The Use of High-Density Polyethylene Implants in Facial Deformities

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Objective: To determine the usefulness of porous high-density polyethylene implants (Medpor) in a variety of facial skeletal deformities and subcutaneous defects, excluding those associated with acute maxillofacial trauma.

Design: Case series.

Setting: Academic tertiary care referral center in Baltimore, Md.

Patients: Thirty-four patients (age range, 20-74 years) with facial deformities requiring skeletal defect reconstruction or augmentation (38 cases), treated between January 1, 1992, and January 1, 1997. Follow-up ranged from 6 months to 40 months.

Main Outcome Measures: Age, type and origin of the deformity treated, type of treatment, and complications.

Results: Types of deformities and defects treated include 7 patients with orbital defects (secondary traumatic or oncologic deformities), 8 with temporal fossa defects, 8 with frontocranial defects, 4 with maxillary or malar defects, 7 with calvarial bone graft donor site defects, 2 with microtia, and 2 with chin deficiency. Forty implants were placed. Complications included implant exposure in 4 patients and inappropriate augmentation in 1 patient (chin implantation).

Conclusions: High-density polyethylene implants offer an excellent alternative to autogenous and other alloplastic materials in reconstruction of many facial defects and deformities. Advantages include its versatility and relatively ideal pore size that allows for excellent soft tissue ingrowth and coverage. Disadvantages include its rigid nature and difficulty in contouring to the surface of complex skeletal structures.


Facial implants may be required to restore anatomical harmony following accidental or iatrogenic trauma, to correct congenital deformities, or in aesthetic surgery. The malar eminence, chin, and nose are common sites for implant placement in cosmetic surgery. Trauma may require the use of implants to reconstruct the orbit or cranium. Facial implants became popular around the turn of the century, but Roussett was using gold implants in the nose as early as 1828. Joseph used ivory inlays for the nose in 1900. Brown et al reported the advantages of silicone implants in 1953, and to this day silicone is one of the most widely used materials.

The ideal alloplastic implant has been described as a material that is inert, noncancerogenic, noninflammatory, and nonallergic. It should resist mechanical strain, and be easy to fabricate and shape. The optimal implant would integrate into the surrounding soft tissues, cartilage, and bone. Realistically, this may not be possible, but soft tissue ingrowth is desirable. Since facial implants replace or modify bone and cartilage of the face, autogenous bone and cartilage have been considered the standard against which alloplastic materials should be judged. In 1896, Israel described using the tibial bone for nasal reconstruction. Costal cartilage was first used for reconstructive purposes in 1900 by Von Mangold. But autogenous bone and cartilage are not without their drawbacks. These include increased surgical time and complexity, donor site morbidity, difficulty in shaping the graft, graft warpage, and resorption. Irradiated homologous bone or cartilage overcomes the increased surgical complexity of harvesting autologous tissues and the resultant donor site morbidity. However, graft warpage and resorption still remain. Long-term follow-up shows unpredictable resorption of irradiated cartilage over an extended period. There is also the fear of transmitted diseases and, while the actual possibilities are remote, public fear remains.

Many synthetic alloplastic materials have been used over the years. Smooth surfaced, solid implants include silicone (Silastic), methylmethacrylate, and titanium. Porous materials including polytetrafluoroeth-

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**PATIENTS, MATERIALS, AND METHODS**

A total of 38 sites in 34 patients were implanted with HDPE implants at the Johns Hopkins Medical Center, Baltimore, Md. Porous high-density polyethylene implants have been routinely used by one of us (J.L.F.) for primary reconstruction of orbital fractures, but these cases are excluded from this series. Twelve cases were secondary reconstruction for traumatic deformities. The largest group, consisting of 16 cases, were reconstruction following oncologic resection. There were 3 reconstructions for congenital deformities and 3 implants for aesthetic purposes. The sites were the orbit (n = 7) in secondary reconstruction, temporal fossa (n = 8), chin (n = 2), ear (n = 2), frontal cranial defects (n = 8), calvarial bone graft donor site (n = 7), and maxilla (n = 4). All patients, excluding one 7-year-old, were adults seen at the Johns Hopkins Medical Center from January 1, 1993, to March 1, 1997, with a minimal follow-up of 6 months. Patients were examined postoperatively and observed for implant infection, exposure, extrusion, and stability.

**SURGICAL TECHNIQUE**

Before implant placement, defect analysis is important. For coverage of defects (eg, in the orbit), thin HDPE (1.5-mm thickness) is adequate. For increasing depth and complexity, thicker implants should be used, which may be cut into the desired shape using a scalpel. Alternately, a 1.5-mm pre-formed implant with 5 × 5-mm symmetric half-spheres (“flexblock”) is useful for complex defects. These half-spheres can be shaped to the desired thickness, allowing sophisticated shaping and tapering. In limited situations, preformed implants are occasionally useful in reshaping orblital rim, malar, and chin deformities or defects.

It is recommended that the material be shaped using a scalpel blade. Other reports have suggested the use of a drill for contouring. However, this method may introduce debris into the pores of the HDPE, thus affecting soft tissue ingrowth. Before implantation, we recommend soaking the formed implant in an antibiotic solution.

Finally, it is critical that the implant has adequate soft tissue coverage to allow for ingrowth and eventual soft tissue fixation. Primary fixation with screws is ideal for early immobilization, but in many instances suture fixation is adequate.

This report describes our experience with porous high-density polyethylene (HDPE, Medpor, Porex Surgical Inc, Atlanta, Ga), an alloplastic implant material that may offer many advantages when compared with previously used materials. Porous high-density polyethylene was developed in the early 1970s. It is somewhat flexible at room temperature and when heated in hot water becomes malleable. This implant material has high-tensile strength and is readily available. Furthermore, the material is available in a variety of preformed shapes and can be customized with a scalpel blade quite easily. Porous high-density polyethylene is a sintered form of high-density polyethylene with an interconnecting network of pores. These pores range in size from 160 to 368 µm and greater than half of the pores are larger than 150 µm in diameter.

**CASE EXAMPLES**

**Case 1**
A patient underwent a globe-sparing total maxillectomy for an ameloblastoma. Primary reconstruction included the use of free bone grafts to reconstruct the infraorbital rim and zygomatic defect and this was covered with temporoparietal fascia. Unfortunately, the central and medial portion of the bone graft resorbed leading to an infraorbital depression, as well as enophthalmos (Figure 1, A). He subsequently underwent reconstruction using a preformed HDPE infraorbital rim prosthesis (Figure 1, B), as well as orbital reconstruction. Figure 1, C shows the postoperative results.

**Case 2**
A woman underwent a right total maxillectomy for an adenocarcinoma of the right maxilla (Figure 2, A). Secondary reconstruction of her upper cheek defect was undertaken using calvarial bone grafts. However, the graft became exposed intraorally, thus necessitating removal. After healing, she underwent a final reconstruction using HDPE flexblock, as well as resection of the overlying contracted skin with facial rotation-advancement flap coverage (Figure 2, B).

**Case 3**
A woman sustained a penetrating injury when a tree branch went through the windshield and penetrated her face between the eyes causing bilateral blindness, a nasal avulsive injury, and anterior cranial fossa disruption. After a primary cranial base repair, she had the resultant frontal cranial deformity (Figure 3, A). Through the same cranial approach, HDPE sheeting was used to augment the temporal regions as well as to smooth the burr hole and avulsive deformities in the superior and infra mid-forehead (Figure 3, B).

**Case 4**
This patient sustained a gunshot wound to the face with resultant scar deformities, and deformities of the left zygomatic arch and temporal fossa and left temporomandibular joint (Figure 4, A). Porous high-density polyethylene was used to reconstruct the temporal defect and to smooth out deformities in the parietal and temporal cranium, along with temporomandibular joint reconstruction (Figure 4, B).
Studies by Klawitter et al\textsuperscript{13} and Spector et al\textsuperscript{14} have shown that pore size greater than 100 µm encourages tissue ingrowth. Of note, other popular materials touting tissue ingrowth, such as polytef (Gore-Tex), have pore sizes much less than 100 µm.\textsuperscript{14} Materials having large pore sizes have had drawbacks of material breakdown when used improperly, such as a woven combination of Teflon and organic fibers (Proplast).\textsuperscript{4,15,16} As expected, several authors have demonstrated rapid ingrowth of fibrous tissue with mature blood vessels and bone.\textsuperscript{17} The tissue ingrowth results in firm attachment and integration of the implant to the surrounding tissue leading to decreased migration of the implant, thus obviating the need for screw or suture fixation in certain cases.\textsuperscript{18} The vascularized soft tissue network throughout the implant reduces the likelihood of infection.\textsuperscript{19,20} The rapidity of vascularized tissue ingrowth in HDPE has been shown to make this material more resistant to infection than other porous implant materials.\textsuperscript{20} If an infection occurs, it may not necessitate the removal of the entire implant.\textsuperscript{21} The degree of vascularization is such that implants modified in situ produced bleeding when cut with a scalpel, and skin grafts have been placed directly over the implants with success particularly after the initial healing phase.\textsuperscript{17,22}

Polyethylene resins are composed of straight-chain aliphatic hydrocarbons. Polyethylene has proven itself to be
a very inert material with very low tissue reactivity. Solid poly-
ethylene has been used for implants in humans since the 1940s
as a substitute for bone or cartilage.23 Follow-up results of
more than 30 years demonstrate favorable tissue response,
and, as such, polyethylene has become a standard reference
material for biocompatibility testing.23 Histological exami-
nation of HDPE implants reveals a lack of capsule forma-
tion and minimal inflammatory and foreign body reactions.17

Previous reports have focused on and validated the
efficacy of this material’s use in primary traumatic orbital
reconstruction.24-26 Our report reviews the use of HDPE in
other aspects of facial reconstruction, emphasizing the ad-
vantages of the soft tissue ingrowth that occurs with this
material.

RESULTS

All implants were found to be fixed to the surrounding tis-
sue at 3 months’ follow-up. Thirty-four of the implants had
no evidence of infection, exposure, or extrusion. One im-
plant had to be removed secondary to infection at 3 weeks,
but this implant was noted to be firmly attached to the sur-
rounding tissue except at the site of infection. In 2 pa-
tients, there was limited exposure of the implant (1 in the
medical infraorbital rim and the other in an outer cortex
calvarial defect). Partial implant removal was taken with
subsequent healing. The final complication was exposure in
2 areas of an auricular implant. One exposed area healed
by secondary intention, and the second area required de´
bridement and local flap closure.

COMMENT

This retrospective review excludes our experience us-
ing HDPE in primary trauma. The literature has con-
firmed the use of HDPE for primary orbital reconstruc-
tion with low incidence of infection.24-26 It is important
to note that in this primary setting there is an obligatory
contamination of the implant by the exposure to the max-
illary sinus, yet infection and extrusion have been rarely
noted.24-26 It was with this experience that we expanded
the use of the material to other areas of primarily bony
tissue reconstruction.

Our present series reviews the use of HDPE in de-
defects other than those associated with acute orbital trauma.
Not surprisingly, the material was quite effective for the
use of secondary orbital reconstruction. We have found its
greatest utility in cranial and temporal defects. The former
has included its use in the coverage of burr holes and other
remodeling defects that have occurred after craniotomies
and in the reconstruction of the donor site deformity after
the harvest of the cortex calvarial bone grafts. We have found
the HDPE flexblock to be particularly effective in the ir-
regular defects created in the cranium. The resultant con-
tours are excellent, particularly when the implants are fixed
with small screws. The latter allows a fine contouring of
the edges using a scalpel after the implant has been posi-
tioned, thus alleviating irregular edges.

We have also found the material useful in the recon-
struction of temporal donor site defects when the tempora-
lis muscle has been used for reconstructive purposes. Once
again, the HDPE flexblock is helpful in this situation. How-
ever, irregularities, as well as both underaugmentation and
overaugmentation, have been a problem. Similarly, if the
skin is thin in the temporal region, the edge of the implant
may be not only palpable but also visible. Accordingly, we
recommend whenever possible to reconstruct the entire
temporal fossa with the material. It should be noted that 3
of the patients with temporal reconstruction underwent sub-
sequent radiotherapy without problems with the implant.
However, in 1 patient who had undergone a previous lat-
eral skull base approach to the skull base with postopera-
tive radiotherapy and who had a large temporal skeletal defect, HDPE was placed in the immediate subcutaneous tissue and onto scar tissue overlying the dura. At the time of the placement of the HDPE implant, the overlying skin was noted to be very thin and atrophic and a portion of the implant eventually became exposed and appeared to be infected. At the time of implant removal, it was noted that a majority of the implant was fixed and had soft tissue ingrowth but it was removed anyway.

We had also found this material to be useful in other aspects of skeletal augmentation. It was used in 2 cases of congenital deformities of the maxilla. In 1 case, it was used as a submalar implant material in a patient with hemifacial microsomia and, in another, it was used to augment the skeletal cleft defect in a patient who had a previously repaired paramedian facial cleft.

As in the case presentation, the materials have been used in 2 occasions to secondarily reconstruct the upper maxilla and the infraorbital rim region following the maxilectomy. We believe that if there is adequate vascularization to the surrounding soft tissues, the implant will do well. In 1 of the patients who had undergone full-course radiotherapy for her primary tumor, the implant became exposed at the medial aspect of the Weber-Ferguson incision. Only the exposed portion of the implant was removed and the patient went on to heal eventually. The literature claims the use of a preformed HDPE prosthesis for an auricular reconstruction.27 We reconstructed 2 secondary traumatic total ear defects with this material, using temporoparietal fascia flap coverage for the material. Unfortunately, in 1 of the ears, the prosthesis became exposed in 2 areas. One of these areas healed by secondary intention with good wound care while second exposure required partial implant removal and local flap coverage. Other authors claim HDPE’s effectiveness not only in treating posttraumatic ear deformities but also in primary microtia repair, but we have not used it for this purpose.

Finally, the material was used for chin augmentation in 2 patients using preformed chin implants. We found the material to be difficult to work with in this situation because of the relative lack of pliability relative to other implants such as Silastic. The other problem we found with our limited experience of using it in the chin is that it did not contour to the natural shape of the bony symphysis such that its resulted in a very wide, rounded unaesthetic appearance. Accordingly, we have ceased using HDPE in this type of cosmetic surgery.

Finally, the use of HDPE as a dorsal nasal implant has been recently reported. The advantages of using this material in the nose is obvious in that soft tissue ingrowth would be promoted as opposed to other alloplastic implants that have been used in the nose. The disadvantage of this material in the nose is its rigidity although it certainly is no more rigid than other autogenous materials such as cartilavial bone grafts and costochondral grafts.

In summary, our experience has shown HDPE to be an excellent alloplastic bony replacement material. While the results with Proplast strongly suggest the polyethylene resin materials should not be used under the strain of a functional load, materials such as HDPE seem to be very effective for skeletal replacement in non-load-bearing regions. We have used it as the material of choice for orbital reconstruction both in the primary and secondary setting and are developing confidence in the use of material even in the face of radiotherapy. However, adequate vascularized soft tissue coverage must be present in the latter situation. It appears to be an excellent material for the repair of some cranial defects although and, while it does become fitted by soft tissue, it does not allow bony ingrowth such as occurs with hydroxyapatite cement.

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