INTRODUCTION
Nasal septal perforations are defined as a defect involving both layers of mucosa, as well as either the cartilaginous septum anteriorly or bony septum posteriorly, leading to direct communication between nasal cavities. The etiology of septal perforations is broad and can include trauma (which may include prior septoplasty, nasal cautery, septal hematoma, nasal intubation or feeding tube placement, and picking), toxins such as nasal sprays or, commonly, cocaine, inflammatory disorders, neoplasms, and infections.

Symptoms of nasal septal perforation depend on its location and size. Posterior perforations are generally asymptomatic. Small perforations can cause whistling sounds with nasal breathing. Anterior perforations can create turbulent airflow within the nasal cavities causing desiccation of the nasal mucosa. This can lead to recurrent epistaxis or a chronic sensation of nasal obstruction. While asymptomatic patients may be observed, surgical correction is the mainstay of treatment for those symptomatic. Septal buttons are generally reserved for those with comorbidities limiting surgical repair or those who refuse surgery. Numerous techniques have been described for repair of septal perforations. Herein, we present a novel endonasal technique with double opposing mucosal flaps and periosteum utilized as an interposition graft.

MATERIALS AND METHODS
Our study received approval from the John Peter Smith Institutional review board (Fort Worth, TX). We reviewed the outcomes of all patients who underwent septal perforation repair by the senior author (Y.D.) between 1998 and 2018. All patients presenting with symptomatic septal perforation were tested for c-ANCA and p-ANCA. Any patient who tested positive were excluded from analysis. Patients were also screened for cocaine use, and those with cocaine-related septal perforation were also excluded. Etiology of septal perforation was elicited and categorized as from prior surgery, trauma related, and unknown. The maximum size of the septal perforation we attempted to repair with our endonasal, double-opposing flap technique was 1.5 cm. Patients were routinely placed on post-operative antibiotic prophylaxis. All patients were followed up for a minimum of 6 months. Post-operative complications measured were perforation, infection, and bleeding requiring packing.

Technique
The nasal mucosa is topicalized with 1% lidocaine with 1:100,000 epinephrine injection followed by 4% cocaine-soaked pledgets. Through an endonasal approach, a left-sided posteriorly-based flap is designed (Fig. 1) with the incision...
brought along the anterior aspect of the perforation then laterally along the floor of nose and under the inferior turbinate. A right-sided, anteriorly-based flap is fashioned along the floor of nose. The incision is made anteriorly along the lateral nasal wall then posteriorly under nasal bones and down to the floor (Fig. 2). Mucoperichondrial flaps are then elevated. A sharp, thin periosteal elevator is crucial to successful flap elevation.

Next, a mastoid periosteal graft is harvested through a post-auricular incision along the sulcus. The periosteal graft is placed in a vein press and then positioned between the two opposing mucoperichondrial flaps. The graft is secured with 4–0 through-and-through chromic gut sutures. The needle is inserted along the edge of the mucosal advancement flap, passed through the interposition periosteum graft to the other side of the nasal cavity, and back just beyond the suture entry to come out along the edge of the septal mucosa that was not advanced; the stitch is tied in a simple interrupted fashion. A total of 6 stitches, at least 3 on each side, are needed to adequately secure the mucosal advancement flaps in position for defects up to 1.5 cm. The bilateral opposing flap repair is bolstered gently with gel foam, and then doyle splints are placed and secured. Splints are removed 2 weeks post-operatively. Patients are instructed on nose blowing precautions for 2 months.

RESULTS

Between February 1998 and February 2019, a total of 104 patients met study criteria. See Table I for patient demographics. The sources of perforation were identified as from prior surgery in 45, from other trauma in 15, and unknown in 44. All patients were closed via the technique described above. No patients required conversion to open rhinoplasty or other approaches to increase exposure.

Ninety-one patients (87.5%) demonstrated complete closure at 6-month follow-up. Of the 13 patients who did not have complete closure, 7/104 (6.7%) had partial opening of their pre-operative septal perforation, while 6/104 (5.8%) had complete or near complete failure. Of the 7 who had partial opening, 4 underwent revision closure with 2 complete closures and 2 persistent failures. When stratified by the source of perforation, success rates were 43/45 (95.6%) for the prior surgery-related group, 13/15 (86.7%) for the trauma group, and 35/44 (79.5%) for the unknown group. The success rates between the prior surgery related group and unknown group were statistically significantly different on chi-square ($\chi^2 = 5.264$, $P = .0218$). The average size of septal perforations between groups is shown in Table II.

Bleeding or infection occurred post-operatively in 3/104 patients (2.8%). No donor site complications were

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**TABLE I.**

<table>
<thead>
<tr>
<th>Patient Demographics.</th>
<th>104</th>
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<tr>
<td>Male (%)</td>
<td>65  (62.5)</td>
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<tr>
<td>Female (%)</td>
<td>39  (37.5)</td>
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<tr>
<td>Average age, in yr (range)</td>
<td>45.4 (22–75)</td>
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encountered. One patient in the prior surgery group developed methicillin-resistant *Staphylococcus aureus* infection treated with trimethoprim-sulfamethoxazole but still experienced subsequent repair failure. Two patients in the unknown group developed bleeding requiring an anterior Merocel pack; both experienced subsequent flap failure.

**DISCUSSION**

**Operative Technique**

Numerous articles exist detailing the various methods for reliable septal perforation repair. Goh and Hussain’s systematic review provided a critical analysis of the various reported surgical techniques and outcomes. Studies using local mucosal flaps only for closure involved turbinate flaps, which have had variable success rates ranging from 30.3% to 92%. Bilateral local mucosal flaps were then utilized with various interpositions grafts with improvement in success rates from 67% to 100%.

In terms of interposition graft material, many studies examined the use of the temporalis fascia graft. Mastoid periosteum has the advantage of increased rigidity when prepared for grafting, making it easier to work with as an interposition graft than temporalis fascia. To date, the use of a mastoid periosteum graft has been described in external rhinoplasty and midfacial degloving approaches but not via closed endonasal approaches as in our study. Several studies have evaluated acellular human dermal grafts as a suitable interposition graft with success rates between 76% and 92% reported. Others have reported utilizing cartilage and septal bone.

The majority of technique papers include small sample sizes and a highly-varied perforation size, leading to confounding factors making closure outcomes difficult to interpret. The largest study in the local flap closure literature included 31 patients. In the local flap and interposition literature, the largest was 28 patients. Surgical approach was not always specified, large perforation size ranges were included, and follow-up time varied from unspecified to 8 years.

In the experience of the senior author, the technique of bilateral opposing advancement flaps has the advantage of overlapping an area of weaker repair on one side with a more robust mucosal flap on the contralateral side, which should in theory decrease the rate of reperforation. Use of mastoid periosteum as an interposition graft has the benefit of an inconspicuous donor site scar along the postauricular crease and rigidity of graft material during surgical manipulation. The large patient population included in this study confirms that an endonasal approach to bilateral opposing mucosal flaps with mastoid periosteum interposition graft is a reliable option for septal perforations up to 1.5 cm.

### Surgical Approach

Various surgical approaches have been described in the literature. Many of the studies previously discussed include endoscopic, endonasal, open rhinoplasty, and midfacial degloving approaches. The decided surgical approach, regardless of what it is, should provide the surgeon adequate exposure to reliable carry out the technical repair. Septal perforations remain difficult to treat because of the technical difficulty of repair. While the decision which type of surgical approach to perform is beyond the scope of this study, the surgeon should be fluid and modify an approach if it will compromise the desired repair technique. Generally, larger perforations require open rhinoplasty or midfacial degloving approaches to obtain the optimal exposure as the area of mucosal advancement is much larger. In our study, none of the patients required conversion from endonasal to other approaches and thus we believe septal perforations up to 1.5 cm can be reliably closed with this technique.

### Complications

Complications are rare after septal perforation repair and were found to occur in only 2.8% of our study patients post-operatively. The majority of complications were infectious and bleeding-related. In patients with post-operative bleeding, conservative management is encouraged with oxymetazoline spray and hemostatic matrix sealants before nasal packing should be attempted. Nasal packing carries a high risk of disrupting the surgical repair. In general, patients who experience post-operative complications have an increased risk of repair failure; all three patients in our study experienced repair failure.

### Etiology-Related Risk Factors

No studies to date report the etiology of septal perforation as risk factors for repair failure. Kim 2012 reported that size of perforation was the single most important factor for complete closure and noted that surgical failure occurred more frequently in patients with perforations

<table>
<thead>
<tr>
<th>Source of Perforation</th>
<th>Size of Perforation, in cm (Range)</th>
<th>n</th>
<th>Success Rate (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior surgery related (%)</td>
<td>1.35 (0.5–1.5)</td>
<td>45 (43.3)</td>
<td>95.6% (43/45)</td>
</tr>
<tr>
<td>Trauma (%)</td>
<td>1.25 (0.7–1.5)</td>
<td>15 (14.4)</td>
<td>86.7% (13/15)</td>
</tr>
<tr>
<td>Unknown (%)</td>
<td>1.3 (1–1.5)</td>
<td>44 (42.3)</td>
<td>79.5% (35/44)</td>
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**TABLE II.**  
Perforation Etiology, Sizes, and Repair Success Rates.
greater than 2 cm. A systematic review of existing literature for perforation etiology and risks to repair failure is limited given the small sample sizes of prior studies. Moon et al examined 35 patients and did not find correlations between surgical failure with graft material and medical conditions. Our results demonstrate improved repair success rates in patients with a known perforation etiology (iatrogenic or trauma-related) compared to those with an unknown etiology.

The causes of septal perforation can be from various infectious and inflammatory diseases. Autoimmune disorders can include granulomatosis with polyangiitis, systemic lupus erythematosus, relapsing polychondritis, and sarcoidosis. These chronic conditions can often be underrecognized and not medically controlled by the time surgical repair is undertaken. It is possible that a subset of our patients in the unknown group had an undiagnosed inflammatory condition that, left untreated, impaired healing of the perforation repair. Patients should be counseled on the increased risk of failure when the etiology of septal perforation is not clear.

CONCLUSION

Herein, we present the largest study evaluating repair of septal perforations smaller than 1.5 cm, and we describe a novel technique for successful local flap repair. Nasal septal perforations remain a challenging problem to address with varied etiology. For symptomatic patients, perforations less than 1.5 cm are reliably closed via an endonasal approach utilizing bilateral mucosal flap advancements with a mastoid peristomeum graft. The etiology of septal perforation may be a risk factor in repair failure, and patients with an unknown cause of perforation may experience higher rates of failure.

REFERENCES