Septal perforation (SP) is a common nasal disorder. A 2003 Swedish study quoted a 0.9% prevalence of SP among the general population. The origin of SP is associated with the following 4 main causes: trauma, iatrogenesis, inflammation or malignancy, and inhalation. Once the mucoperichondrium of the nasal septum becomes traumatized, diminished blood supply can lead to cartilaginous and mucosal necrosis. Local reepithelialization of the mucosal edges then occurs, preventing closure of the defect.

Patients with SP may be seen with various symptoms and signs that often correspond to the size and location of the SP. An asymptomatic SP does not require any intervention. Most symptomatic SPs are large and anterior, while posterior SPs tend to be less symptomatic due to humidification of the passing air by nasal mucosa and turbinates. Common symptoms include nasal crusting, discharge, epistaxis, parosmia, neuralgia, and a whistling sound with inspiration. Some patients may manifest low-grade perichondritis, requiring long-term antibiotic therapy. Larger long-standing SPs can also cause atrophic rhinitis and saddle nose from a lack of nasal dorsal support.

Despite their being a common problem, SPs have been a distinctive challenge for otolaryngologists and facial plastic surgeons. Various techniques have been described to close SPs, and no single technique is recognized as being uniformly reliable in applying to all cases. Furthermore, SP repair is often performed in noses that have already undergone surgery and have limited tissue and a compromised blood supply for reconstruction. Therefore, most SPs remain unclosed because available techniques are technically difficult and require extensive training and experience to master.
The present study describes a novel technique to close an SP using a polyethylene orbital implant (Medpor; Porex Technologies). General indications for the use of implant materials include reconstruction or augmentation of soft and bony tissues. An ideal implant should theoretically be nonallergenic, noncarcinogenic, sterilizable, resistant to external and internal forces, and unable to induce a foreign-body response. Polyethylene implants have been shown to exhibit rapid tissue ingrowth, forming a stable complex resistant to infection, exposure, and deformity. The usefulness of the polyethylene implant has been demonstrated in various applications, including auricular reconstruction, cranioskeletal reconstruction, facial contouring, orbital floor repair, and nasal dorsum restoration. When placed into bony structures, the polyethylene implant is stabilized by the ingrowth of surrounding tissues along 125-μm to 250-μm pores.

This study aimed to demonstrate the efficacy of the polyethylene orbital implant in the repair of nasal SPs. Our approach has advantages over previously described techniques because it is easy and cost-effective. It is associated with low patient morbidity because it does not require the harvesting of any tissue from other donor sites, such as the pericranium, temporalis fascia, or conchal bowl of the ear.

Methods

Patients
Consecutive patients seen at a tertiary referral center with an SP between March 1, 2008, and February 1, 2011, were considered for the study. Verbal and written consent was obtained from all the patients for the surgical procedure and for participation in the present study. All SPs (regardless of shape, size, or location) diagnosed during this period were included in the study. Among patients older than 18 years, elective closure of nasal SPs was performed with a polyethylene orbital floor sheet implant using a closed endonasal technique. The exclusion criteria for study participation were uncorrectable coagulopathy and a poorly controlled disease process of the nasal septum (including cocaine abuse), as well as unavailability for standard postoperative follow-up surveillance.

Surgical Technique
Closure of SPs with polyethylene (0.85-mm) orbital floor sheet implants was performed in all the patients using general anesthesia. We intentionally used the endonasal approach because this technique was familiar to one of us (P.A.M.) performing the septoplasty (Figure 1). The patient’s nasal cavity was treated before surgery with 0.1% xylometazoline hydrochloride–soaked nasal pledgets. The size of the SP was then measured, and the nasal septum was injected with lidocaine hydrochloride, 1%, and 1:100 000 epinephrine in the submucoperichondrial plane. A hemitransfixion incision was then made on the appropriate side, and the mucoperichondrial flap was raised circumferentially around the SP.

The implant was trimmed to the appropriate size, circumferentially slightly larger than the size of the SP, and inserted along the submucoperichondrial plane. The polyethylene orbital floor sheet implant (0.85-mm thick) was presoaked in a solution of combined saline with bacitracin for 20 to 30 minutes to soften the material to allow for some pliability, if necessary, for insertion. The implant was secured, and the mucoperichondrial flaps were advanced as much as possible without excessive tension. The flaps were then sutured meticulously in a transseptal manner using 3-0 plain gut sutures and secured to the polyethylene with apposition to the implant bilaterally to facilitate epithelial migration (Figure 2). For SPs larger than 2.0 cm, an inferior turbinate mucosal graft was harvested and placed over the exposed implant to expedite re-mucosalization. The hemitransfixion incision was closed with...
4-0 chromic gut sutures. Neither stents nor packing was used in any of the patients. Standard postoperative care was implemented.

Patients were discharged the same day with instructions on proper nasal hygiene. This consisted of a combined 5-day course of prophylactic oral amoxicillin and antibiotic ointment application twice daily and as needed to bilateral nares, as well as gentle saline irrigations 3 times daily and as needed starting after the 1-week postoperative visit. Patients were also advised to avoid forceful blowing of their nose for 2 weeks after surgery.

Data Collection
Preoperative data collected included age, sex, and size and location of nasal SPs. Initial symptoms related to the SP were documented. Medical comorbidities and previous nasal surgical procedures were recorded. The intraoperative data included documentation of any adjunctive procedures, such as the use of a turbinate mucosal graft.

Postoperative data were collected at the following 4 dates after surgery: 1 month, 3 months, 6 months, and 1 year. Success of the closure of a nasal SP and mucosal coverage of the implant were monitored at each visit. Successful closure was defined as an intact polyethylene graft with complete remucosalization of at least one side of the graft by the 1-year follow-up visit. Extrusion, infection, or any other complications were recorded. To determine the level of symptom resolution, patients were asked about preoperative and postoperative symptoms, such as nasal crusting, discharge, epistaxis, parosmia or cacosmia, and obstruction. Patients’ responses to questions about the presence of symptoms were recorded as dichotomous data (yes or no answers).

Statistical Analysis
To compare preoperative with postoperative symptoms, statistical analysis was performed using the McNemar exact test for nonparametric matched-pair data. Statistical significance was set at $\alpha < 0.05$.

Results
Sixteen patients were recruited for the study; 2 of them were lost to follow-up surveillance (they did not respond to follow-up calls and failed to show for follow-up visits). Therefore, 14 patients were included in our analysis. Patient demographics are summarized in Table 1. Their initial symptoms included crusting ($n = 10$), nasal discharge ($n = 6$), epistaxis ($n = 5$), dysosmia ($n = 5$), nasal obstruction ($n = 5$), and whistling ($n = 4$). The mean (SD) size of the SPs was 1.6 (0.6) cm at the greatest dimension.

Of 14 patients included in our study, 13 patients (93%) had successful closure of their SP by the 1-year follow-up visit. One patient had to have the implant removed because the SP failed to close and the implant had extruded. This patient had the largest SP, measuring 4.0 cm. All the SPs were located in the anterior septum in the region of the quadrangular cartilage. No postoperative infections occurred.

The mean (SD) operative time was 28 (6) minutes from the time of lidocaine injection to closure. Within this time frame, 3 patients received an inferior turbinate graft, including the patient whose implant had extruded.

At the 1-month postoperative visit, all polyethylene implants were intact, although mucosal coverage was incomplete in all the patients. Remucosalization results are summarized in Table 2. Once the cohort reached 3 months after surgery, 4 patients had 75% to 99% mucosal coverage of the polyethylene implant, 6 patients had 50% to 74% mucosal coverage, and 3 patients had 25% to 49% mucosal coverage. One patient’s implant had extruded at the 3-month point; that patient had not been compliant with postoperative care.

At the 6-month follow-up visit, 13 of 14 implants (93%) were intact. One patient’s implant, although intact, had migrated slightly caudally and had to be revised and trimmed using local anesthesia. There was complete bilateral mucosal cover-
The polyethylene implant is an effective and cost-effective method of closing SPs for several reasons. In the present study, we found the polyethylene implant to be robust and resistant to cracking or distortion during insertion, despite some significant bending at times. The implant was easy to customize to the size and shape of the SP. Once placed between the mucoperichondrial and mucoperiosteal flaps, the implant was stable and was not susceptible to shifting or displacement by local influences, such as hydrostatic pressure. This property facilitates the avoidance of postoperative nasal stents or packs that cause prolonged postoperative nasal obstruction, which is poorly tolerated in this population. Although connective tissue autografts, such as temporalis fascia and pericranium, are commonly used as interpositional grafts in the repair of nasal SPs, they require additional operative time (leading to increased expense) for harvesting and are often difficult to handle and manipulate. In addition, they are associated with donor-site morbidity.14

As an interpositional graft, the polyethylene implant acts as a barrier to prevent the formation of an epithelialized tract between the 2 surfaces of the septum. Other allografts,

Table 3. Postoperative Symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>1 mo</th>
<th>3 mo</th>
<th>6 mo</th>
<th>1 y</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crusting</td>
<td>14</td>
<td>12</td>
<td>5</td>
<td>2</td>
<td>.007</td>
</tr>
<tr>
<td>Whistling</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>.13</td>
</tr>
<tr>
<td>Epistaxis</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>.06</td>
</tr>
<tr>
<td>Nasal obstruction</td>
<td>14</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td>.25</td>
</tr>
<tr>
<td>Nasal discharge</td>
<td>14</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>.03</td>
</tr>
<tr>
<td>Dysosmia</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>.50</td>
</tr>
</tbody>
</table>

* Comparing postoperative symptoms with postoperative symptoms at 1 year.

Table 4. Literature Comparison for Nasal Septal Perforation Closure Rates

<table>
<thead>
<tr>
<th>Technique</th>
<th>Source</th>
<th>Closure Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene (Medpor; Porex Technologies) implants using an endonasal approach</td>
<td>Present study</td>
<td>93% (n = 14)</td>
</tr>
<tr>
<td>Temporalis fascia using an endonasal approach</td>
<td>Lee et al,7 2006</td>
<td>86% (n = 11)</td>
</tr>
<tr>
<td>Regenerative tissue matrix (Allo-Derm; LifeCell Corporation) between bilateral mucoperichondrial flaps using an intranasal approach</td>
<td>Lee et al,6 2008</td>
<td>91% (n = 11)</td>
</tr>
<tr>
<td>Bilateral posteriorly based unipedicled flaps using a midface degloving technique</td>
<td>Romo et al,13 1988</td>
<td>75% (n = 14)*</td>
</tr>
<tr>
<td>Acellular human dermal graft using interposition grafting between mucoperichondrial flaps</td>
<td>Kridel et al,14 1998</td>
<td>92% (n = 12)</td>
</tr>
<tr>
<td>Supporting graft of mastoid peristomeum, cartilage, or ethmoid bone using an external rhinoplasty approach</td>
<td>Kridel et al,6 1986</td>
<td>77% (n = 22)</td>
</tr>
<tr>
<td>Inferior turbinate free graft via an endoscopic approach</td>
<td>Mansour,15 2011</td>
<td>83% (n = 6)</td>
</tr>
<tr>
<td>Unilateral septal flap based on the anterior ethmoid artery via an endoscopic approach</td>
<td>Castelnuovo et al,16 2011</td>
<td>100% (n = 11)</td>
</tr>
<tr>
<td>Nasal mucosal flap from the nasal floor, inferior nasal meatus, and inferior turbinate via an endoscopic assisted approach</td>
<td>Teymoortash et al,17 2011</td>
<td>95% (n = 55)</td>
</tr>
<tr>
<td>Septal mucosal flap via an endoscopic assisted approach</td>
<td>Li et al,18 2011</td>
<td>93% (n = 28)</td>
</tr>
</tbody>
</table>

* Of previously failed closures.

Comment

The results of this study suggest that the polyethylene implant is a feasible option for SP closure. The presence of an SP in the nasal septum leads to altered intranasal airflow, temperature, and humidity. This results in the patient experienc-
such as regenerative tissue matrix (AlloDerm; LifeCell Corporation), have been described in the use of SP repair. However, the added cost of regenerative tissue matrix is significantly more expensive than that of the polyethylene implant. The cost of a polyethylene orbital floor sheet implant was CAD$585. A regenerative tissue matrix sheet of equivalent size is approximately CAD$1500. The polyethylene implant is more robust and more resistant to drying, crusting, and reperforation.

The main limitation to our technique is that it relies on delayed mucosal closure via epithelial migration. However, Mansour15 also described a technique using remucosalization of a free inferior turbinate graft, with an 83% success rate. As was the case in the study by Mansour, herein the rate of remucosalization on one side seemed to closely mirror the rate of remucosalization on the contralateral side (Table 2). However, the application in our study of the inferior turbinate graft did not seem to speed up the rate of remucosalization. Instead, we emphasize the importance of regular postoperative debridements and patient education with respect to meticulous nasal hygiene; the single patient herein with an extruded implant was not compliant with these recommendations. The use of nasal saline irrigations and ointments alone may have contributed to the reduction in symptoms for some of our patients. Further studies are needed to delineate the effect of nasal hygiene alone on the resolution of nasal symptoms in this population.

Future studies should look at long-term closure results of patients who underwent the repair of their SPs with polyethylene implants. In addition, a study investigating the closure of larger (>3.0-cm) SPs with polyethylene implants covered with temporalis fascia may be worthwhile because this would incorporate the benefits of the polyethylene implant, while potentially expediting the remucosalization process.

In conclusion, the application of the polyethylene interpositional graft with the endonasal technique resulted in successful closure rates comparable to those of other techniques. Our technique has several advantages, including a shorter operative time, resolution of patients’ symptoms, and prevention of saddle nose, as well as the fact that the approach is familiar to surgeons performing septoplasties. Patients benefited from the absence of a visible external scar, a lack of associated donor-site morbidity, and no need for a second surgical procedure or nasal stents and packing.

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Conflict of Interest Disclosures: None reported.

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REFERENCES