

# Versatile Applications of the Polydioxanone Plate in Rhinoplasty and Septal Surgery

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**Background:** Rhinoplasty and septal surgery often require the use of cartilage grafts. Autologous cartilage may be thin or deviated, and the use of an absorbable scaffold material to support the reimplanted cartilage during healing can improve technique and outcomes.

**Objective:** To describe the use of a polydioxanone plate not only as a template in extracorporeal septoplasty but also for various other grafts commonly used in rhinoplasty and for the repair of septal perforations.

**Methods:** A retrospective case note review was performed between November 1, 2007, and February 28, 2011, for all patients treated using a polydioxanone plate. Surgical outcomes are discussed.

**Results:** A polydioxanone plate was used in septal and/or rhinoplasty surgery in 102 patients treated during a 40-month period. Follow-up was 9 to 18 months (mean, 12 months), with 96 patients reporting a good cosmetic or functional result. Up to 15% of patients experienced temporary septal swelling, but there were only 2 postoperative infections and no other significant complications.

**Conclusions:** The polydioxanone plate is a safe and reliable absorbable implant that has many different applications in rhinoplasty and septal surgery. It not only acts as a scaffold but also stimulates and guides cartilage regeneration.

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**R**HINOPLASTY AND SEPTAL surgery often require the use of graft materials for augmentation, reconstruction, or structural support. Although the ideal graft is septal cartilage, this may be unavailable, for example, after trauma, in revision surgery, or in cases of septal perforation. When cartilage is present, it may be too thin, short, or deformed to be useful. Various graft materials, autologous and exogenous, have been used to overcome this problem. Autologous tissue is undoubtedly the most reliable and best graft to use; for example, conchal cartilage is commonly harvested in such cases. However, it has a natural curve and may not provide sufficient length. Harvesting any extraseptal autologous tissue for grafting immediately increases morbidity, with scarring, postoperative pain, and the potential for additional complications. Operative time will be increased, as will surgical complexity.

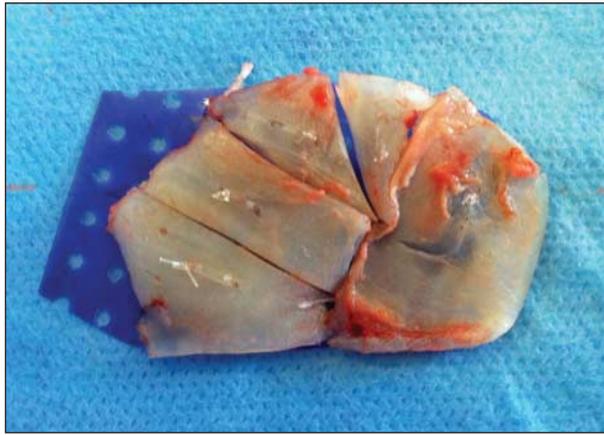
Complications of any graft, autologous or otherwise, include infection, migration, and extrusion, as well as the standard operative complications of bleeding, hematoma formation, and ongoing cosmetic or functional problems. The ideal synthetic graft would, therefore, be non-

inflammatory, noncarcinogenic, nonallergenic, resistant to mechanical strain (ie, elastic not plastic), able to integrate into host tissue, readily available, easy to shape, and fully sterilizable.<sup>1</sup> This material has yet to be found, and the best option is still to use the patient's own cartilage. In circumstances in which this cartilage seems inadequate, or excessively deviated, it is possible to resect and reconstruct it to form a graft of an appropriate size and shape that can then be implanted back into the nose. This is best achieved by using an absorbable allograft as a scaffold to support the cartilage during the early postoperative period. By using an absorbable material, the risk of long-term complications associated with grafts is considerably reduced. We have found the polydioxanone (PDS) plate to be the ideal graft in these circumstances.

Polydioxanone is a colorless crystalline resorbable polymer that is degraded by hydrolysis and completely metabolized in the body. It is available as perforated and unperforated PDS plates (Ethicon Inc, Johnson & Johnson). It is available in different thicknesses (0.15 mm perforated, 0.25 mm unperforated, and 0.55 mm unperforated), is flexible but can preserve its shape, and can be fixed to car-

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**Figure 1.** Cartilaginous septum fixed to a polydioxanone plate after dividing it along fracture lines. A “tail” of polydioxanone plate is left posteriorly for fixation.

tilage with sutures. Thinner plates are resorbed within 25 weeks, thicker plates within 8 months.<sup>2</sup> The use of a PDS plate for orbital floor reconstruction has been well-documented, and it has been shown to be a safe graft material.<sup>3</sup> In addition, evidence from animal experiments indicate that it may actually stimulate cartilage regeneration.<sup>4</sup>

In the nose, the PDS plate was originally described in extracorporeal septorhinoplasty, but one of us (H.A.S.) has gradually developed many other applications, which are discussed herein.

## METHODS

### PATIENTS

One of us (H.A.S.) has used PDS plates in more than 200 patients since 2004. A retrospective case note review was performed in all patients treated with a PDS plate. Complete records were available from November 1, 2007, onward, and, therefore, results are presented for November 1, 2007, to February 28, 2011. The surgical procedure(s) performed, complications, and outcomes were obtained for each patient. A successful outcome was based on the subjective opinions of the surgeon and the patient and on clinical examination findings. The different applications of the PDS plate are described herein, with outcome data for each. All the patients were given a 7-day course of antibiotics (a combination of amoxicillin–clavulanic acid or something similar) postoperatively and were also started on regular saline douches for at least 6 weeks.

### APPLICATIONS

#### Extracorporeal Septorhinoplasty

This technique involves complete removal of the septum from the nose to allow reshaping and reimplantation of a straight “neoseptum.” It has traditionally been described using sutures to connect individual pieces of septal cartilage and/or bone together. It is our experience that reattaching pieces of cartilage using sutures alone may not provide sufficient structural support to maintain an acceptable cosmetic appearance of the external nose, especially the nasal dorsum. The technique uses a 0.15-mm perforated PDS plate template of the nasal septum, to which straight pieces of septal cartilage are fixed with 4/0 PDS sutures. It is a good idea to draw or cut around the origi-

nal quadrilateral cartilage so that an appropriate shape is obtained; a “tail” of PDS plate should be included to run posteriorly for stability. Fracture lines should be used, and the cartilage divided along them; in cases in which the cartilage is twisted with no fracture lines, the divisions are made in the areas of maximum convexity (**Figure 1**). Each piece of cartilage is sutured to the plate separately for secure fixation. Once the cartilage has been reshaped and sutured to the PDS plate, it is reinserted into the nose and sutured to the anterior nasal spine at the appropriate point; care must be taken not to attach the “new” septum more caudally than it should be. The second point of fixation is into the upper lateral cartilages using 1 mattress suture. The third point of fixation uses standard transseptal mattress (quilting) sutures. **Figure 2A-D** shows a 21-year-old patient with ongoing deformity and nasal obstruction after a septorhinoplasty; note the thick skin and deviated upper and middle thirds, with an underprojected tip and lack of support. Revision open-approach extracorporeal septorhinoplasty was undertaken using conchal cartilage grafts to supplement the neoseptum and create a columellar strut sutured to the PDS plate. Lateral and left transverse osteotomies were performed, and spreader grafts were used to open the nasal valve. Finally, the tip was refined by the use of transdomal and interdomal suturing, and the skin was thinned (**Figure 2E-H**).

#### Columellar Struts

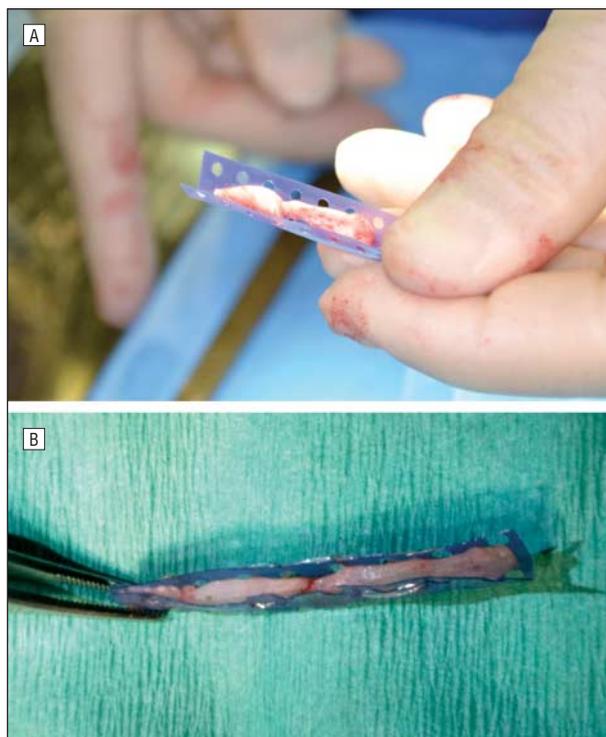
We have found that the 0.15-mm perforated PDS plate is extremely useful as a scaffold for columellar struts in circumstances in which available cartilage grafts are either of insufficient length or strength. One of us (H.A.S.) devised a “doubled” PDS plate by folding it on itself and inserting a cartilage graft between the 2 layers, creating a PDS plate/cartilage sandwich. This allows 2 or 3 pieces of cartilage to be aligned end-to-end, forming a strut of optimal length. These pieces are secured using Aiach forceps (Medicon) and are sutured into the sandwich using 4/0 PDS sutures (**Figure 3**). The strut is then inserted between the medial crura in the same way as a standard columellar strut. The effect of the strut on projection and rotation is maintained after PDS plate resorption by the healed cartilage fragments. The technique is also applicable to weak cartilage fragments that can be layered in parallel for reinforcement and stitched into a PDS plate sandwich. **Figure 4A** shows a patient with “cleft lip nose” and an underprojected tip. The patient underwent a secondary rhinoplasty with insertion of a columellar strut using the PDS sandwich technique. Tip projection has been enhanced and maintained 1 year postoperatively (**Figure 4B**).

#### Alar Battens/Lateral Crural Struts

We have regularly used PDS plates to create alar battens or lateral crural struts. The technique uses the PDS plate to support multiple cartilage fragments or weak cartilage. We usually suture the cartilage fragments to 1 layer of 0.15-mm perforated PDS plate (**Figure 5**). The cartilage/PDS graft is then inserted between the vestibular skin and alar cartilage. The PDS plate is always positioned beneath the alar cartilage with the cartilage graft facing the vestibular skin. It is then sutured to the alar cartilage and through the skin with 4/0 PDS. A 40-year-old woman was first seen after 2 previous rhinoplasties, requesting further revision to improve her nasal deformity and obstruction. Previous overresection of her alar and upper lateral cartilages had resulted in a deviated nose and septum, with a narrow middle third and an asymmetrical tip (**Figure 6A-D**). The patient underwent extracorporeal septorhinoplasty using a perforated PDS plate. Conchal cartilage was harvested for



**Figure 2.** Preoperative (A-D) and postoperative (E-H) photographs of a 21-year-old patient with ongoing deformity and nasal obstruction after a septorhinoplasty.



**Figure 3.** Polydioxanone "sandwich" with 2 pieces of conchal cartilage secured end-to-end to form a columellar strut of sufficient length. A, Cartilage pieces in place. B, Columellar strut after suturing.

spreader grafts and was also used with a PDS plate to create alar and columellar struts. Transdomal and interdomal sutur-

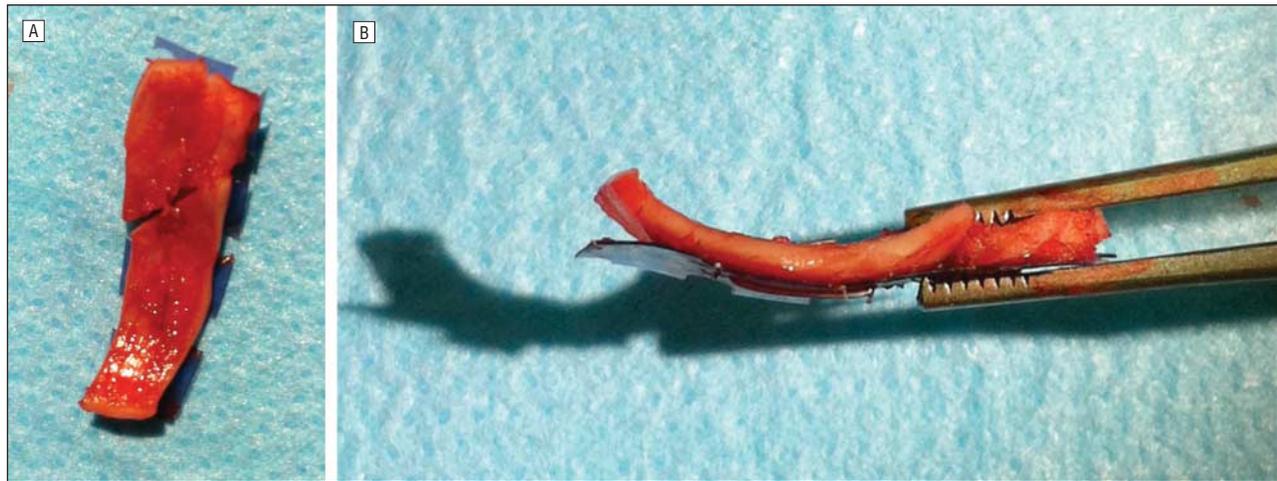


**Figure 4.** Preoperative (A) and 1-year postoperative (B) photographs of a patient with "cleft lip nose" and an underprojected tip.

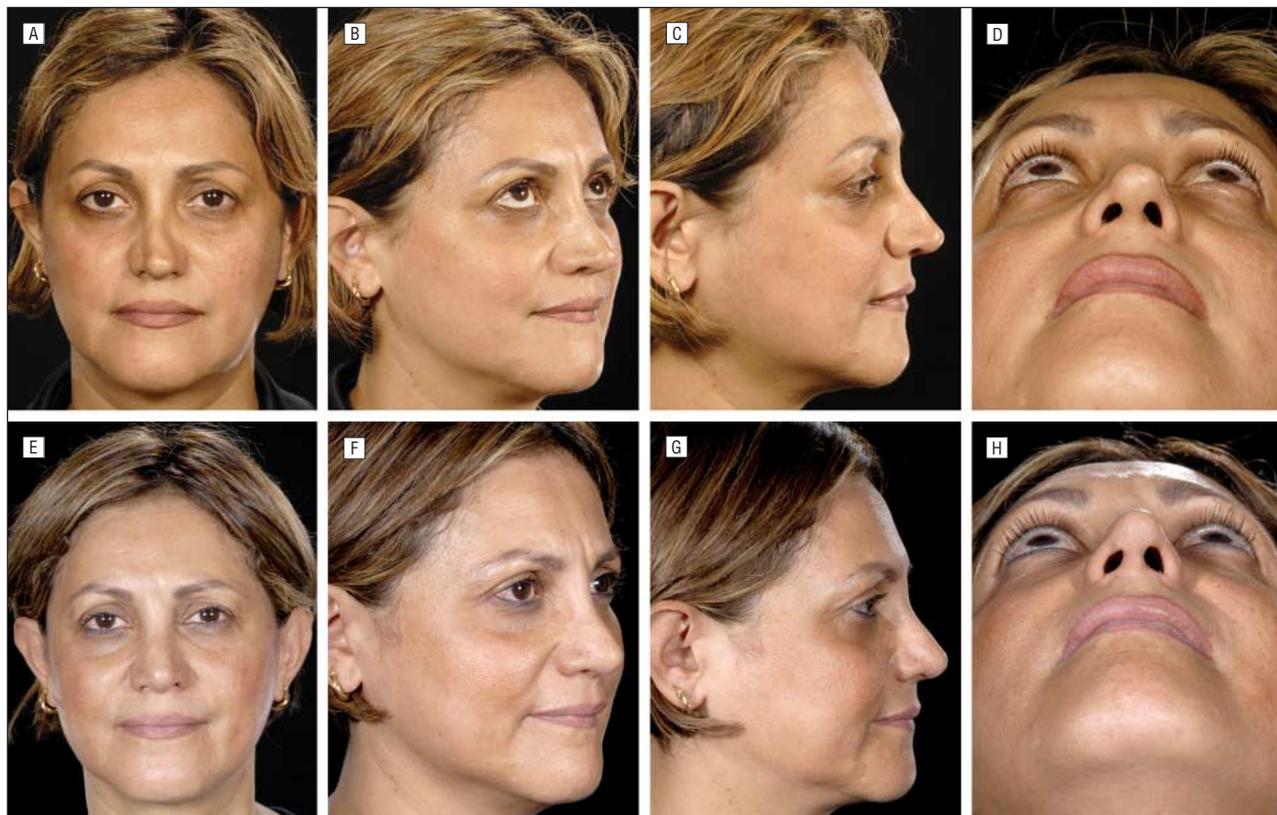
ing was performed for tip refining. Figure 6E-H shows the postoperative results after 1 year.

### Septal Extension Grafts

In short noses, a PDS plate can be useful in securing extension grafts to the caudal septum. Whether the graft is formed by 1 or multiple fragments, the PDS plate facilitates its fixation to the septum. After the graft is measured, it is sutured to the 0.15-mm perforated PDS plate, leaving a 10- to 20-mm tail for fixation onto the septum. This tail is fixed to the caudal septum using 4/0 PDS sutures, avoiding any overlap with the graft, which is, in turn, sutured to the nasal spine. Robust extension grafts can be created using this technique. **Figure 7**A-D shows preoperative images of a 31-year-old patient first seen with a collapsed dorsum and saddling secondary to resorption of the caudal and dorsal sep-



**Figure 5.** A, Alar batten graft using 2 pieces of conchal cartilage fixed to a polydioxanone plate; B, the natural curve of the conchal cartilage is similar to that of the alar cartilage.



**Figure 6.** Preoperative (A-D) and 1-year postoperative (E-H) photographs of a 40-year-old woman who underwent revision extracorporeal septorhinoplasty using perforated polydioxanone plate.

tum after previous septoplasty. Conchal cartilage fixed to the PDS plate was used to create a septal extension graft to replace the missing cartilage. A tail of the PDS plate was sutured to the proximal septum to build the dorsum and caudal septum. Figure 7E-H shows the results 1 year postoperatively.

### Spreader Grafts

A PDS plate (again, the 0.15-mm perforated plate) can be used in the same way as described previously herein to link short pieces of cartilage together, forming a spreader graft of

sufficient length. In cases of extracorporeal septorhinoplasty, the spreader grafts can be secured to the cartilage-PDS composite template before the complete graft is inserted into the nose, which simplifies their insertion and fixation (**Figure 8**).

### Endonasal Septoplasty

In cases of very caudal or superior septal deviations with no additional cosmetic problems, an endonasal septoplasty may be sufficient, perhaps with a partial extracorporeal compo-



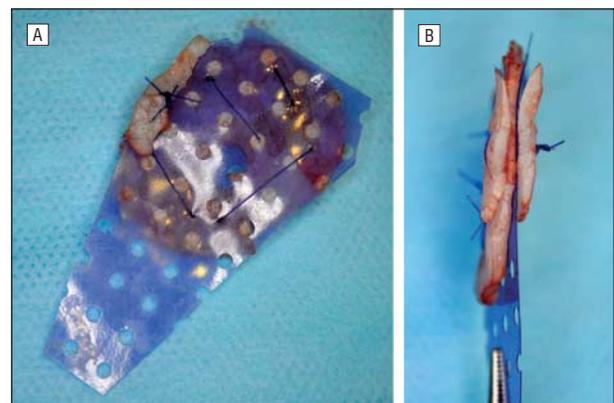
**Figure 7.** Preoperative (A-D) and 1-year postoperative (E-H) photographs of a 31-year-old patient with a collapsed dorsum and saddling secondary to resorption of the caudal and dorsal septum after previous septoplasty.

ment. A PDS plate can be useful in supporting the healing cartilage in this situation, allowing adequate correction without affecting the shape or stability of the nose.

A standard hemitransfixion incision is made, and bilateral mucoperichondrial flaps are elevated along the length of the septum. After correcting any posterior bony septal deviation, the quadrilateral cartilage should be separated from the vomer posteroinferiorly and from the maxillary crest inferiorly along its full length, including the anterior nasal spine. The septal cartilage is incised through its full thickness at the most deviated convex point, which is usually along a fracture line. The incision should initially extend almost to the dorsal edge but not completely, leaving the cartilage attached superiorly. In many cases, this will allow the cartilage to sit in the midline without tending to deviate. If the cartilage persistently deviates at this point, then the incision should be completed superiorly and the free anterior piece of cartilage removed from the nose.

A piece of 0.15-mm perforated PDS plate is cut to approximately the same size and shape as the anterior piece of cartilage but with a tail extending backward; this tail will sit alongside the more stable posterior part of the septum and is essential for fixing the anterior septum in position. If the caudal septum remains in the nose, the plate can be inserted between the cartilage and the mucoperichondrial flap on the previously convex side to support the cartilage in its new position as it heals. If the cartilage has been removed, it should be sutured to the PDS plate (**Figure 9**).

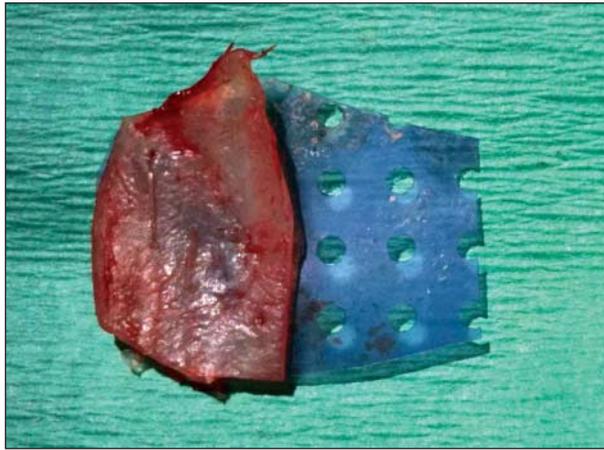
The PDS plate or plate-cartilage graft is then inserted into the nose, between the cartilage and mucoperichondrial flap, as described previously herein. The tail of the PDS plate should lie between the mucoperichondrial flap and cartilage on the previously convex side. The caudal end of the septal cartilage is sutured to the anterior nasal spine and the PDS plate. Standard 4/0 polyglactin transseptal quilting (mattress) sutures



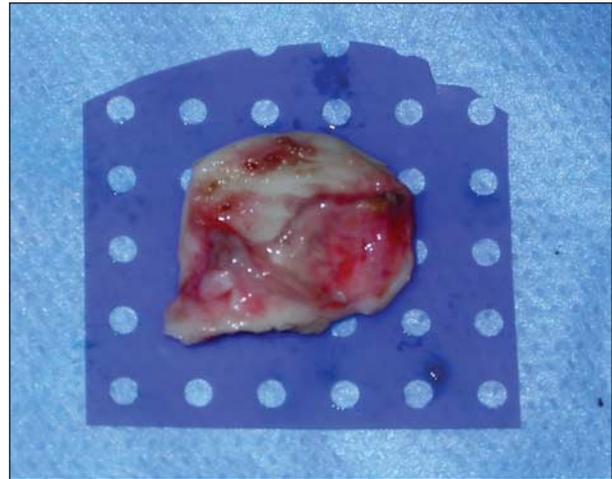
**Figure 8.** Spreader graft fixed to the cartilage-polydioxanone template extracorporeally. Lateral view (A) and superior view (B).

should be placed, providing further support for the PDS plate-cartilage graft and closing the dead space and reducing the risk of hematoma formation. **Figure 10A** and **B** shows preoperative images of a patient with a dislocated caudal septum secondary to trauma. The caudal end of the septum was separated from the proximal septum through a fracture line and was fixed extracorporeally to a PDS plate. The cartilage-PDS template was reinserted and then was fixed to the nasal spine and proximal septum. Dorsal dehumping was also performed (Figure 10C and D).

A PDS plate can also be used in standard septoplasty, where the straightened septum is found to be mobile or weak. A large PDS plate is cut to size and is simply inserted on one side of the septal cartilage as a scaffold. It is then sutured to the mucoperichondrial flaps and cartilage using a standard mattress



**Figure 9.** Caudal end of a severely deviated septum after removal and suturing to a polydioxanone plate, leaving a "tail" for fixation to the proximal septum.



**Figure 11.** An "island" of conchal cartilage fixed to a larger polydioxanone plate to facilitate fitting into a cartilage defect when repairing a septal perforation.



**Figure 10.** Preoperative (A and B) and postoperative (C and D) photographs of a patient with a dislocated caudal septum secondary to trauma.

(quilting) suture with 4/0 polyglactin. This 4-layered repair is robust, and the septum is maintained in the midline after resorption of the PDS plate.

### Septal Perforation Repair

A PDS plate can be used in septal perforation repair as a scaffold for cartilage and for facilitating flap approximation. For large perforations (>15 mm), the senior author (H.A.S.) uses a piece of 0.15-mm perforated PDS plate as a scaffold for an "island" of cartilage that fits the size of the defect (**Figure 11**). This plate-cartilage graft is then inserted between the septal flaps, with the cartilage fitting into the cartilaginous defect. We have

found this to be a useful technique in preventing displacement and mobility of the cartilage graft. In smaller perforations, we often just insert the PDS plate between the mucoperichondrial flaps without additional cartilage. The PDS plate creates a solid surface for advancing and suturing the flaps. The perforations in the plate mean that the septal blood supply is not compromised.

## RESULTS

A PDS plate was used in septal and/or rhinoplasty surgery in 102 patients treated between November 1, 2007, and February 28, 2011 (40 months). Follow-up ranged from 9 to 18 months postoperatively (mean, 12 months). Owing to the nature of the surgery, we found that some patients did not attend planned follow-up appointments once they felt that things were satisfactory. There were 69 male and 33 female patients, with a mean age of 36.5 years (age range, 20-63 years). Forty-eight patients had a history of nasal trauma as a contributing factor to their functional and/or cosmetic concern. Previous surgery had been performed on 38 of the patients. **Table 1** provides the distribution of procedures performed.

Twenty-nine patients underwent an extracorporeal septoplasty using a PDS plate as a scaffold; 16 reconstructions were complete and 13 were partial. The plate was used in 16 patients undergoing endonasal septoplasty and in 39 patients undergoing septorhinoplasty, with or without a columellar strut. In total, 37 patients had a columellar strut fashioned using a PDS plate as described previously herein. Thirteen septal perforations were repaired using a PDS plate as the middle supporting layer between the 2 mucosal flaps. Of these perforations, 7 were smaller than 15 mm in diameter and were repaired using a PDS plate alone and 6 were larger than 15 mm and were repaired using a PDS plate and cartilage as described previously herein.

At an initial 3-month review, 97 patients reported a good result. Of the 5 patients who were dissatisfied, 3 (60%) had undergone septal perforation repair that had failed; 2

**Table 1. Applications of the Polydioxanone Plate in the 102 Study Patients**

| Application   | Patients, No. |
|---|---------------|
| Extracorporeal septoplasty (without columellar strut)         | 16            |
| Extracorporeal septoplasty (with columellar strut)            | 13            |
| Septal support in septoplasty (without columellar strut)      | 13            |
| Septal support in septoplasty (with columellar strut)         | 3             |
| Septal support in septorhinoplasty (without columellar strut) | 20            |
| Septal support in septorhinoplasty (with columellar strut)    | 19            |
| Columellar strut alone  | 2             |
| Septal perforation  | 8             |
| Septal perforation with septorhinoplasty                      | 3             |
| Septal perforation with septoplasty                           | 2             |
| Augmentation rhinoplasty                                      | 1             |
| Alar grafting   | 2             |

of these 3 patients had undergone revision procedures using a PDS plate alone after failed repairs elsewhere. The third failure occurred after further septal trauma due to cocaine use; a PDS plate and cartilage had been used to repair a 3-cm perforation. This patient was not believed to be suitable for further surgery, but the other 2 went on to have successful closure performed via a formal external septorhinoplasty approach, again using a PDS plate alone.

**Table 2** lists the complications reported, including the 3 failed septal perforation repairs. Fifteen patients had minor swelling of the septum at 6 weeks, resulting in a variable degree of ongoing nasal blockage. These patients were treated with fluticasone propionate nasal spray for 6 weeks, and the swelling had resolved in most patients by 3 months; all the patients were satisfied. One patient developed a postoperative infection with subsequent extrusion of the unperforated PDS plate. This was easily removed in the clinic, and the infection was successfully treated with oral antibiotics. One patient developed a more severe infection, with ultimate nasal dorsal collapse despite treatment with intravenous antibiotics. He was initially seen after significant trauma to the nose and ultimately required revision surgery with rib cartilage grafting. No other patients required revision surgery (follow-up, 9-18 months).

#### COMMENT

The PDS plate has been used for many years in orbital floor reconstruction and has been shown to be histoconductive, stimulating the regeneration of bone.<sup>4</sup> In initial animal experiments,<sup>2</sup> an area of cartilage was resected from rabbit outer ear and then a perforated PDS plate was implanted to cover the defect and remaining cartilage. After 2 weeks, the implant was unchanged, with minimal surrounding tissue reaction, no inflammatory infiltrate, and no foreign body reaction; the native cartilage was unchanged. Similar appearances were seen after 5 weeks. After 10 weeks, resorption had begun, still with a surrounding thin layer of reactive tissue that was filling the perforations and thereby ensuring good fixation to the cartilage; chondroblasts were seen along the edge of the cartilage defect. At 15 weeks, resorption had progressed and

**Table 2. Complications Reported in the 102 Study Patients**

| Complication                             | Patients, No. | Treatment  |
|--|---------------|--|
| Failure of septal perforation repair     | 3             | 2 Patients had further surgery (successful)<br>1 Patient had conservative management |
| Infection and collapse of septum         | 1             | Revision surgery   |
| Infection and extrusion of the PDS plate | 1             | Conservative management  |
| Local septal swelling                    | 15            | Conservative management  |

Abbreviation: PDS, polydioxanone.

new cartilage had formed at the borders of the defect. After 25 weeks, the PDS plate was completely resorbed. Cartilage below the plate remained completely unchanged, and new cartilage had developed in the defect.<sup>2</sup> The surrounding tissue reaction had disappeared after resorption, so there was no unilateral scarring, which may lead to secondary deviation or thickening of the septum.

After septal cartilage trauma, the regenerated cartilage formed during healing is different from the original, with smaller chondrocytes lacking a normal columnar arrangement. Sections of cartilage also often overlap at fracture lines. Animal experiments have also been conducted to more closely mimic the use of a PDS plate in septal surgery. Various procedures have been performed, from simply raising mucoperichondrial flaps to resecting and replacing cartilage; all were completed with and without the use of a PDS plate.<sup>5</sup> Placing a PDS plate beneath mucoperichondrial flaps without resecting any cartilage confirmed that it was partly reabsorbed after 16 weeks, completely after 25 weeks. When cartilage was resected, it was seen to regenerate after 10 weeks. Without the use of a PDS plate, new cartilage formation often had secondary deviations and showed smaller chondrocytes without a regular columnar arrangement. When PDS was used, there was straight cartilage with mature histologic features, similar to the original cartilage. When cartilage was reimplanted without an additional PDS plate graft, there was overlapping of the fragments; this was not seen when PDS was used. The PDS plate seemed to act as a guide for tissue regeneration and to encourage the formation of a complete plate of cartilage. It also stimulates cartilage regeneration, with histologically more mature cartilage produced.

King and Ashley<sup>6</sup> first described extracorporeal septoplasty in 1952. Results using this technique are generally good. Gubisch<sup>7</sup> reviewed his series of 459 patients who were operated on during a 23-year period. The cartilaginous and bony septum were removed intact, redundant cartilage and fracture lines were excised, and then the pieces were sutured together. Although he reported good/excellent function in 96% of patients, there was a 12% complication rate. The particular complications he noted were dorsal irregularities and saddle deformities. We believe that this is where use of a PDS plate improves the technique by supporting the reimplanted cartilage and encouraging support and stability.

The use of a PDS plate in extracorporeal septoplasty has been previously reported,<sup>2,8-11</sup> via endonasal and external approaches. Excellent functional and cosmetic results have been reported in most patients, although there are several reports<sup>9,12</sup> of temporary thickening of the nasal septum for the first few weeks that fully resolved in all cases, including the present series.

Some complications have been reported, including subluxation at the caudal border.<sup>2,8</sup> One series<sup>11</sup> noted several saddle deformities after using unperforated foil and advised that only perforated foil should be used for this technique. We agree with this advice and suggest that the septal collapse seems likely to be due to loss of the blood supply to the healing septal cartilage, which would normally come from the overlying perichondrium. As animal studies<sup>4</sup> have shown that resorption of the PDS plate does not begin for at least 10 weeks, if an unperforated plate is used, it would sit between the septal cartilage and its perichondrium (on 1 side at least) during this time, obstructing the ipsilateral blood supply. Perforations allow some contact between the cartilage and its overlying perichondrium through the plate, thereby preserving its blood supply.

We have also found that the PDS plate is a useful scaffold elsewhere in rhinoplasty surgery, as discussed previously herein. Its use in such areas has been mentioned previously, but the specific techniques were not described.<sup>13</sup> It does seem to be a versatile way of making use of discarded cartilage fragments, even from areas that would traditionally not be thought strong enough, such as that removed from the lower lateral cartilage in cephalic trim.

Although other physicians have used a PDS plate only when the overlying mucosa is intact to limit the potential risks of extrusion or septal perforation, our experience of using it for the repair of septal perforations suggests that complete coverage of the PDS plate is not essential for normal healing.

In conclusion, the PDS plate seems to be an ideal graft choice to provide support and stability to regenerating healing cartilage in the septum and in other areas of the nose. It provides a structural template to which it is easy to attach cartilage, even small pieces, and it facilitates the insertion of such grafts into the nose. The rate of post-operative complications does not seem to be increased with its use, and because it is fully resorbed after 25 weeks, the long-term complications of a synthetic graft material are avoided. We believe that PDS is a useful and safe

material that can facilitate complex functional and cosmetic nasal reconstruction.

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