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Reconstruction of the Skull Base and Cranium Adjacent to Sinuses with Porous Polyethylene Implant: Preliminary Report

ABSTRACT—Surgical reconstruction of the skull base and cranium adjacent to open paranasal sinuses with alloplastic materials is problematic secondary to an increased risk of implant infection in these locations. The authors report their initial experience with the use of a porous polyethylene implant for closure of defects in these locations in 20 patients, in 14 of these with the implant placed in direct contact with the mastoid or paranasal sinuses. The implant is flexible, which facilitates surgical reconstruction of the cranial base, and porous in nature, which enhances soft tissue and bone ingrowth to decrease the risk of infection. The implant is radiolucent on plain roentgenograms and CT, and produces no imaging artifact on MRI. The implant was utilized for a variety of skull base or cranium adjacent to sinus reconstructive applications with no infectious complications, with a follow-up period ranging from 8 to 50 months. This preliminary experience suggests that the alloplast may be a useful adjunct in skull base reconstruction, and further evaluation of its use in this application is warranted.

Historically, autogenous materials have preferentially been used for surgical reconstruction of the cranial base due to the liability of infection associated with implantation of alloplastic materials adjacent to contaminated paranasal sinuses. Suitable alloplastic materials with a reduced potential for infection would be beneficial for this application.

The porous polyethylene implant is composed of high-density polyethylene microspheres sintered to create a framework of interconnected pores.[1–4] Polyethylene is a highly inert material and has been used in some cases with followup of more than 30 years in the craniofacial skeleton.[5] It has long been used as a standard reference material for biocompatibility testing.[6] The porous character permits ingrowth of vascularity, bone, and soft tissue to reduce the incidence of infection while increasing the strength of the implant.[2] Although experience with porous polyethylene in craniofacial repair and standard neurosurgical cranioplasty has been reported,[1,2,7,8] the authors have found this to be a favorable material for skull base or cranial reconstruction adjacent to air cells and paranasal sinuses, which has prompted the present report in which they describe their initial experience with the implant for these applications.

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MATERIALS AND METHODS

The porous polyethylene implant (Medpor©, Porex Surgical, College Park, GA) is constructed from high-density polyethylene that contains a system of interconnecting pores of approximately 150 μm in diameter.[1,8] The implant is available in a variety of sheet thicknesses and sizes as Flexblock, which has a smooth exterior surface and a series of conical projections on the undersurface that enable the implant to be flexed to achieve a contoured shape (Fig. 1). Alternatively, a smooth, thin sheet of porous polyethylene is available (1.5 mm thickness) that is very flexible and is primarily used for implantation in non weight-bearing applications. The implant is also available in a variety of preformed shapes for specific craniofacial applications.

To utilize the porous polyethylene implant in the closure of skull base or cranial vault defects, the soft implant may be fashioned to the desired shape with Mayo scissors or a scalpel. To facilitate an adequate fit, a pattern of the defect may first be drawn on a "template" of paper and then transferred to the smooth surface of the implant. The implant may then be cut slightly larger than the template with a pair of large Mayo scissors. With the thicker flexblock design, it may be helpful to "feather" the edge slightly to obtain an smooth contour (performed easily with a No. 10 blade and not necessary with use of thin 1.5-mm sheets). Fixation of the implant is performed by placing titanium screws directly through the implant into the bone (Figs. 2 and 3) or together with the use of titanium miniplates.

RESULTS

In the present report, the porous polyethylene implant was used in 20 cases requiring either skull base reconstruction or closure of cranial defects adjacent to an open sinus. Eight of the defects closed were for primary cranial defects adjacent to an open sinus (paranasal or mastoid), and nine were for closure of a primary skull base defect (adjacent to a sinus in three cases), with the remaining three defects involving both regions (Figs. 2–4). These cases included a variety of defects of small to medium size (<4 cm) of the frontal, middle, and posterior fossa (Table 1; larger defects were not encountered in this series). In 14 of the 20 cases, the defect closed was produced for purposes of tumor removal, in 3 for microvascular decompression, and in the remaining 3 cases the implant was utilized to close traumatic defects. All patients received 1 g of intravenous cefazolin sodium (Ancef©, Smithkline Beecham Pharmaceuticals, Philadelphia) preoperatively and three additional doses every 8 hours postoperatively. In those patients with known se-

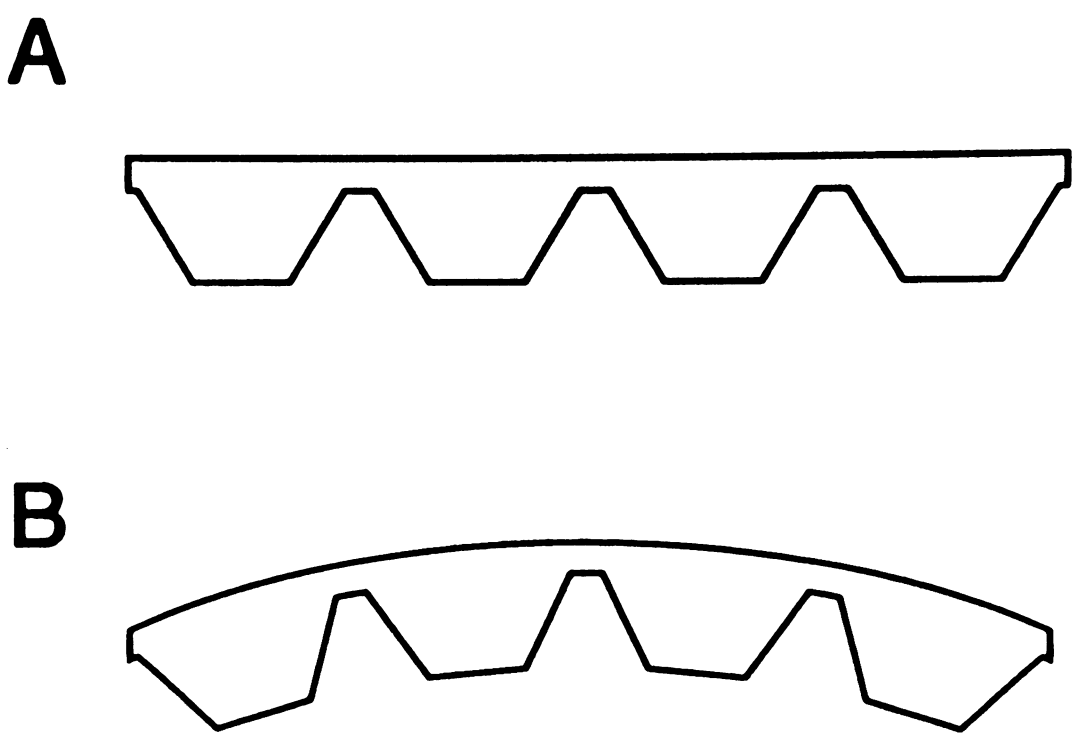


Figure 1. Illustration of the porous polyethylene flexblock implant. Cross section of the implant (**A**) demonstrating the cones on the undersurface, which enable the implant to be flexed to the desired contour (**B**).

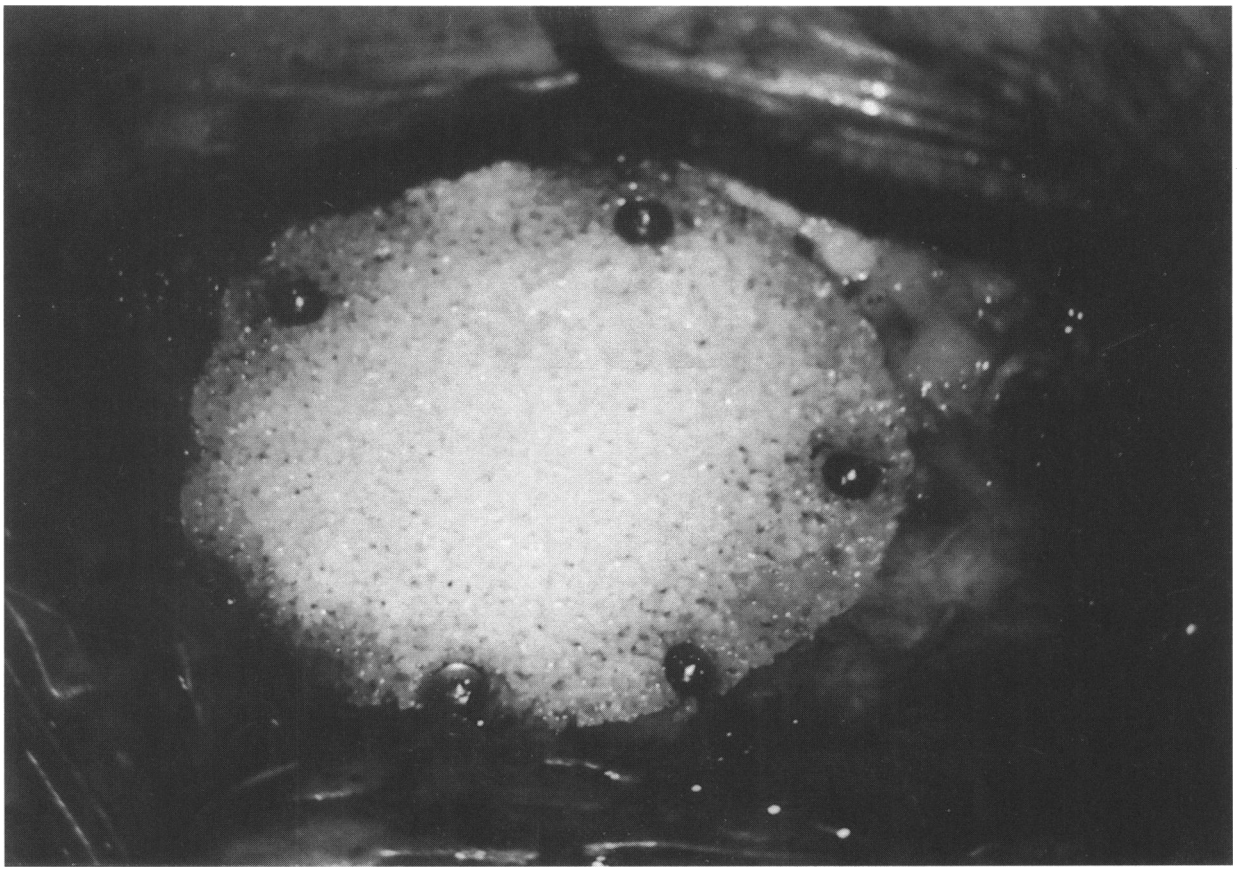


Figure 2. Porous polyethylene sheet used to cover a small mastoid defect. A keyhole defect created for a microvascular decompression for trigeminal neuralgia entering the mastoid has been closed with a 1.5-mm sheet of porous polyethylene. Four-millimeter titanium screws are used to fasten the implant to the surrounding mastoid and suboccipital bone in this case.

vere hypersensitivity to penicillin, vancomycin (Vancocin©, Eli Lilly and Company, Indianapolis) 500 mg intravenously was administered preoperatively and for three additional doses every 6 hours postoperatively.

Follow-up period for implant cases range from 8 to 50 months. There were no implant-related complications; in all cases with use adjacent to open sinuses no evidence of infection has been noted during the follow-up period (Fig. 4).

DISCUSSION

While autogenous materials for skull base and craniofacial reconstruction possess optimal biocompatibility characteristics, complications arising from the donor site and increased operative time are disadvantages to their use. For these reasons, using an appropriate alloplastic alternative material is desirable. The use of standard methylmethacrylate in these applications may be associated with potential complications, including an exothermic reaction produced during the curing process that may result in local tissue damage, fracture of the brittle implant, and a prohibitively high rate of infection when used adjacent to contaminated paranasal sinuses.[1,3]

Polyethylene is a highly inert material that has been proven stable over many years of use in humans. The porous architecture of the porous polyethylene implant enables the ingrowth of vascularity and soft tissue within a short period of 3 to 4 weeks to form a stable interface that anchors the implant.[1,2,8] Over longer periods, it permits the incorporation of bone at the implant-bone interface.[2,3,8] Merritt et al[3] demonstrated that, following healing, dense ceramic implants were more susceptible to infection than porous polyethylene and suggested that the vascular ingrowth may protect the implant from infection. In this regard, in a series of 140 open facial fractures reported by Romano et al[7] the implant was used with no infectious complications. Furthermore, in an orbital blow-out fracture model in rabbits, ingrowth of vascularized soft tissue occurred with porous polyethylene implanted adjacent to the contaminated maxillary sinus,

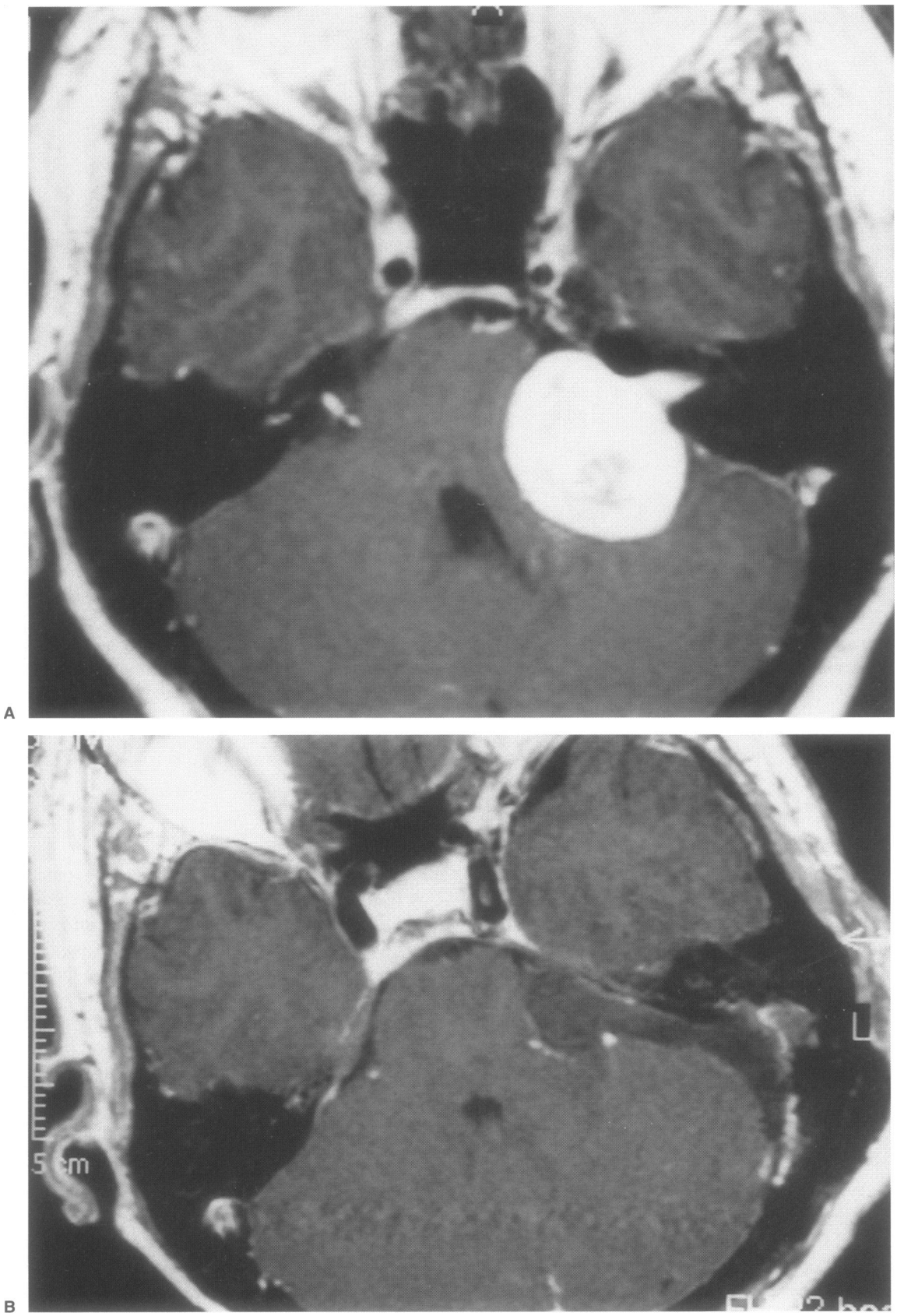
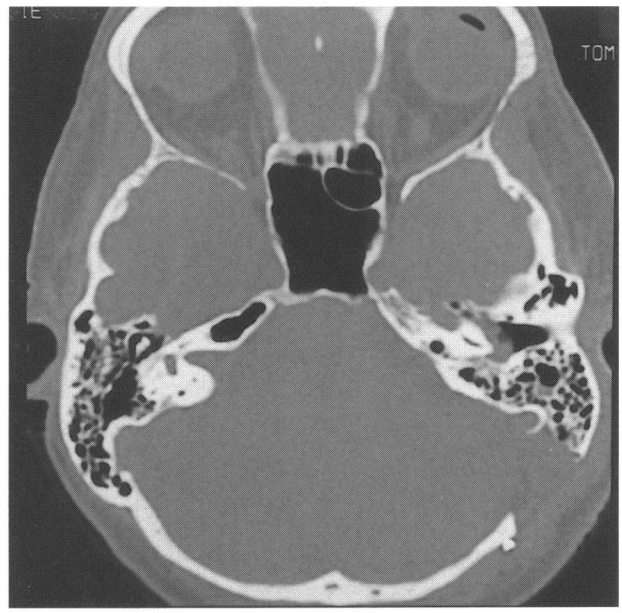


Figure 3. Porous polyethylene produces no artifact on postoperative imaging studies. This 52-year-old female underwent an uncomplicated removal of a 3.5-cm acoustic tumor by the suboccipital route with exposure of the mastoid air cells (**A**). The postoperative MRI (**B**) demonstrates the defect closed with the implant, with no imaging artifact produced. (Figure continued on the next page.)



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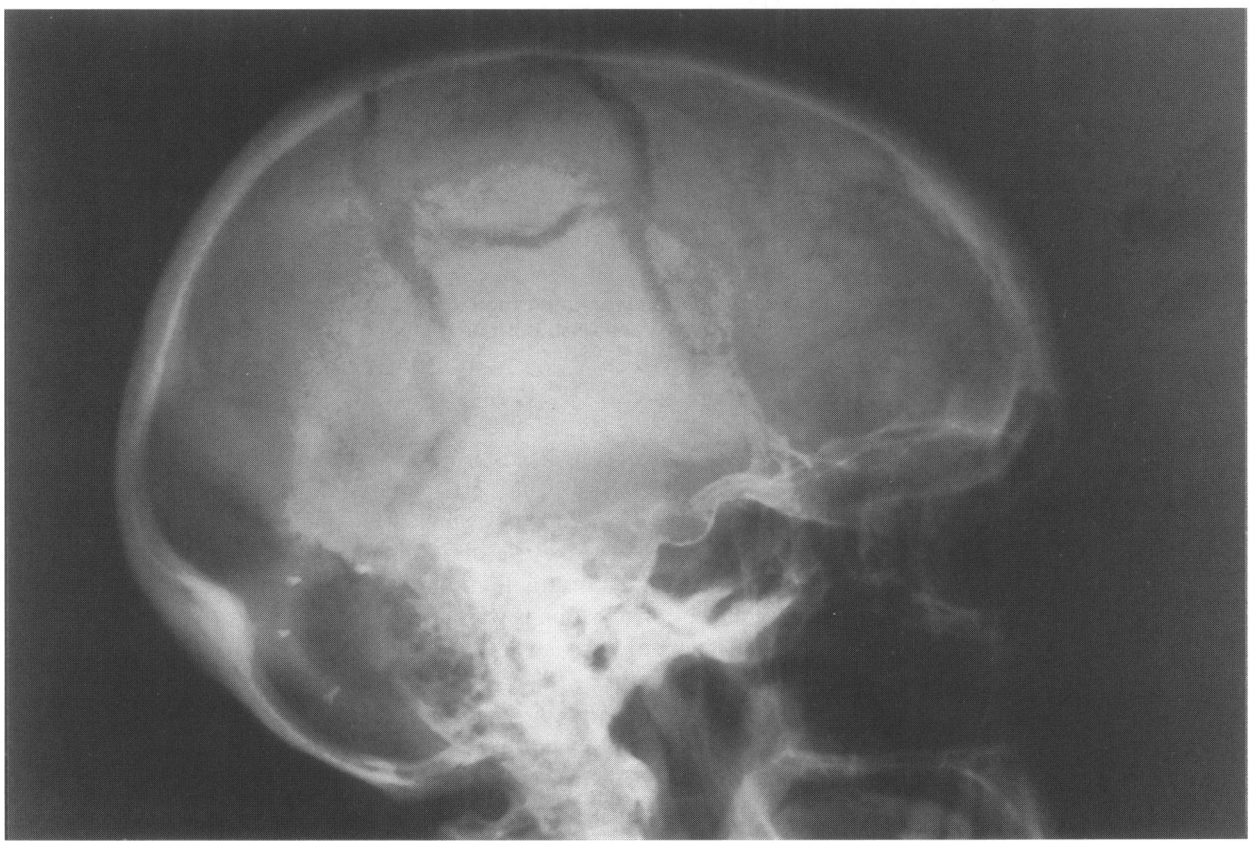

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Figure 3. (Continued). Similarly, the postoperative CT (**C**) and lateral skull roentgenogram (**D**) show that the implant is radiolucent. Note the titanium miniscrews used to fasten the implant.

eventually resulting in normal mucosal covering of the implant. Recently, its use has been reported with success in humans for fractures in this location.[9]

The authors have previously reported their initial experience with the use of porous polyethylene implant in small- or medium-sized cranioplasty and craniofacial applications.[1,8] Subsequent to these reports, the implant has been extensively utilized for these applications with continued minimal associated complications. In the present series of patients, the implant has been used for coverage of small- and medium-sized (<4 cm) skull base and cranial defects in various locations, in most

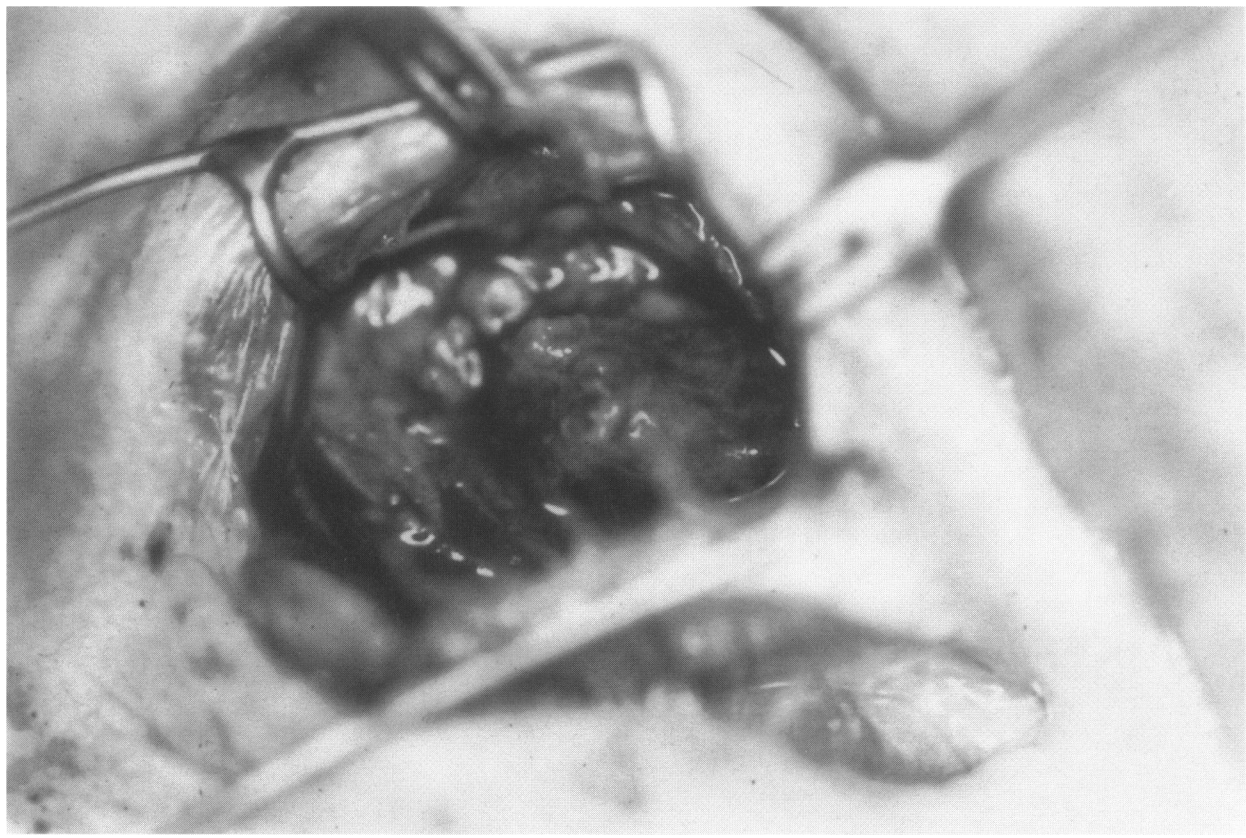

Figure 4. This 53-year-old female patient underwent a craniofacial resection for a malignant ethmoid and maxillary sinus tumor. The extensive tumor involved the medial orbital wall and floor, which was resected during the oncologic removal. A 1.5-mm sheet of porous polyethylene was utilized to reconstruct the orbital floor adjacent to the open maxillary sinus. Following the resection, the patient underwent a cosmetic facial wound revision several months later; the intraoperative photograph of the open maxillary sinus demonstrates complete mucosal overgrowth over the implant, despite extensive postoperative radiation therapy.

cases with exposure to open paranasal sinuses. As noted in Figure 4, in a similar fashion to the animal work noted above, the implant enabled mucosal overgrowth within the adjacent sinus, despite postoperative radiation therapy. The implant is completely radiolucent on roentgenograms and produces no imaging artifact on MRI studies, which may be an advantage in comparison to the use of wire or titanium mesh, to enable improved visualization of postoperative studies following skull base tumor removal.

Table 1. Skull Base or Cranial Defect Location and Size in 20 Cases

Location	*No. of Cases*	*Size**
Frontal fossa	6	Small, 2; medium, 4
Middle fossa	4	Small, 2; medium, 2
Posterior fossa	10	Small, 6; medium, 4

*Small: <2 cm; medium: 2–4 cm. The defect size indicates the diameter of the skull base or cranial defect closed with the alloplast in the largest dimension.

This preliminary experience suggests that the porous polyethylene implant offers comparable results to the use of autologous bone grafts for skull base reconstruction. Further evaluation of its use in this application is warranted.

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