Current Otorhinolaryngology Reports (2022) 10:271–277
https://doi.org/10.1007/s40136-022-00416-3

FACIAL PLASTICS: FUNCTIONAL RHINOPLASTY (TD WANG AND CZ JOHNSON, SECTION EDITORS)

Septal Perforations: A to Z

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Accepted: 29 June 2022 / Published online: 11 July 2022

Abstract

Purpose of Review This article aims to provide a comprehensive review of nasal septal perforations from diagnosis and workup to surgical management options**.**

Recent Findings Nasal septal perforations can present both diagnostic and management challenges for clinicians because of varied presentation and multiple options for repair. There is no standardized technique for repair, though traditional methods of mucosal flap coverage with or without interposition grafts are giving way to newer techniques of fascial interposition grafts that forgo pedicled mucosal coverage altogether.

Summary Nasal septal perforations have varied etiologies, clinical presentations, and methods of management. Surgical repair of perforations can be challenging, and many techniques have been described without a standardized method of management.

Keywords Nasal septal perforation · Nasal septum · Pedicled flap · Mucosal flap · Interposition graft · Temporalis fascia

Introduction

Nasal septal perforations (NSP) are full thickness defects of the nasal septum, involving both the mucosal lining and the underlying cartilage and bone. NSPs have classically been diagnosed via direct visualization with a prevalence of approximately 1% [1]. However, diagnosis may also be made via commuted tomography (CT) imaging, with a recent study reviewing over 3000 facial CT images estimating a 2.05% prevalence of NSPs [2]. There are a wide variety of causes of NSP including trauma, previous surgery, intranasal drug and medication use, and autoimmune/inflammatory diseases. While many patients with NSP are asymptomatic, those that report symptoms often complain of nasal obstruction, crusting, and/or epistaxis because of turbulent intranasal airflow. There are multiple factors that contribute to a symptomatic NSP including size, location, and air flow across the perforation. The severity of symptoms and etiology of the perforation both guide the clinician in recommending either conservative or surgical management. Surgical repair can be challenging and many techniques for closure have been described in the literature. This article aims to provide a comprehensive review of nasal septal perforations from diagnosis and workup to surgical management options.

Causes

The differential diagnosis for nasal septal perforation is broad and relies on a thorough history and physical exam for diagnosis (Table 1). Identifying the underlying cause is critical, as some of the etiologies including neoplasm and autoimmune disease may potentially be life-threatening [3•]. A retrospective review of 180 patients undergoing septal perforation repair revealed that 62.4% were caused by previous rhinoplasty or septoplasty [4]. Another review of 74 patients attributed 39% of clinically diagnosed

This article is part of the Topical collection on *FACIAL PLASTICS: Functional Rhinoplasty*

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Table 1 Causes of nasal septal perforation [3•, 5, 9, 10]

Trauma	Nasal fracture, septal hematoma, foreign body, digital trauma, piercing
Iatrogenic	Nasal surgery, septoplasty, turbinate reduction, rhinoplasty, nasal packing, nasal intubation, septal cauterization, nasogastric tube
Neoplasm	Squamous cell carcinoma, adenoid cystic carcinoma, basal cell carcinoma, mucosal melanoma, lymphoma, metastatic carcinoma
Autoimmune	Granulomatosis polyangiitis, Churg-Strauss syndrome, system lupus erythematosus, sarcoidosis, Bechet's syndrome, rheumatoid arthritis, Chron's disease
Infectious	Septal abscess, invasive fungal infection, tuberculosis, syphilis, typhoid, diptheria, HIV, leprosy
Drug/toxin	Cocaine, intranasal steroids, vasoconstrictive nasal sprays, heavy metals

perforations to trauma, 11% to inflammatory diseases, and 3% to infectious causes [5]. Granulomatosis with polyangiitis, formerly known as Wegener's granulomatosis, and sarcoidosis are the inflammatory diseases most commonly associated with septal perforation [6]. Intranasal drug use has also been cited as a cause of NSP; 4.8% of all intranasal cocaine users have been found to have a perforation, making this the most common intranasal complication of cocaine use [7]. Other intranasal medications including intranasal steroids and vasoconstrictive medications have been reported as a cause of NSP. A retrospective review of 197 patients in Norway from 1996–2005 attributed 28.4% of NSPs to nasal steroid and decongestant sprays, over 50% of whom were female. However, this diagnosis was based purely on a patient's reported history of medication use prior to the diagnosis of septal perforation [8]. In the USA, the risk of NSP with these medications has not been clearly quantified, but septal perforation is reported as a "rare" occurrence by the Food and Drug Administration (FDA), with approximately 50 cases reported by the FDA from 1997–2006 [7].

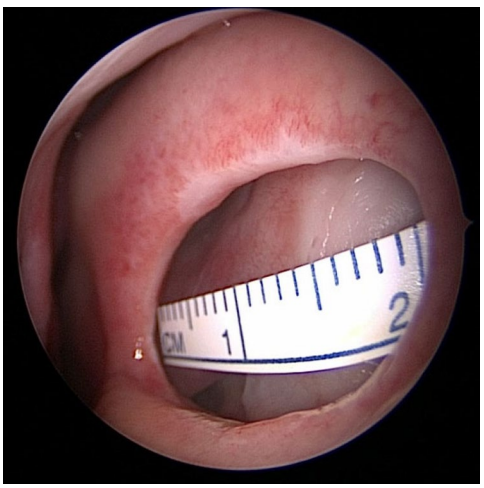

Fig. 1 Endoscopic visualization of NSP with measurement. (From: Dedhia RD et al. Curr Opin Otolaryngol Head Neck Surg, 2020. 28(4): p. 212–217, with permission from Wolters Kluwer Health, Inc.) [16•]

Clinical Presentation

The diagnosis of NSP is best made on a physical exam with either anterior rhinoscopy or nasal endoscopy (Fig. 1). Key features that may determine symptom severity and guide treatment include the location and size of the perforation, which may be more accurately defined with endoscopic visualization. A review of 74 patients found that 92% of perforations were located on the anterior septum, defined as within 1 cm of the head of the inferior turbinate [5]. Anterior perforations have been noted to be more symptomatic than posterior perforations, which may lead to a higher frequency of diagnosis [3•].

The size of the perforation is a key factor in characterizing NSP because this has been correlated with the success rate of surgery for perforation repair [11]. A systematic review reported a closure rate of 93% of NSPs < 2 cm and 78% of NSPs > 2 cm with surgery. There is no defined system for categorizing perforation size, but many clinicians consider a size greater than 2 cm in any dimension to be a large perforation [11]. Perforations may also be described as "favorable" or "unfavorable," as demonstrated in Fig. 2. Favorable perforations are described as well-mucosalized mucosal borders with no evidence of exposed cartilage or bone and are less likely to be symptomatic [12].

Patients present with a variety of symptoms based on features of their NSP. Up to 40% of patients may be completely

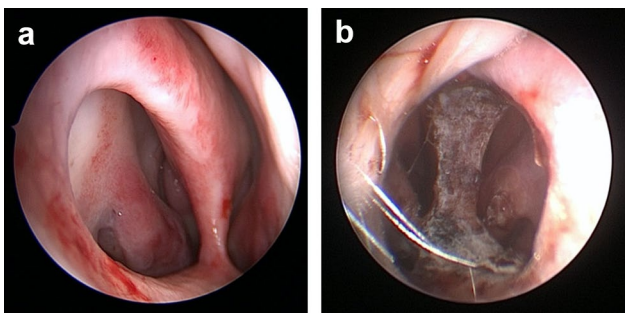

Fig. 2 **a** Favorable septal perforation with well-healed mucosal edges. **b** Unfavorable septal perforation with exposed bone and cartilage leading to crusting

asymptomatic, while other patients complain of nasal obstruction, whistling, crusting, bleeding, nasal pain, and dryness [5, 13, 14]. Small perforations can cause whistling with nasal breathing, while large, anterior perforations have traditionally been thought to cause more nasal dryness because of turbulent nasal airflow through the perforation. Mucosal dryness leads to symptoms of crusting and bleeding, which exacerbate nasal obstruction symptoms [14, 15]. However, recent studies using computational fluid dynamic (CFD) models have suggested that there are more factors than size and location that contribute to a patient's symptoms. Li et al. found that higher septal wall sheer stress (WSS) at the posterior edge of perforation was tightly correlated with a symptomatic patient, regardless of location or size [13]. This study was able to calculate the WSS threshold at which patients became symptomatic from their perforation. Though the clinical application of this knowledge and other CFD models is not yet clear, this field appears useful in fully understanding the physiology of NSP [16•].

Beyond intranasal symptoms, large perforations may also cause external nasal deformity. Septal cartilage or bone loss that involves the L-strut may lead to loss of structural support for the nose, which can result in saddle nose deformity, tip ptosis, or columellar retraction (Fig. 3) [3•].

Work Up

A workup of NSP etiology is recommended if there is not a clearly identifiable cause based on the patient's history [16•]. This workup begins with screening labs for systemic and autoimmune disease, which may include complete blood count (CBC), basic metabolic panel (BMP), thyroid-stimulating hormone (TSH), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), angiotensin-converting enzyme (ACE), antineutrophil antibodies (ANA), double-stranded DNA (dsDNA), rheumatoid factor (RF), anti-Ro and anti-La antibodies, antineutrophil cytoplasmic antibodies (cANCA), perinuclear antineutrophil cytoplasmic antibody (pANCA), proteinase 3, myeloperoxidase rapid plasma reagin, fluorescent treponemal antibody absorption, and HIV antibodies [10, 17]. Biopsy of the mucosal edge of the perforation is an option in cases where vasculitis or neoplasm is expected, though a retrospective review of 63 patients who underwent biopsy of their perforation found no cases in which the results altered their clinical diagnosis or management of the patient [18]. Thus, a routine biopsy is not recommended and should be reserved for patients with a high clinical suspicion for malignancy or vasculitis.

Treatment

Nasal septal perforation management is guided by the nature of the patient's symptoms. For asymptomatic or minimally symptomatic patients, conservative therapy with nasal saline and emollients may be sufficient [7]. These methods decrease crusting and local inflammation, which improve the quality of the nasal mucosa around the perforation. Nasal moisturization is also an essential initial therapy to decrease crusting and optimize the health of the nasal mucosa preoperatively in patients with symptomatic NSP who desire surgery. Other options for optimizing the septal perforation to minimize symptoms include slightly enlarging the NSP surgically in an attempt to create a more favorable perforation environment. This involves performing a posterior septoplasty to remove exposed bone and cartilage and allow for improved laminar airflow and mucosal coverage [12].

Another nonsurgical option to address an NSP is a septal button. This prosthetic grommet is commonly made of silicone and can be modified to fit the size of the individual perforation. It is placed across the perforation to separate the right and left nasal cavities and decrease the turbulent airflow across the perforation [7, 19]. Septal buttons may be

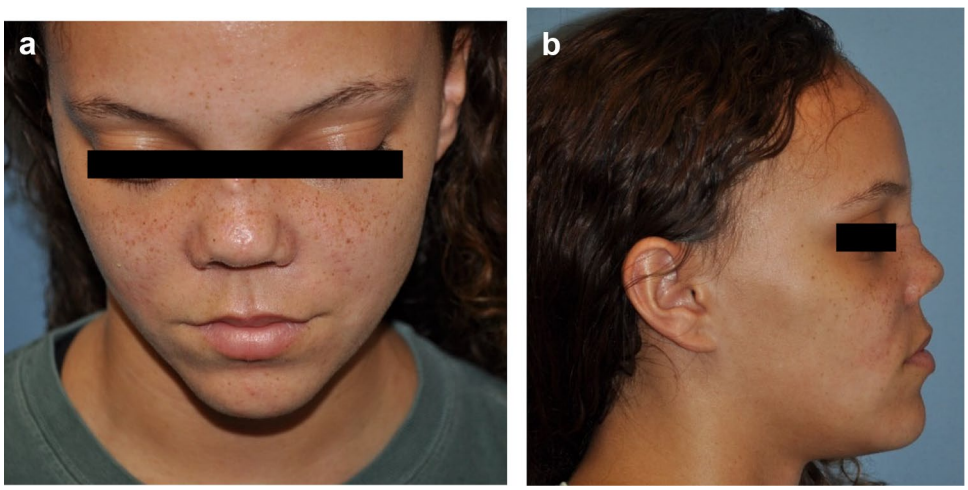

Fig. 3 **a** Bird's eye and **b** lateral views of a patient with saddle nose deformity secondary to NSP

placed under local anesthesia in the clinic or in the operating room depending on the patient's preference and perforation size. This is an option for patients who are poor surgical candidates for NSP repair, those who do not desire to undergo a lengthy surgery, [3•] or for patients whose primary complaint is whistling. There are some disadvantages of a septal button, including the need for regular replacement of the prosthesis, routine nasal hygiene demands, and variable patient satisfaction. In multiple reviews of patient outcomes after septal button placement, the rates of patient dissatisfaction leading to reshaping or removal of the prosthesis ranged from 25 to 50%. The reasons stated for patient dissatisfaction in these cases were infection, discomfort, perforation enlargement, and poor reduction in symptoms of crusting and bleeding [20–22].

Surgical repair should be considered in patients who have symptomatic perforations despite maximal medical therapy with the goal of restoring normal laminar nasal airflow and reducing symptoms. Many methods have been described with a variety of success rates, but no standardized approach has been established in the literature. The approach and method depend on multiple factors including the size and location of the perforation, the quality of the surrounding tissues, and the need for concurrent rhinoplasty to correct the external nasal deformity. Pioneered by Fairbanks in 1970, the traditional approach to NSP repair involves using vascularized mucosal flaps to close the perforation completely with or without interposition grafts [23, 24]. A systematic review performed in 2012 by Kim and Rhee examined factors predicting the surgical success of NSP repair and found that bilateral mucosal coverage improved the likelihood of long-term closure to 84.5% compared to the 73.4% success rate in patients with unilateral mucosal coverage. Kim and Rhee also advocate for the placement of interposition grafts, though their systematic review did not find a significant improvement in surgical success rate with the use of these grafts [11]. Since this systematic review, new techniques using fascial interposition grafts without pedicled mucosal coverage have gained ground with success rates of up to 100% in some series [23, 25•]. These techniques do not rely on mobilizing local mucosal flaps and represent a novel and promising option for repair.

Pedicled Flaps

Many variations of pedicled flaps that rely on donor tissue from either nasal mucosa or regional tissues have been described for NSP repair. Nasal mucoperichondrial or mucoperiosteal flaps include unilateral or bilateral advancement flaps, inferior turbinate flaps, and rotational flaps. These flaps recruit local nasal mucosa and underlying perichondrium and have the benefit of closing the perforation with ciliated respiratory epithelium. Other regional flaps include facial artery myomucosal flaps, sublabial mucosal flaps, and pericranial flaps. These may be beneficial in patients who do not have sufficient nasal mucosa to close the perforation, though they can increase post-operative crusting since, in these examples, the perforation is closed with nonciliated epithelium [11]. The inferior turbinate flap, another repair option reported in the literature, is a rotational flap that has been associated with higher failure rates and nasal obstruction secondary to the bulky nature of the flap [19, 26]. The anterior ethmoid artery flap is a rotation-advancement flap that has been used with excellent success rates [27, 28] Pedicled advancement flaps of septal and nasal floor mucosa have been described both unilaterally and bilaterally. Though the unilateral mucosal flap allows for only a single donor site that must re-mucosalize, bilateral coverage has been associated with significantly high closure rates [11, 29]. Kridel and Delany describe a four-quadrant mucosal advancement flap that utilizes both superiorly and inferiorly based bipedicled mucosal advancement flaps, which has been successful in closing even large perforations with deficient nasal mucosa [4]. Many of these flaps have been successfully used for repair, but none is universally accepted as the most reliable or preferred choice.

Interposition Grafts

Interposition grafts, which are placed between the rotated mucosal layers, are used by many surgeons to reinforce mucosal repair by providing scaffolding for mucosal migration [30]. Though the systematic review by Kim and Rhee failed to establish the interposition graft as a significant factor in the surgical success of NSP repair [11], other reviews have concluded that these grafts significantly improve surgical success rates [29]. There are myriad options for interposition grafts including autografts like septal or auricular cartilage, temporalis fascia, mastoid fascia, or pericranium, and alloplasts such as acellular human dermis (Alloderm), polytetrafluoroethylene (Gortex), and polydioxanone (PDS) [11, 23, 24, 29–31]. Moon et al. concluded that though the interposition graft improved the surgical success rate, the type of interposition graft was not significant [29].

Fascial Interposition Grafts

Though interposition grafts have traditionally been used in addition to mucosal flaps for NSP repair, newer techniques have forgone epithelial coverage of the interposition grafts altogether [23]. This approach does not attempt to close the mucosal edges across the perforation but instead provides a mesenchymal scaffold for the perforation to revascularize and

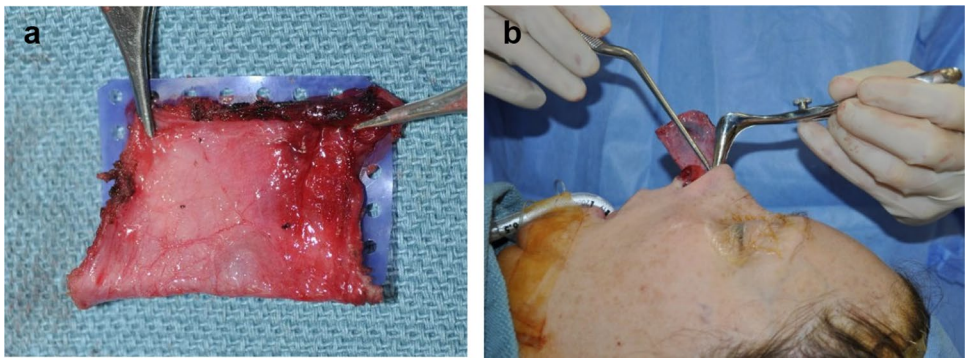

Fig. 4 **a** TPF-PDS construct and **b** insert of construct via open rhinoplasty approach. (From: Dedhia RD et al. Curr Opin Otolaryngol Head Neck Surg, 2020. 28(4): p. 212–217, with permission from Wolters Kluwer Health, Inc.) [16•]

remucosalize [25•]. Flavill and Gilmore described a method which employed a 0.25 mm PDS plate enveloped around temporoparietal fascia (TPF). The edges of the NSP were elevated via an open rhinoplasty approach and the graft was placed between the mucoperichondrial flaps (Fig. 4). Silastic sheets were used to cover the fascial interposition graft for several weeks [23]. Other surgeons have modified this technique and have covered a thinner 0.15 mm PDS sheet with thin TPF bilaterally without fascial loss on either side [16•, 25•, 32]. TPF has been used for this fascial interposition because it has a well-organized extracellular matrix with a large number of collagen and elastic fibers that make it an excellent template for cellular migration [23, 25•, 33]. These grafts have had an excellent success rate with an 88–100% closure rate over multiple series [23, 25•, 32]. Morse et al. also reported an 88% rate of symptom resolution in addition to their 100% closure rate in a 17-patient series [25•]. Figure 5 displays preoperative, 3 months post-operative, and 9-month post-operative images of NSP repair with TPF fascial interposition graft. Though this technique has proven very promising, there are several questions that remain open to further investigation regarding the fascial interposition graft. These questions include the importance of post-operative stenting in achieving mature remucosalization, the maximal NSP size that is appropriate for closure with technique, and the ideal scaffold material for the fascial interposition graft.

Endoscopic Versus Open Approach

Intranasal, external, midfacial degloving, and sublabial approaches have all been described for NSP repair. External rhinoplasty approaches remain the most described, but over the past two decades, endoscopic techniques have been increasingly reported [27, 34]. Advantages of endoscopic NSP repair include improved visualization and that it is minimally invasive, requiring no external incisions. Cassano performed a review of endoscopic approaches for NSP repair and reported a 76.4–100% success rate [27]. In their systematic review, Kim and Rhee showed that external rhinoplasty approaches for repair had a statistically higher failure rate than endonasal and endoscopic techniques [11, 16•]. However, this failure rate is confounded by multiple factors including perforation size. Larger perforations, which are more likely to fail repair, are more frequently addressed via an external approach. While the endoscopic approach does compromise the anterior septal mucosal blood supply on one side in contrast to the external approach, the clinical relevance of this difference has yet to be determined. The main disadvantage of the endoscopic technique is that it is technically challenging and may be time-consuming if not performed by a surgeon experienced with these techniques [27].

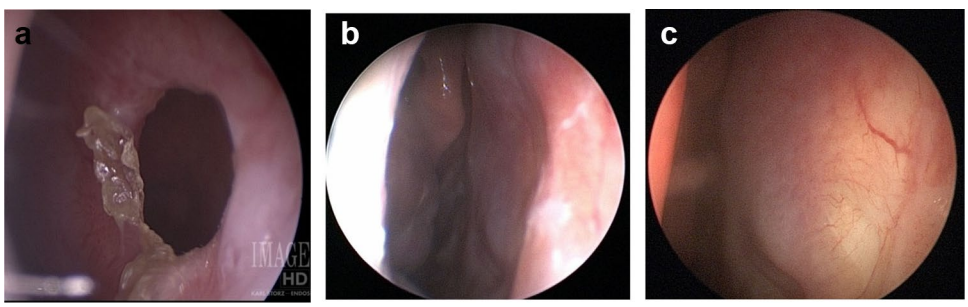

Fig. 5 Septal perforation repair with TPF fascial interposition graft **a** pre-operative, **b** 3 months post-op, and **c** 9 months post-op

Conclusions

Nasal septal perforations are complex pathologies with a wide spectrum of etiologies, symptoms, and options for management. There is no standardized approach for surgical repair of these defects, but there are many techniques for closure via both external rhinoplasty and endonasal approaches. Pedicled flaps for mucosal coverage with or without interposition grafts have been traditionally used for NSP closure, though newer techniques using fascial interposition grafts without mucosal coverage have been successful. Though all of these options have been described with good success rates in different case series, there has not been a large study with standardized metrics that has firmly established the ideal method for NSP repair.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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