Clinical Experience in Cranioplasty With Porous Polyethylene Implant

Porus Polietilen İmplant ile Kranioplasti Klinik Deneyimi

SERDAR KAHRAMAN, HAKAN KAYALI, SAİT ŞİRİN, ALİ KAFADAR*
MURAT AKBÖRÜ*, ERDENER TİMURKAYNAK

Department of Neurosurgery, School of Medicine, Gülhane Military Medical Academy, Etlik, Ankara, Turkey
* Department of Neurourgery, Air Force Hospital, Etimesgut, Ankara, Turkey

Received: 14.11.2002 ⇨ Accepted: 01.11.2003

Abstract : ***Objective:*** Cranial defects and their optimum reconstructions have been a deal in neurosurgical practice. In the recent time, we used porous polyethylene implants for cranioplasty to provide better cosmetic, surgical and long-term safety results.
Material and method: Porous polyethylene implants (Medpor", PorexMedical, Atlanta, GA) were used in 36 patients with different localization and size of cranial defects.
Result: Using porous polyethylene has shortened the operation time and led no complication except one late infection due to skin trauma.
Conclusion: Porous polyethylene has many advantages in restoring all cranial defects with low morbidity.

Key Words: Alloplastic material, cranioplasty, porous polyethylene

Özet : ***Amaç:*** Nöroşirürji pratiğinde kranial defektlerin en iyi şekilde onarımı problem oluşturmaya devam etmektedir. Son dönemde kranioplasti için daha iyi kozmetik, cerrahi ve uzun süreli güvenilir sonuçları olan porous polyethylene kullandık.
Materyal ve Metod: 36 hastada farklı lokalizasyon ve genişlikte olan kranial defektler için porous polyethylene implant kullanıldı..
Sonuç: Porous polyethlene kullanımı operasyon zamanını kısaltmaktadır. Travmatik cilt defektine bağlı geç dönem enfeksiyonu olan bir olgu dışında komplikasyon görülmemiştir. Kranial defektlerin porous polyethylen ile onarımı düşük morbiditeyle beraber pek çok avantaja sahiptir.

Anahtar Kelimeler: Alloplastik materyal, kranioplasti, porous polyethylene

INTRODUCTION

Desirable properties of alloplastic materials for closure of skull defects include rigid fixation and cosmetically acceptable edge-to-edge contact and contour. Many techniques using alloplastic and autogenous materials have been championed for this purpose, including autogenous bone grafts, silicone, porous hydroxyapatite, and various metals either alone or in association with methyl methacrylate (6,11,13,16,18).

An alloplastic material should have some ideal properties, which include ease of adaptation, biocompatibility, permitting ingrowth of new tissue, stability of shape, low level of resorption.

Polyethylene has been used in the craniofacial skeleton, in some cases with follow-up periods of more than 30 years (15), it has long been used a standart reference material for biocompatibility testing (8). The porous polyethylene implant is a highly stable and somewhat flexible porous alloplast that has been shown to exhibit rapid tissue ingrowth into its pores (19) and may be used to cover any shape of cranial defect (2).

Here, we present our experience with porous polyethylene for the restoring of cranial defects.

MATERIAL AND METHOD

We used porous polyethylene implant for cranioplasty in 36 patients between 1998 and 2001. All patients were male and their ages were between 20-35 years. Cranial defect localizations and the pathological diagnoses of the patients were summarized in Table 1. Four cases with frontal defect had also frontal sinus damage. Cranial defects were also classified as small, medium and large in respect of their largest diameter which is considered to be a very important parameter, particularly in stability (Table 2). In five cases, orbital reconstructions have also been performed together with cranioplasty. Timing of surgery was variable depending on the pathologies of the patients. In traumatic cases, cranioplasty was performed after following infection-free period of one-year. Simultaneous cranioplasty was done in the remaining cases. No patient had a radiation therapy before cranioplasty operation.

Table 2. Classification of the cranial defects

Type	Largest diameter of cranial defect	No
Small	< 4 cm	9
Medium	4-8 cm	22
Large	> 8 cm	5

Porous polyethylene implants were adapted to the cranial defects with trimming the edges of the implants after softenning in sterile warm saline. Consequently, the implants were fixed on the cranium using titanium or bioabsorbable mini-screws and in some cases titanium or bioabsorbable mini-plates (Figure 1 a-b and 2 a-b, Figure 3). Follow-up periods ranged from 1 to 4 years.

Table 1. Localizations of the cranial defects and pathological diagnoses of the patients.

Localization/Pathology	Fibrous dysplasia	Leptomeningeal cyst	Posttraumatic cranial defect	Secondary to cranial operation	No
Left frontal	-	-	9	1	10
Right frontal	-	-	4	1	5
Right fronto-orbital	3	-	-	-	3
Left fronto-orbital	1	-	1	-	2
Occipital	-	-	3	-	3
Right parietal	-	1	3	2	6
Right temporal	-	-	2	-	2
Right temporo-parietal	-	-	3	-	3
Right fronto-parietal	-	-	1	1	2
Total	4	1	26	5	36

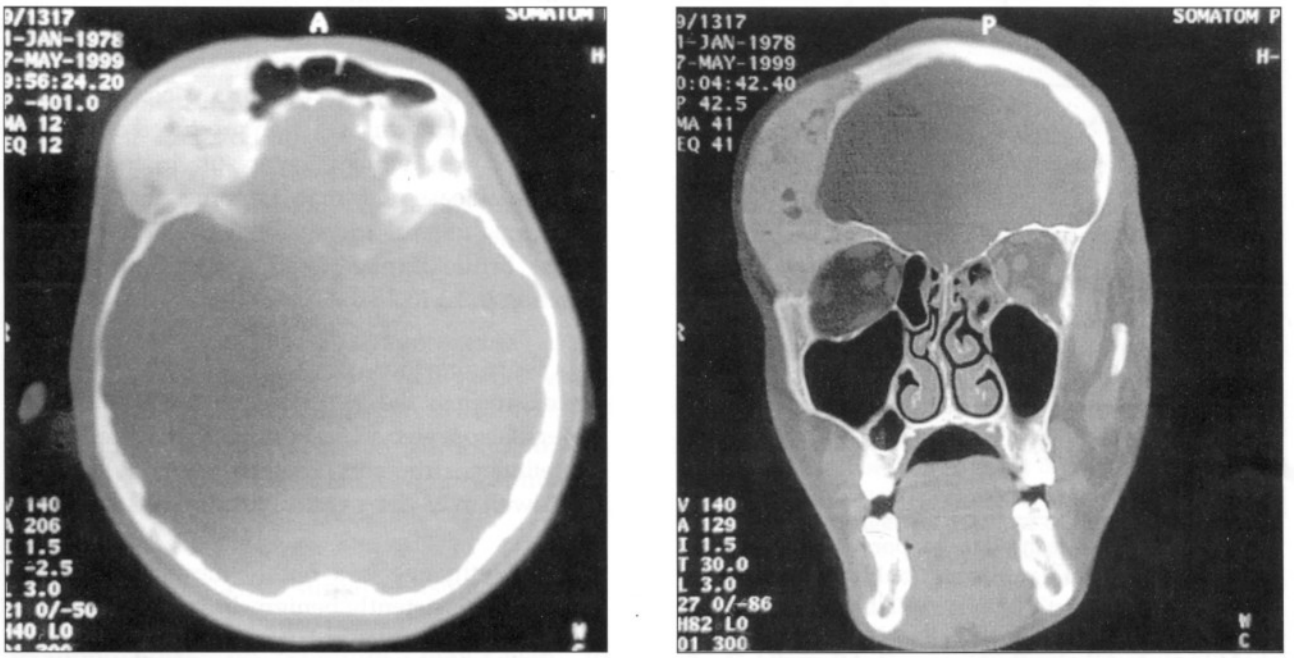

Figure 1: Preoperative axial (a) and coronal (b) computed tomography scans of the patient with fronto-orbital fibrous dysplasia.

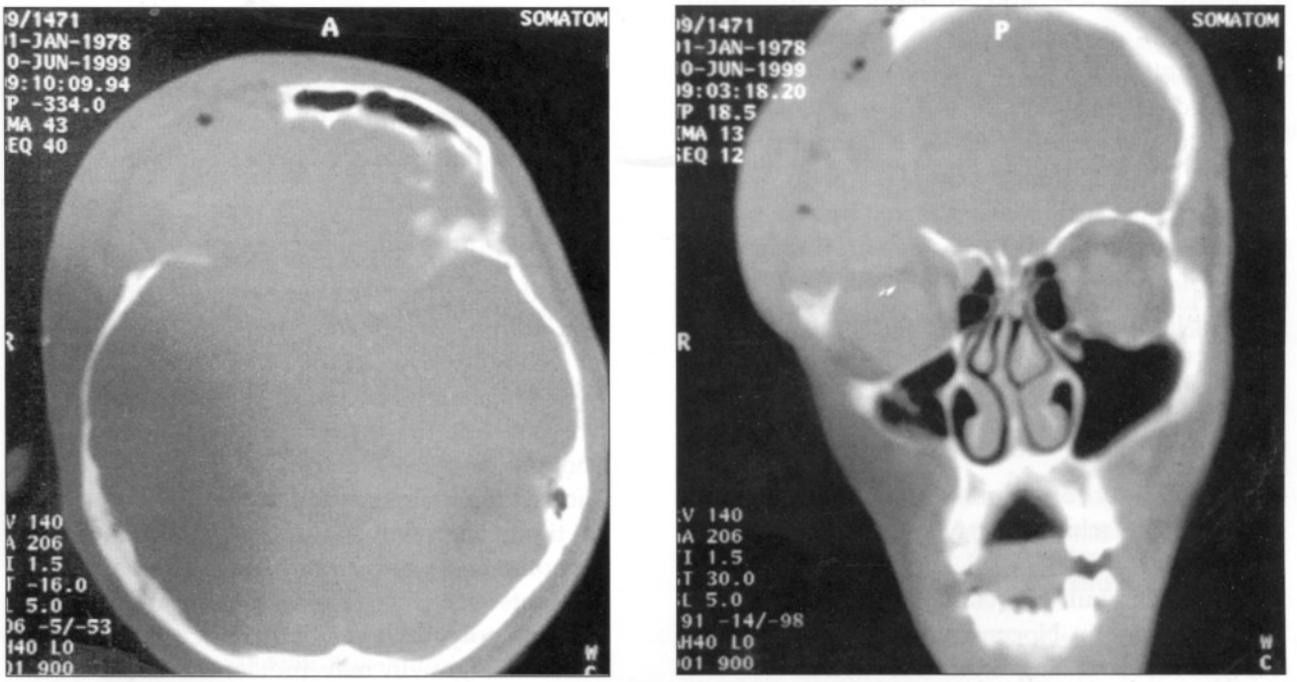

Figure 2: Axial (a) and coronal (b) computed tomography scans of the patient after cranioplasty with porous polyethylene

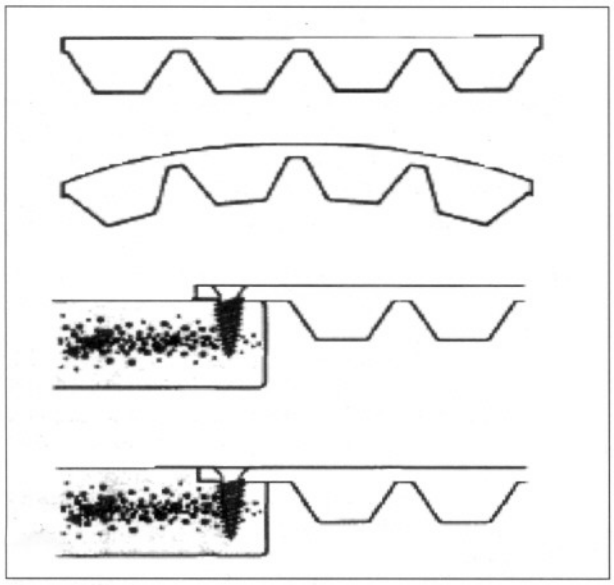

Figure 3: Surgical technique of porous polyethylene implant (An original figure from Couldwell WT et al.)

RESULTS

After exposing the cranial defect, the avarage time for implantation of the alloplast was 25 minutes. There are different shapes of porous polyethylene implants which are suitable for different sites and shapes of cranial defects. Excellent surgical and cosmetic results were obtained in all cases except in one case with left fronto-orbital defect. In this case, infection was observed in implant site due to traumatic skin defect in the second year of cranioplasty. After removal of the infected implant with leaving orbital reconstruction, we followed up the patient for one-year infection-free time for secondary cranioplasty with porous polyethylene again. Follow-up the patient for one year showed no further complication.

DISCUSSION

A variety of cranioplasty materials and implantation techniques have been reported in the literature (6,11,13,16,18). While autogenous materials for skull and craniofacial reconstruction possess optimum biocompatibility characteristics, complications arising from the donor site and increased operation time limit their widespread use. For these reasons alloplastic materials continue to be popular, the most widely used being methyl methacrylate alone or in combination with titanium or wire mesh (11,13).

However, the use of methyl methacrylate may be associated with potential complications including exothermic reaction produced during the curing process which may result in local tissue damage, release of a toxic monomer that has been implicated in local and systemic reactions, fracture of the brittle implant, and a significant rate of infection (6,12,13,16).

Since previous alloplastic materials had some disadvantages, the necessity of new alloplastic materials appeared in neurosurgical practice. Porous polyethylene implants were successfuly used by Couldwell in 25 cases with cranial defects (2).

Polyethylene is a highly inert material that exhibits a consistently benign clinical response and has been proven stable over many years of use in humans. Porous polyethylene is a form of high-density polyethylene that contains a system of interconnecting pores of approximately 150 mm. in diameter (18). This porous architecture enables the ingrowth of vascularity and soft tissue within a period of 3 to 4 weeks to form a stable interface that anchors the implant (3,5,9). Over longer periods, it permits the incorporation of bone at the implant-bone interface (3,9,17). Porous polyethylene was determined to be well tolerated histologically with only mild chronic inflammation, thin capsule formation, and partial fibrovascular ingrowth (7).

Maas et al. compared various porous materials (proplast, silastic, supramid and porous polyethylene) for facial bone augmentation in dogs and found the greatest implant stability with porous polyethylene (10). Proplast has poor tissue ingrowth ability because of its sponge like frame. The pores do not interconnect and are not strong enough to resist collapse. Berghaus et al. also showed the fragmentation of proplast implant due to tissue ingrowth (1). Moreover, Merritt et al. demonstrated that after healing dense ceramic implants were more susceptible to infection than porous polyethylene, they suggested that the vascular ingrowth may protect the implant from infection (12).

A multi-center experience using porous polyethylene implants in 140 patients with facial

fractures was presented by Romano et al. in 1993 (14). In patients with acute injuries, the implant was placed in the orbit, exposed to open facial sinuses. Despite the use of this implant for acute trauma reconstruction, there was only one instance of implant infection requring removal, and no implant migration or exposure. Similiarly Duman et al. reported that no implant migration, resorption or infection in their 12 consequtive patients (4).

In our 36 cases, infection was observed only in one case (2.7%) due to traumatic skin defect which could not be contributed to the porous polyethylene implant itself. In addition to this result, no implant fragmentation, resorption or migration occured in our cases.

In cranioplasty surgery using alloplast releasing of dural adhesions for preperation of fixation holes on cranium may lead to complications such as epidural hematoma or cerebrospinal fluid leakage. We experienced that cranioplasty with porous polyethylene does not require dural seperation for the fixation of alloplastic material. Thus, the operation time and complication rate are possibly decreased.

CONCLUSION

Others and our experiences suggest that the porous polyethylene implant offers a safer, cosmetically equivalent alternative to standart methyl methacrylate cranioplasty while ease of implantation shortens operation time. Porous polyethylene implant is easy to use, readily curved, time saving and does not lead to any donor site morbidity. This material described was found to be a simple and effective method for restoring cranial defects with low further complication . The results obtained in our series were excellent.

Corresponding : Serdar Kahraman, M.D.
Assistant Professor,
Department of Neurosurgery,
School of Medicine,
Gülhane Military Medical Academy,
06018 Etlik, Ankara-Turkey
Phone: +90 312 304 5302
Fax : +90 312 304 5300

Running Title: Cranioplasty with Porous Polyethylene

REFERENCES

1. Berghaus A, Mulch G, Handrock M: Porous polyethylene and Proplast: their behaviour in a bony implant bed. Arch Otorhinolaryngol 240:115-123,1984
2. Couldwell WT, Chen TC, Weiss MH, Fukushima T, Dougherty M,: Cranioplasty with the Porous polyethylene flexblock implant J Neurosurg 81: 483-486, 1994
3. Dougherty W, Wellisz T: The natural history of alloplastic implants in orbital floor reconstruction: an animal model. J Craniofac Surg 5: 26-32,1994
4. Duman H, Deveci M, Uygur F, Şengezer M: Reconstruction of contour and anterior wall defects of frontal bone with porous polyethylene implant Journal of Cranio-Maxillofacial surgery 27, 298-301,1999
5. Eppley BL, Sadove AM: Effects of material porosity on implant bonding strenght in a craniofacial model. J Craniofac Surg 1: 191-195,1991
6. Futrel JW, Edgerton MT: Use of methylmethacrylate in reconstructive craniofacial surgery, in converse JM, McCarthy JG, Wood-Smith D(eds): Symposium on Diagnosis and Treatment of Craniofacial Anomalies. St Louis: CV Mosby, 1979,pp 194-202
7. Goldberg RA, Dresner SC, Braslo RA: Animal Model of Porous Polyethylene Orbital implants. Opthal. Plast. Reconstr. Surg. 10:104-109,1994
8. Homsy CA: Biocompatibility in selection of materials for implantation. J Biomed Mater Res 4: 34356,1970
9. Klawitter JJ, Bagwell JG, Weinstein AM: An evaluation of bone growth into porous high density polyethylene. J Biomed Mater Res 10: 311-323, 1976
10. Maas CS, Merwin GE, Wilson J,: Comparison of biomaterials for facial bone augmentation. Arch Otolaryngol Head Neck Surg 116: 551-556, 1990
11. Malis LI: Titanium mesh and acrylic cranioplasty. Neurosurgery 25: 351-355, 1989
12. Merritt K, Shafer J, Brown SA: Implant site infection rates with porous and dense materials. J Biomed Mater Res 13: 101-108, 1979
13. Rish BL, Dilon JD, Meirowsky AM: Cranioplasty: a review of 1030 cases of penetrating head injury: Neurosurgery 4: 381-385, 1979
14. Romano jj, Iliff NT, Manson PN: Use of Porous polyethylene implants in 140 patients with facial fractures. J Craniofac Surg 4: 142-147, 1993
15. Rubin LR: Polyethylene as a bone and cartilage substitute: a 32-year retrospective, in Rubin LR(ed): Biomaterials in Plastic Surgery. St louis: CV Mosby, 1983, pp 474-492
16. Schulz RC: Reconstruction of facial deformities with alloplastic materials. Ann Plast Surg 7: 434-446, 1981
17. Spector M, Flemming WR, Kreutner A: Bone growth into porous high-density polyethylene. J Biomed Mater Res 10: 595-603, 1976
18. Wellisz T, Dougherty W, Gross J: Craniofacial applications for the Porous polyethylene flexblock implant. J Craniofac Surg 3: 101-107, 1992
19. Wellisz T: Clinical experience with the Porous polyethylene implant Aesthetic Plast Surg 17 (4): 339-44, 1993