Background: Porous polyethylene implants are commonly used in orbital blowout fracture repair because of purported biocompatibility, durability, and low frequency of complications. Delayed inflammation related to porous polyethylene sheet implants is very rare and no case series of this condition have been reported.

Case Presentation: This is a retrospective review of clinical presentations, radiographic findings, histopathological findings, treatments, and outcomes of patients who developed delayed complications in orbital blowout fracture repair using porous polyethylene sheets. Four male patients were included with a mean age of 49 years (range 35–69 years). Blowout fracture repair was complicated with implant-related inflammation 10 months, 2 years, 3 years, and 8 years after surgery. Chronic and subacute orbital inflammatory signs were noted in two patients and acute fulminant orbital inflammation was found in two patients. Three patients developed peri-implant abscesses and one patient had a soft tissue mass around the implant. All patients underwent implant removal and two of these patients with paranasal sinusitis had sinus surgery. Histopathological findings revealed chronic inflammatory changes with fibrosis, and one patient had foreign body granuloma with culture positive Staphylococcus aureus.

Conclusions: Delayed complications with porous polyethylene sheets used in orbital blowout fracture repair may occur many years following the initial surgery in immunocompetent patients. Low-grade or fulminant inflammation could complicate blowout fracture repair related with the implant.

Keywords: Delayed inflammation, Orbital fracture, Porous polyethylene
Case presentation
Medical records of four consecutive patients who developed delayed complications related to porous polyethylene sheets after orbital blowout fracture repair at Samsung Medical Center between 2007 and 2010 were retrospectively reviewed. Delayed onset inflammation was regarded if an implant-related inflammation occurred 6 months later than the fracture repair. The clinical presentations, radiographic findings, histopathological findings, and treatment and outcome data were collected. The Samsung Medical Center Institutional Review Board approved the retrospective review of the patients’ data, and the study adhered to the tenets of the Declaration of Helsinki.

All patients were male with mean age of 49 years (range 35–69 years) (Table 1). None had a significant past medical history or current disease. Orbital blowout fracture occurred after automobile traffic accidents (two patients), sports injury (one patient), and an accidental fall (one patient). All patients had uneventful blowout fracture repair using porous polyethylene sheets (Medpor®, Porex Surgical, Newnan, GA, USA) of 1 mm thickness for correction of enophthalmos and diplopia, using a transconjunctival approach for the inferior wall and a transcaruncular approach for the medial wall fracture. All implants were soaked in gentamicin solution before implantation. Methylprednisolone (250 mg) was infused intravenously at the end of the surgery, and postoperative systemic antibiotics were administered. None of the patients showed sinusitis at the time of blowout fracture repair.

The onset of symptoms varied among the patients. Patients 1 and 2 presented with subacute and chronic eyelid swelling and pain, respectively (Figs. 1a, 2a). Acute fulminant orbital inflammation was seen in patients 3 and 4, who had eye pain, conjunctival injection, and eyelid swelling with concurrent sinusitis. Patient 4 had an upper respiratory infection 2 weeks prior to the presentation of orbital inflammation. None of them had any anterior and posterior segment abnormalities or optic nerve dysfunction. The implants for the patients were well placed in the computed tomography (CT) scan except for one patient. The implant in the patient 3 was misplaced in the posterior orbit showing a gap between bony edge and the implant. All four patients underwent surgical exploration and implant removal under coverage of systemic antibiotics. The fibrotic tissue around the implant was resected partially and left behind for avoidance of vital orbital tissue damage. All the explanted implants were submitted for Gram staining and microbial culture.

Histopathological findings of the orbital mass revealed fibrosis and chronic inflammation (Fig. 1). Patient 2

Table 1 Clinical presentations, radiographic findings, histopathological findings, treatments, and outcomes

| Patient number/ Duration of onset of complication/ Location of implant | Age (yrs) | Clinical presentation | Imaging studies | Histopathological findings/Results of culture | Treatments | Outcomes | F/U (mos) |
|---|---|---|---|---|---|---|---|
| 1/8 years/Medial | 41 | Eye pain, diplopia with 2 mm hyperglobus, hypoesthesia for 14 days | Peri-implant soft tissue mass, clear sinus in CT | Fibrosis with chronic inflammation and calcification/negative culture | Implant removal, mass debulking | Postoperative persistent hypoesthesia of the cheek, 0.5 mm of the hyperglobus | 4.7 |
| 2/3 years/ Inferomedial | 69 | Persistent eyelid swelling for 5 months | Peri-implant low-signal intensity with surrounding tissue enhancement in T1-enhanced MR, clear sinus | Foreign body granuloma/positive CoNS® culture | Implant removal, abscess drainage | Infection resolved without complications | 3.1 |
| 3/2 years/Medial | 51 | Eye pain, skin redness, conjunctival injection, eyelid swelling, hyperdeviation with diplopia for 2 days | D-shaped low density mass with enhanced rim, mucosal thickening of ethmoid and maxillary sinuses in CT | Chronic sinusitis with eosinophils, features compatible with inflammation in the nasal mucosa/negative culture | Implant removal, abscess drainage, sinus drainage by ENT® surgeons | 3 mm of enophthalmos | 5.1 |
| 4/10 month/Inferior | 35 | Eye pain, skin redness, conjunctival injection, eyelid swelling, protrusion for 1 day | D-shaped soft tissue-density mass with enhanced rim, mucosal thickening of ethmoid and maxillary sinuses in CT | Chronic inflammation in the nasal mucosal tissue/negative culture | Implant removal, abscess drainage, sinus drainage by ENT surgeons | Infection resolved without complications | 2.1 |

*Yrs years, F/U follow-up, mos months, CoNS coagulase negative Staphylococcus aureus, CT computed tomography, MR magnetic resonance imaging, ENT ear, nose and throat
showed foreign body granuloma with giant cell infiltration adjacent to the fragmented implant spicules (Fig. 2). Coagulase negative *Staphylococcus aureus* was cultured from the explant. All patients had clinical resolution after explantation and systemic broad spectrum antibiotic treatment (Figs. 1b, 2b).

**Discussion**

Delayed inflammation related to orbital implantation for orbital fracture repair is very rare. Approximately 350 cases underwent orbital fracture repair using porous polyethylene sheets during the same period from 2007 to 2010 at Samsung Medical Center. Furthermore, there
were no other cases out of 1000 patients throughout the entire surgical log of orbital fracture repair at the same institution since 1994. This complication is very rare but should be reported for clinicians who care for orbital fracture patients.

A lack or reduction of fibrovascularization into the implant for orbital fracture repair might play a role in implant infection. Porous polyethylene is susceptible to infection in the early postoperative period before sufficient fibrovascular ingrowth occurs in 3 months [3, 8–11]. Our patient series showed delayed onset of porous polyethylene sheet-related infection or inflammation after 10 months and up to 8 years, which lagged beyond the duration for fibrovascularization. Mauriello et al. studied 10 patients who developed infections after alloplastic implants with silicone and gelatin film for orbital floor fracture repair, and noted that the predisposing factors were dental surgery, upper respiratory infection, implant extrusion into the maxillary sinus, medial implant migration resulting in dacryocystitis, rhinoplasty, and snorting cocaine [12]. Custer et al. reported small fistulous tracts between the supramid implant capsule and the maxillary sinus that led to infection [2]. In our case series, we speculate that the implanted porous polyethylene sheet and integrated surrounding fibrous tissue adjacent to the paranasal sinuses could still be an incompetent barrier to sinus infection, even after a long postoperative period. In patient 3, the edge of the implant did not cover the whole defect of the medial wall fracture, and which might serve as a precipitating cause of infection (Fig. 3).

Patient 2 showed chronic inflammatory signs with abscess formation without sinusitis. The explanted porous polyethylene sheet was brittle and histopathological examination showed foreign body granuloma adjacent to the implant spicules. Microbial infection and long-term tissue inflammation could result in implant degradation. In an experimental study to examine the responses of implanted porous polyethylene after direct inoculation of *Staphylococcus aureus* into rats, electron microscopy showed bacteria and active inflammatory infiltrates on the degraded implant surface [11]. In another animal study, giant cells were detected at the interface between the implants and surrounding granulation tissue, indicating a chronic foreign body reaction [13]. In specific circumstances, porous polyethylene in the fracture site can precipitate chronic inflammation and foreign body reactions.

Three of the patients in this series were culture negative for microorganisms. We could not determine whether the reasons involved prior use of antibiotics or sterile inflammation.

Absorbable alloplastic materials are manufactured and used for orbital wall fracture. They were originally designed to sustain the prolapsed orbital tissue as long as the implant support was needed, and not to serve as a foreign body in the fracture site [14–20]. Long-term follow-up and accumulation of clinical experiences can help identify the proper implant for orbital wall fracture repair.

**Conclusions**

Porous polyethylene implants are commonly used in orbital blowout fracture repair because of purported...

---

**Fig. 3** Patient 3. **a** Coronal CT showed a D-shaped low density mass (asterisk) adjacent to the radiolucent sheet (arrows). Sinus opacification was evident in the frontal and ethmoid sinuses. **b** An axial CT image showing a large low density mass (asterisk) extending to the entire medial wall of the orbit. **c, d** Five months after the explantation and sinus surgery.
biocompatibility, durability, and low frequency of complications. However, delayed onset of porous polyethylene implant infection or inflammation may complicate orbital fracture repair. Porous polyethylene sheets may provide an incompetent barrier to sinus infection, and can remain as a foreign body in the fracture site, resulting in an implant-related inflammation.

Abbreviations
CT, computed tomography; ENT, ear, nose and throat; MR, magnetic resonance imaging

Acknowledgements
None.

Availability of data and materials
All the data supporting the findings is contained within the manuscript.

Authors’ contributions
OA analyzed and interpreted the clinical data and wrote the manuscript. DN also assisted in writing and revising the original manuscript and its English revision. AG made substantial contributions to the experimental design and acquisition of clinical data. KWJ and KYD conceived the study, participated in its design and coordination, and revised the manuscript. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

Consent for publication
Written informed consent was obtained from the patients for publication of this case report and any accompanying images.

Ethics approval and consent to participate
The Samsung Medical Center Institutional Review Board approved the retrospective review of the patients’ data.

Author details
1Department of Ophthalmology, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla, Thailand. 2Department of Ophthalmology and Visual Sciences, Faculty of Medicine, The Chinese University of Hong Kong, Kowloon, Hong Kong. 3International Specialist Eye Center (ISEC), Kuala Lumpur, Malaysia. 4Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, South Korea.

Received: 19 March 2015 Accepted: 21 June 2016
Published online: 07 July 2016

References
1. Warrier S, Prabhakaran VC, Davis G, Selva D. Delayed complications of silicone implants used in orbital fracture repairs. Orbit. 2008;27:147–51.
2. Custer PL, Lind A, Trinkaus KM. Complications of supramid orbital implants. Ophthal Plast Reconstr Surg. 2003;19:62–7.
3. Yilmaz M, Vayvada H, Aydin E, Menderes A, Atabay A. Repair of fractures of the orbital floor with porous polyethylene implants. Br J Oral Maxillofac Surg. 2007;45:640–4.
4. Gostuk S, Senggezer M, Isik S, Tucegun M, Deveci M, Ci Y. Long-term outcomes of ultra-thin porous polyethylene implants used for reconstruction of orbital floor defects. J Craniofac Surg. 2005;16:973–7.
5. Ng SG, Madill SA, Inkster CF, Maloof AJ, Leatherbarrow B. Medpor porous polyethylene implants in orbital blowout fracture repair. Eye (Lond). 2001;15:578–82.
6. Samimi DB, Bielory BP, Miller D, Johnson TE. Microbiologic trends and biofilm growth on explanted periocular biomaterials: a 30-year review. Ophthal Plast Reconstr Surg. 2013;29:376–81.
7. Lee S, Maronian N, Most SP, Whipple ME, McCulloch TM, Stanley RB, et al. Porous high-density polyethylene for orbital reconstruction. Arch Otolaryngol Head Neck Surg. 2005;131:446–50.
8. Villareal PM, Monje F, Morillo AJ, Junquera LM, Gonzalez C, Barbon JJ. Porous polyethylene implants in orbital floor reconstruction. Plast Reconstr Surg. 2002;109:877–85.
9. Han DH, Chi M. Comparison of the outcomes of blowout fracture repair according to the orbital implant. J Craniofac Surg. 2011;22:1422–5.
10. Kent SS, Kent JS, Allen LH. Porous polyethylene implant associated with orbital cellulitis and intraorbital abscess. Can J Ophthalmol. 2012;47:38–9.
11. Schifani AP, Thomas JR, Cox AJ, Cooper MH. Clinical and histologic response of subcutaneous expanded polytetrafluoroethylene (Gore-Tex) and porous high-density polyethylene (Medpor) implants to acute and early infection. Arch Otolaryngol Head Neck Surg. 1997;123:328–36.
12. Mauriello JR JA, Hargrave S, Yee S, Mostafavi R, Kapila R. Infection after insertion of alloplastic orbital floor implants. Am J Ophthalmol. 1994;117: 246–52.
13. Ehrmantraut S, Laschke MW, Merkel D, Scheuer C, Willinecker V, Meyer-Lindenberg A, et al. Perioperative host tissue response to porous polyethylene (Medpor) implants. Eur Cell Mater. 2010;19:107–16.
14. Cordewener PW, Bos RR, Rozema FR, Houtman WA. Poly(L-lactide) implants for repair of human orbital floor defects: clinical and magnetic resonance imaging evaluation of long-term results. J Oral Maxillofac Surg. 1996;54:9–13. discussion 13–4.
15. Dietz A, Ziegler CM, Dacho A, Althof F, Conradt C, Kolling G, et al. Effectiveness of a new perforated 0.15 mm poly-p-dioxanone-foil versus titanium139 dynamic mesh in reconstruction of the orbital floor. J Craniofac Surg. 2001;12:982–8.
16. Jank S, Emshoff R, Schuchter B, Strobl H, Brandimair I, Norer B. Orbital floor reconstruction with flexible Ethisorb patches: a retrospective long-term follow-up study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2003;95:16–22.
17. Al-Sukhun J, Lindqvist C. A comparative study of 2 implants used to repair inferior orbital wall bony defects: autogenous bone graft versus bioresorbable poly-D,L-148 Lactide [PLDLA] 70/30 plate. J Oral Maxillofac Surg. 2006;64:1038–48.
18. Liewer O, Schaller B, Zit K, Kellner F, Iizuka T. Repair of orbital floor fractures using biodegradable poly-L/DL-lactide plates. Arch Facial Plast Surg. 2010;12: 399–404.
19. Gunarasaj DR, Samman N. Biomaterials for repair of orbital floor blowout fractures: a systematic review. J Oral Maxillofac Surg. 2013;71:550–70.
20. Baumann A, Buggasser G, Gauss N, Ewers R. Orbital floor reconstruction with an alloplastic resorbable polydioxanone sheet. Int J Oral Maxillofac Surg. 2002;31:367–73.