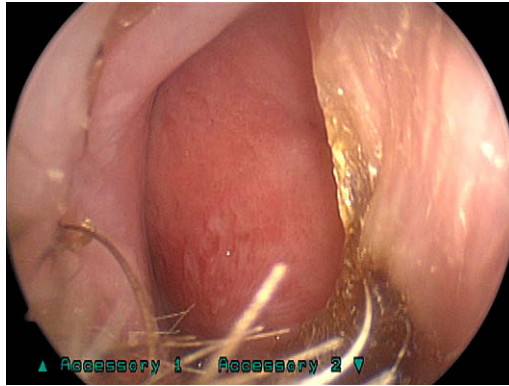
Fig. 3. A septal abscess is seen after septoplasty. It is bulging into the right nasal cavity causing complete nasal obstruction on that side. This complication must be drained immediately to prevent further destruction of the remaining septal cartilage.

To treat a septal hematoma, one must first be able to make the diagnosis effectively. Often, a septal hematoma can be confused with significant postoperative hemorrhage. One way to differentiate between the two entities, other than direct intranasal visualization, is the time of occurrence. A septal hematoma most often occurs during the final phases of surgery and does not appear until the packs or splints are removed.[1]

One method of prevention is the replacement of nasal packing with a continuous mattress or interrupted septal suturing technique. According to Lee and Vukovic,[25] this technique reduces the possibility of a septal hematoma by providing a fine closure, closing any inadvertent tears in the septal mucosa in addition to giving support to the cartilage pieces retained after the septoplasty and keeping them in optimal position. In addition, it reduces patient discomfort by eliminating the need for nasal packing. These are considerations that may outweigh the minor increase in operating time that it takes to perform the suture. Hari and colleagues[24] agree that the use of transseptal sutures obviates the need for packing after surgery. These researchers promote an endoscopic septal suturing technique using a curved needle that they have shown is a more precise method than using a straight septal Keith needle, reducing the risk for accidental needle trauma to the turbinates. Additionally, by placing the knot in the vestibular skin, these researchers have demonstrated a reduction in the risk for intranasal granulation tissue formation. Given this information, however, the senior author (SAG) uses a shorter 11-mm septal Keith needle and closes the mucosal flaps starting anterior to the nasal valve, working along the dorsum and moving posteriorly back to the anterior head of the middle turbinates. The aid of loupes avoids the additional equipment setup. The endoscope is certainly helpful if the middle turbinates are being medialized with the suture in concomitant sinus or concha bullosa surgery. It is important to ensure adequate tension along the suture if there is still slight convexity of the septum. A mild curvature is better treated first with scoring techniques, structural grafting, or additional techniques as opposed to relying on the suture. The position and redraping of the mucoperichondrial flaps is also paramount for balanced healing. The suture knots are removed at 7 to 14 days to minimize crusting and to avoid minor bleeding or irritation. Septal stitches that are supporting grafts are maintained for 2 weeks to allow for resolution of nasal edema. One must be certain not to tighten septal sutures excessively because this may prolong edema and possibly cause septal necrosis.

Should a septal abscess develop, it should be drained immediately. This is most often done first with needle aspiration and then by reopening the septal incision, allowing the abscess to drain. Bilateral nasal packing should then be placed to eliminate septal dead space and prevent fluid reaccumulation. If grafts were used during the operation, they should be removed at that time, if they have become separated. Delayed reconstruction of completely reabsorbed septal cartilage after an untreated septal hematoma or abscess is necessary to prevent septal deformity and further complications. This is done using septal bone, ear cartilage, or even specially prepared allogenic human costal cartilage.[9] Antibiotics should be given after surgery and drainage to prevent further infection and abscess reformation.[1]

Overcorrected Septum: Early or Late

Because of its inherent nature and its underlying structure, septal cartilage is highly unpredictable when disturbed. At the basic level, septal cartilage is a system of interwoven fibers under stress. The stress on the right side of the nasal septum balances the stress on the left side of the nasal septum. Combined, this stress provides equilibrium, allowing the cartilage to remain straight and not curl toward one particular side or the other. Should this equilibrium of stress be disturbed because of injury or surgery, the cartilage could curl or bend away from the weakened side.

Many techniques exist to alter or stabilize septal cartilage. Alterations in the cartilage may range from simple crosshatching of the concave surface to release the surface tension or more aggressive techniques that include partial or full thickness slicing or fracturing of the cartilage, with or without removing the pieces. When full thickness cuts are employed maintaining one mucoperichondrial flap aids the stabilization.[26] Structural grafting provides long term support while internal or external splinting can stabilize the nose during the early phase of healing. For example, one of these techniques uses microcuts in the cartilaginous surface, which can cause stress disequilibrium on the cartilage and may put the septum at risk for secondary curling.[1] One way to correct for this is to reinforce the weakened septum with a Mustarde stitch[27] followed with or without structural grafts. Autogenous cartilage grafts or bone from the posterior septum is used for this purpose because both form a support for the natural septum and have a better chance to endure compared with other implants.[1] Another way to prevent overcorrection of the septum is to provide septal fixation once the intraoperative reconstruction is complete. Fixation can be performed intraseptally, intranasally with packs and or splints, externally by taping through the use of mattress sutures through all layers of the caudal septum, or with a combination of these techniques. Schwab and Pirsig[1] have stated that because of the unpredictability of septal cartilage, none of these techniques always achieves the desired results. The unpredictability, in part, comes from "the memory effect" of cartilage. This is not well understood, but it essentially accounts for the warping of the cartilage back to the preoperative state after septoplasty. This represents one of the reasons why recurrent deformities and deviations can occur. Unfortunately, this is a circumstance that is not always under the control of the surgeon.[9] Given that this is a problem with septoplasty that can be out of the surgeon's hands, it should be explained in layman's terms and included as part of the informed consent process. This problem probably accounts for many of the revision septoplasties that are performed (**Fig. 4**).

To account for this septal unpredictability, many surgeons have compensated clinically by overcorrecting the septum. This complication of septoplasty particularly affects younger patients because they are at higher risk. The incidence of septal overcorrection overall is 2.0%, whereas the incidence for patients younger than the age of 20 years is 7.3%.[28] It is theorized that the need for overcorrection in younger patients
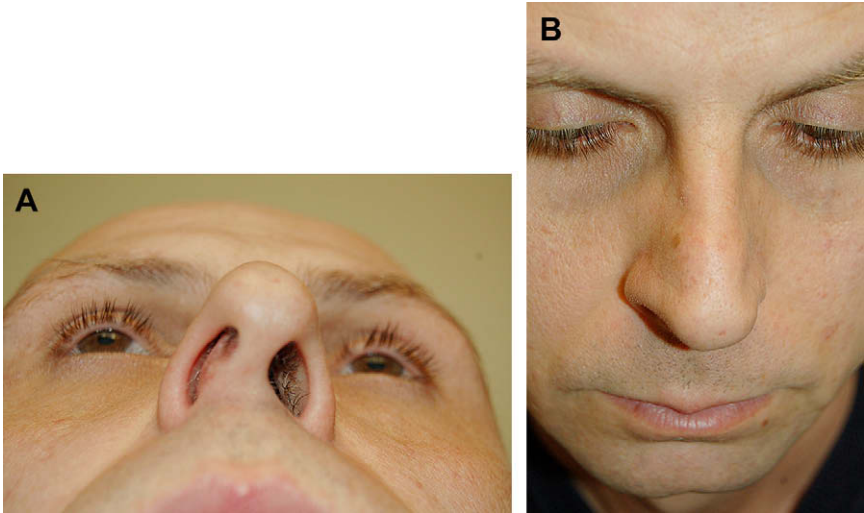
Fig. 4. These photographs demonstrate a postoperative caudal deflection that occurred 2 weeks after the patient's septoplasty. His nose also reveals a nasal pyramid asymmetry that was not addressed at the time of primary surgery.

is related to the growing quadrangular cartilage. According to Lee and colleagues,[28] the central quadrangular cartilage has a high level of metabolic activity, cell replication, and proliferative capacity, all of which decline with age. The anterior free end of the cartilage, however, retains high levels of these aspects throughout the aging process. When overcorrection does occur, it usually presents with symptoms of nasal obstruction on the opposite side of the initial deviation, at least 1 month after the operation is performed.

Septal Perforation: Late

Septoplasty or nasal surgery is the second leading cause of septal perforation after trauma. It is usually a late complication of septoplasty, with an occurrence rate reported between less than 1% and as high as 6.7% (**Fig. 5**).[1,2,5,9,29,30] This complication

Fig. 5. This patient had a prior septoplasty after a nasal injury. An anterior septal perforation with an additional synechial band is seen at the level of the inferior turbinate.

usually arises as a result of bilateral mucosal tears in corresponding areas on the septum. The symptoms of septal perforation include nasal obstruction, crusting, dryness of the mucosa, intermittent epistaxis, nasal discharge, rhinorrhea, abnormal airflow, whistling during inspiratory nasal breathing, headache, and local pain. Most perforations are small and anterior, interfering with the humidification of inspired air. Larger perforations can lead to other nasal problems, such as atrophic rhinitis. Some perforations may even continue to enlarge and then compromise the structural support mechanisms of the nose, causing a saddle nose deformity.[31] That being stated, most septal perforations are asymptomatic, especially if they occur in the posterior cartilaginous septum. It has been reported that 62% of patients with septal perforations do not experience any symptoms at all.[9,30–32]

Prevention has been found to be the best way to avoid this complication. Otolaryngologists or nasal surgeons need to have a keen awareness of their dissection during septoplasty. Gentle elevation of the mucoperichondrial and mucoperiosteal flaps, especially at the junction of the septal cartilage, vomer, and perpendicular plate of the ethmoid, can help to prevent septal perforation.[2] A common error in nasal septal surgery is the inadvertent dissection in a supraperichondrial submucosal plane (**Fig. 6**), thus leading to perichondrial or periosteal resection and only leaving behind mucosa.[31]

As Kim and colleagues[31] have discovered, the perichondrial layer imparts most of the biomechanical strength to the septal lining. Lining flaps containing perichondrium and mucosa are stronger then flaps with perichondrium or mucosa alone. Dissection in the subperichondrial plane during septal surgery provides a stronger septal flap and may prevent the development of nasal septal perforation during septoplasty and other nasal surgery.

Any intraoperative perforations should be repaired immediately. Simple interrupted 5.0 chromic sutures are placed endoscopically at the time of injury to aid in mucosal healing and prevent perforations. Tears occur mostly over convexities, spurs, or crests, and the resulting surplus of mucosa facilitates endonasal sutures without tension.[9] Vertical tears may be worse than horizontal tears because the septal vessels tend to run forward in an oblique fashion.[2] Additionally, tight suturing of the tears with the use of septal splints and nasal packing should be avoided because septal necrosis can occur.
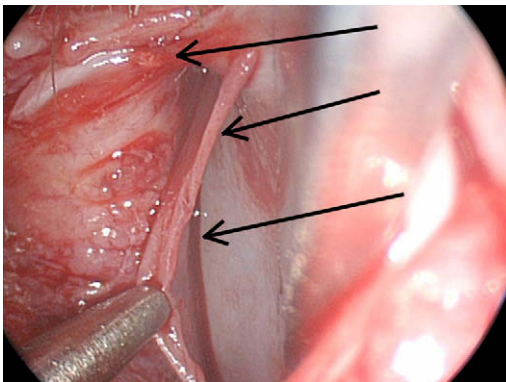

Fig. 6. This photograph reveals the elevation of the septal flap with subperichondrial and submucosal layers. The surgeon needs to stay underneath the perichondrial layer to maintain flap integrity. Submucosal side of mucosal flap (*top arrow*); perichondrial flap (*middle arrow*); subpreichondrial plane above septum (*bottom arrow*).

When septal perforations occur, they should first be managed conservatively with observation and improved nasal hygiene, such as humidification. Even placement of a silastic septal button is a simple procedure to help lessen patient symptoms. If a patient is still experiencing symptoms, a delayed repair can be an option. Closure is usually necessary to alleviate breathing problems, bleeding, crusting, frontal headaches, and nasal whistling. A residual posterior septal deflection of the septum is often present and may also require treatment. It is critical not to destabilize the nose when attempting this repair. It is important to correct these defects because perforations do have a tendency to enlarge slowly over time. Patients often exacerbate the problem and enlarge the size of the perforation from repeated trauma and picking at the crusting that occurs. Again, ample humidification mitigates the intranasal crusting, hopefully avoiding some of these issues.

Bilateral bipedicled mucosal flaps with autogenous grafts seem to be the method of choice for closure of small- to medium-sized (<20 mm) nasoseptal perforations.[30] Closure using this method has resulted in a 90% closure rate and significant improvement in patients' symptoms.[32] Similar results utilizing acellular dermis or porcine small intestine sub-mucosa grafts have also been reported.[33,34] Depending on the type of perforation, a unilateral flap might be more advantageous. The advantages include the fact that it is less invasive and it limits the septal donor area to one side. Additionally, an open or external rhinoplasty approach is sometimes useful because it may facilitate the placement of large connective tissue or homologous grafts to replace the septal cartilage defect.[32] This method is extremely helpful for exposure, especially in helping to close larger (>20 mm) septal perforations.

Adhesions or Synechiae: Late

Adhesions, also known as synechiae, are inflamed bands of adherent mucosa that may cause postoperative nasal obstruction after septoplasty or other sinonasal operations. They are especially common spanning opposing surfaces of abraded or injured mucosa in the nose, most commonly occurring between the septum and inferior or middle turbinates (see **Fig. 5**). They are a common complication of septoplasty, occurring in approximately 7% of patients.[2] Adhesions occur during the late wound-healing phases of recovery. The patient usually remains asymptomatic if the adhesions occur posterior enough; however, patients may complain of postoperative disturbances, attributable to adhesions, from the change in the direction of their nasal airflow.[9] Additionally, not only do adhesions occur intranasally but intercartilaginous incisions for a septorhinoplasty may cause internal nasal valve synechia and result in nasal obstruction from internal nasal valve scarring and narrowing.

Like most complications of septoplasty, the best way to decrease the formation of adhesions is to prevent them. Adhesion formation is best avoided by controlling postoperative infection and minimizing trauma at the time of surgery. There is a great deal of debate in the otolaryngology community about the proper way to prevent adhesions and maintain support of the septum after surgery. Many reports have been published with differing views on the most appropriate method. Here, the authors compare the three most common.

Endonasal applied splints are commonly used to stabilize the reconstructed septum and to prevent the formation of synechia.[1,9] They are usually made of silastic sheeting, and they are left in place for approximately 1 to 2 weeks after surgery. The senior author (SAG) tends to use thin 0.5-mm silicone sheets along the septum if there is significant mucosal trauma or Reuter type splints if the mucosal injury is close to the internal nasal valve and valve support is needed. Although septal splints have been shown to protect against synechiae, there are many disadvantages to using

these splints. There seems to be a considerable increase in morbidity when using nasal splints because they can cause a significant increase in pain and discomfort after surgery, especially at the 1-week mark. As a result of nasal splinting, there is a high frequency of drip pad changes related to an increased sanguinous nasal drainage anteriorly and frequent episodes of emesis, potentially indicative of increased posterior drainage, both of which contribute to patient discomfort.[35–37] Interestingly, Malki and colleagues[35] have shown that there is no significant difference in the incidence of adhesions between splinted and nonsplinted patient groups and that if the aim is to prevent adhesions, nasal splints are not justified. Therefore, many surgeons argue that there are no clear advantages to inserting intranasal splints and they should be used sparingly, if at all.[37]

The level of discomfort that patients were experiencing with nasal splinting for long periods led otolaryngologists to employ the use of nasal packing. Usually, nasal packing is used for 4 to 7 days; however, studies have shown that 1 day of intranasal packing is exceedingly preferable to that of 2 or more days because of less patient discomfort and increased cost-effectiveness without an increase in complications.[38] In a study by Schwab and Pirsig,[1] patients with nasal packing were less likely to develop recurrent septal deviation and synechiae and were more likely to have an improvement in the nasal airway, namely, 96% of the patients in the nasal packing group and 64% in the group without nasal packing. Guyuron and Vaughan[36] have shown that when using nasal splints, 60% of patients exhibit discomfort, compared with 22% of patients with nasal packing. Additionally, recurrent septal deviation occurred in 25% of patients who were splinted, as opposed to 23% of those who were packed. Despite the data supporting nasal packing over splinting, in terms of recurrent septal deviation, the role of the septal splint has been relegated to selected cases in which support for the reconstructed nasal septum is necessary.[35]

Although it may seem that most doctors would choose nasal packing as a quick and easy way to support the septum, there are still drawbacks to using this as well. Nasal packing can cause injury to the nares, septum, and nasal mucosa. The packing can dislodge, leading to a risk for aspiration. Long-standing nasal obstruction from packing can lead to nose bleeds, and if the packing remains in place and the patient is not taking antibiotics, it can lead to further infections of the nose, sinuses, and middle ear.[1] Yildirim and colleagues[39] considered the complications related to nasal packing and pointed to the fact that nasal packing after septoplasty causes significant eustachian tube dysfunction, reduction in P_{O_2}, and elevation in P_{CO_2}. The more recent use of septal sutures avoids this gas exchange abnormality, and this same group now believes that it should be the preferred method of nasal septal stabilization as an alternative to intranasal packing. The advantages of septal suturing include the elimination of discomfort for the patients, minimal complications, and septal support outcomes that are almost the same as with nasal packing. When septal suturing is used, there is also a reported shorter hospital stay after septoplasty.[40]

Finally, companies are currently working on products to make septoplasty easier and improve septal support after surgery. Septal staplers are currently in early development; however, long-term studies and cost-benefit ratios are still needed.

Sensory Disturbances: Early-Late

Other complications of septoplasty, and often the most disturbing to the patient, involve the risk for sensory disturbances. These complications include anosmia, palatal sensory impairment, gustatory rhinorrhea, and even blindness.

Anosmia or hyposmia occurs in approximately 1% of patients undergoing septoplasty, with total anosmia on long-term follow-up occurring at a rate of 0.3% to

2.9%.[1,5,9] Transient anosmia can be attributable to nasal packing, clotted blood or crusting, and mucosal edema in the immediate postoperative period. Postoperative anosmia is most likely associated with viral infection, scarring of the ethmoid region, or rare injury to small fibers of the olfactory nerve.[1,9] Although there is little in the way of preventing this occurrence, it is important to understand when this dysfunction occurs. Preoperative testing of olfaction is necessary for comparison with the postoperative state. Should there be any preoperative olfactory disorder, whether temporary or permanent, it should be documented and drawn to the patient's attention.[41]

Some level of sensory disturbance to the anterior palate and central incisors has been reported in 2.8% of patients after septal surgery.[42] This is most likely a result of nasopalatine nerve injury and seems to be secondary to chiseling of the maxillary crest. Conservative resection along the maxillary crest is therefore recommended. Chandra and colleagues[42] also believe that there is a relation between this complication and the use of monopolar suction cautery. To that extent, electrocautery should be avoided near the incisive foramen to minimize this complication. It could be advantageous to make use of bone wax to control blood loss first and to only resort to cautery if necessary.

Guyuron and colleagues[43] have also reported on seven patients with gustatory rhinorrhea after septoplasty. These patients experienced a profuse flow of thin clear nasal drainage on mastication. These researchers postulate that similar to the palatal sensory disturbance, this may be caused by inadvertent injury to the nasopalatine nerve within the septal layers after removal of the deviated portion of the vomer and the perpendicular plate of the ethmoid bone. These patients were treated with antihistamines, which proved to be helpful in these cases.

Additionally, the loss of vision is a rare and frightening complication of septoplasty. The pathogenesis of blindness after a septoplasty may not always be the same, and it may actually arise by means of a variety of mechanisms. One mechanism relates this complication to the use of high-pressure intra-arterial injections of local anesthetics and vasoconstrictors. When these solutions are injected into the membranous part of the caudal septum or into the turbinates, retrograde flow of the injected substances can get into the branches of the ophthalmic artery. These substances can lead to embolism and subsequent occlusion of the feeding vessels of the ophthalmic artery, causing unilateral blindness. Schwab and Pirsig[1] and Monteiro therefore postulate that the loss of visual acuity is best prevented by injecting anesthetic solution (<10 mL) and by avoiding multiple injection sites to reduce the risk of intra-arterial injection. The authors additionally recommend a slower injection to lower the pressure of the injection.

Although rare, direct trauma during septoplasty is another mechanism that has been reported to have caused blindness. While performing a septoplasty, an instrument used to fracture the bony part of the septum may be placed too high and too laterally in the posterior nasal cavity, reaching the area of the optic canal.[44] Again, the importance of recognition and diagnosis of these complications cannot be understated.

AESTHETIC COMPLICATIONS
Deformities after Septal Surgery

The risk for aesthetic complications after septoplasty has specifically been reported as between 4% and 8%.[9] Of these aesthetic complications, there is a 21% to 39.5% risk for a minor aesthetic change and a 1% to 4.5% risk for a major aesthetic change.[4,5,27] There are three major types of septal deformities that may occur secondary to septoplasty. The deformities include aesthetic changes in tip projection, supratip

depression or dorsal saddling, and columellar retraction. In some cases, more than one of these complications can occur at a once, and the deformities are often interrelated. According to Daudia and colleagues,[27] the incidence of a minor change (≤2 mm) in tip projection is 22.5% and the incidence of a major change (≥3 mm) is 3.5%. The incidence of minor saddling is 2.7%, and that of major saddling is 0%. The incidence of minor columellar retraction is 15.4%, and that of major retraction is 0%. Interestingly, Vuyk and Langenhuijsen[4] have shown that there is no relation between general surgical risk factors for septoplasty and the possibility of aesthetic deformity after the procedure. Additionally, there is no increased risk for aesthetic complications in patients who have had previous septal surgery, a frequent situation for patients undergoing septoplasty.

Generally, these aesthetic nasal deformities can occur secondary to a loss of support, cartilaginous mobilization, weakening, and partial resection. For example, after a partial septal resection, if the patient is left with a short dorsal strut, which is now mobile and not properly fixated, the anterior septal angle could counterrotate downward and inward, leading to all three of the previously mentioned deformities.

It is important to keep in mind that although many of the complications of septoplasty happen during surgery, there are a few of these complications that may occur during the recovery period. For example, deformities can occur secondary to scarring between the columellar skin and mucoperichondrial septal flap, with subsequent inward contraction of the columella and nasal vestibule.[4] Scarring has been shown to be less prevalent when incisions are made over underlying cartilage, as witnessed with a hemitransfixion incision. Poorly designed incisions or inadequate closure technique can lead to entrapment of epithelium into the suture line from the nasal vestibule or lining mucosa. Additionally, scar formation can occur secondary to excessive cauterization of the nasal mucosa. Therefore, the surgeon must be cautious when using this tool to prevent tissue necrosis from the cautery.[1]

Saddle Nose and the Widened Nasal Base

Saddle nose deformity is caused by septal instability and inadequate dorsal cartilage support. The K area, or keystone, is a critical area in which the septal cartilage, paired nasal bones, perpendicular plate of the ethmoid, and upper lateral cartilages meet. When the K-area is disturbed, it can act as a pivot point for the cartilage, leading to the downward and inward rotation of the anterior septal cartilage. This direction of rotation also may cause a subsequently widened nasal base.[9]

A saddle nose deformity is of particular concern among children. As Schwab and Pirsig[1] have pointed out, the introduction of septal trauma or surgery can inhibit the growth of the child's nasal cartilage early in life, and although the septum is fixed in childhood, it can develop into a saddle deformity after puberty. Again, this is partially attributable to the mechanical and biochemical properties of the damaged nasal cartilage.

Saddle nose deformity can be prevented with appropriate septal stability. One way to accomplish this is by keeping the mucosa attached on one side of the septum when tunneling and raising mucoperichondrial flaps. This provides adequate support and preserves the fibers to the premaxillary wing and the anterior nasal spine.[9] Additionally, if septal cartilage is resected to remove a septal deviation or for grafting purposes, it is important to maintain a 1-cm "L-shaped" strut of cartilage along the nasal dorsum and caudal septum to prevent dorsal collapse. Another way to prevent this complication is by making sure that the junction between the septal cartilage and perpendicular plate of the ethmoid bone remains intact and impervious to mobilization. As a precaution, remember to check the mobility of the caudal septum and fix it with a Wright

suture into the nasal spine if it lacks stability. A dislocated septal cartilage can be repositioned with a guide suture through the columella. This is done with a figure-of-eight stitch to avoid lateral displacement of the caudal septum.[9] At the conclusion of the case, gentle palpation of the dorsum and tip support should be standard. If subtle weakness is present, additional techniques should be performed before waking the patient.

Fig. 7 reveals a patient who had a deviated septum corrected with a trans sphenoidal hypophysectomy approach for a pituitary adenoma. One month after surgery, she developed a dorsal cellulitis that cleared quickly with a course of antibiotics. No evidence of sinus disease was seen on endoscopy in the sphenoethmoid recess. As her nose healed, left nasal obstruction occurred. Her midvault and internal valves collapsed. These were repaired with a small butterfly graft 6 months after the infection resolved.

Loss of Tip Projection

A loss of tip projection can arise when there is resection of the septum at the attachment point to the perpendicular plate or resection of the basal strip of septal cartilage. With these two areas of cartilage resected, mobilization of the septum can take place, effectively leading to ventral nasal collapse.[4] Essentially, in this example, the caudal septum is not appropriately fixated to the anterior nasal spine, leading to a drooping nasal dorsum and sometimes to columellar retraction. Additionally, there is an increased risk for nasal vault collapse and nasal obstruction in patients who have short nasal bones with long upper lateral cartilages.[3]

One way to prevent this problem from occurring is to drill a groove into the premaxilla. This groove can be used to stabilize the septum in place and provide improved fixation.[1] Other ways to correct for loss of nasal tip projection include such techniques as columellar strut grafts, dome-binding sutures, extended columellar strut-tip grafts, caudal extension grafts, premaxillary grafting, shield-like tip grafts, and various onlay tip grafts.[3]

Fig. 7. (A) Anteroposterior view seen 4 months after surgery with slight concavity in the mid-dorsum. (B) Left lateral view reveals mild 1- to 2-mm midvault collapse causing internal valve collapse.

Columella Retraction

Columella retraction can also transpire in the same manner by which a loss of tip projection occurs. Cartilage resection without proper dorsal and caudal cartilaginous struts or reconstruction causes instability and mobilization at the K-area pivot point.[1]

This deformity can also occur secondary to scar contracture, pulling the remaining septal strut in a ventral and cephalic direction, causing supratip saddling and columellar retraction in addition to possible loss of nasal tip projection. For this reason, it is important to allow 3 to 9 months to pass before evaluating for deformity.[4] Just like the previously listed aesthetic complications of septoplasty, a proper septal reconstruction technique that provides stability for the septum is the only way to prevent this from occurring. In addition, as stated previously, cautious surgical skill that minimizes trauma and scarring is essential.

SUMMARY

Complications after septoplasty can profoundly compromise a patient's functional and aesthetic outcome. The problems associated with septoplasty can lead the nasal airway to obstruct from a loss of support or as a result of the contractile forces of scarring. Incomplete resection, inadvertent nasal trauma, or even overcorrection of the septum may be at fault. It is therefore important for every nasal surgeon performing this procedure to be thorough and meticulous. A surgeon with a strong knowledge base and experience, quality surgical technique, and extensive planning can minimize these complications from occurring.

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