Reconstruction of Orbital Floor Fractures with Porous Polyethylene Implants: A Prospective Study

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Abstract

Purpose The main aim of our study was to assess and evaluate the efficacy, long standing outcome and infection of porous polyethylene implants in treatment of orbital floor fractures.

Patient and methods Twelve patients with fractures of orbital floor were included in the study. The cause of fracture was road traffic accident, self fall and cow hit respectively. They also complained of enophthalmos (n = 9), diplopia (n = 3), restricted eye movement (n = 2), impairment of infraorbital nerve (n = 3) and dystopia (n = 6). All the fractures were reconstructed with thin porous polyethylene sheets.

Results No implants were extruded and there were no signs of inflammatory reactions against porous polyethylene implant. In all nine patients with pre-op enophthalmos it was corrected post-operatively with *p* value = 0.000 and was statistically significant; diplopia in one patient was corrected; persistence of double vision was noted in two patients. Restricted eye movement was corrected in all patients, dystopia was corrected in four patients and in two patients have persisting dystopia. Paresthesia persisted in all three patients.

Conclusion Our experience was that reconstruction of orbital floor fracture using porous polyethylene implant is reliable, safe and effective and may be used for

reconstruction of the orbital floor fracture with no donor site morbidity.

Keywords Porous polyethylene implants · Orbital floor fractures · Enophthalmos · Diplopia

Introduction

The orbit, like maxillary antrum, is an anatomical region which is of clinical and surgical interest to many disciplines. It may be regarded as ‘cross-roads’, where sign posts in the more complex injuries, clearly indicate the necessity for additional expertise which can only be provided by other specialities [1]. Injuries to and around the eyes vary greatly in their severity [2].

The face should have a harmonious symmetrical relationship between the paired and unpaired facial structures that form our first impression of what the person is like. The eyes—their colour, 3D position and synchronous movement are the major contributors to this overall picture. The eye position, colour and movement should be symmetrical and is important from an aesthetic point of view [3].

Few injuries are challenging as those of face. Surgeons who undertake treatment of facial injuries have a dual responsibility.

1. Repair of the aesthetic defect i.e. restoration of pre injury appearance.
2. Restoration of function.

The consequences of orbital floor fractures are dramatic. They vary from diplopia, enophthalmos, hypoglobus, restriction of ocular movements, epiphora, a disturbing loss of facial sensation to an unsightly and unacceptable

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appearance of the eye and the hard and soft tissues around it. These injuries demand careful attention [3].

The defect of orbital floor should be reconstructed either with autograft or synthetic material [4–16].

There are two kinds of alloplastic implants for reconstruction of orbital floor (absorbable and non-absorbable) [17]. Non absorbable materials may be non porous or porous. Porous or integrated implants such as porous polyethylene and hydroxyapatite are the most commonly used materials for orbital floor reconstruction.

Our study is all about reconstruction with porous polyethylene implant and assessing and evaluating the efficacy, long standing outcome and infection of porous polyethylene implants in treatment of orbital floor fractures.

Polyethylene implant is highly biocompatible, durable and processed specifically to include and control pore size. It is insoluble in tissue fluids, does not resorb or degenerate, incites minimal surrounding soft tissue reaction and possesses high tensile strength. Pore size range from 100 to 200 μm . The porous structure permits tissue ingrowth, fibrovascularisation of the implant and incorporation of surrounding soft tissue and bone [6].

We present our 1 year long term results.

Patients and Methods

The present study was undertaken in the Department of Oral and Maxillofacial Surgery from 2012 to 2014, after obtaining ethical clearance. This study involved patients with zygomatico-orbital fractures requiring orbital wall reconstruction. The selected 12 patients with orbital floor defect were consented and reconstructed using porous polyethylene implant.

In our present study, patient's age ranged from 15 to 49 years (mean 31.25). The cause of fractures was road traffic accident in seven patients, four with history of self fall and one patient was hit by a cow in the field (Table 1). Eleven patients presented with impure blow out fracture and one patient with pure blow out fracture (Table 2). All patients had thorough maxillofacial examination when they first presented. Patients with suspicious findings were

Table 1 Pre and post-operative evaluation of symptoms of 12 patients

Symptoms	Pre-operative	Post-operative
Enophthalmos	9	0
Diplopia	3	2
Restricted ocular movement	2	0
Impairment of infraorbital nerve	3	3
Dystopia	6	2

Table 2 Type of fracture

Type of fracture	
Pure blow out	1
Impure blow out	11

evaluated first by conventional radiographs followed by axial and coronal computed tomogram.

The degree of enophthalmos was recorded using Hertels exophthalmometer and diplopia using Hess charting in all nine cardinal gazes and muscle entrapment using forced duction test. Infraorbital nerve paresthesia was assessed by clinical examination before and after operation.

In our study 10 patients underwent surgery immediately following injury within 12 days and in two patients surgery was delayed. Minimum time lapse between trauma and surgery was 4 days and maximum period was of 1½ years (secondary correction of enophthalmos).

Pre-operative evaluation of the patients reveals enophthalmos in 9, diplopia in 3 and restricted ocular movement in 2, dystopia in 6 and infraorbital nerve paresthesia in three patients respectively.

The anatomy of paper thin orbit floor is complex. It is 'S' shaped and is concave just posterior to the orbital rim and becomes convex immediately behind the globe forming the post bulbar bulge [3].

The post bulbar bulge is formed by the maxillary sinus expansion posterior to the globe and this helps in maintaining the eye ball in its proper antero-posterior position and it has to be reconstructed to prevent latent enophthalmos.

Rowe and Williams [1] studied 48 orbits in 24 skulls to arrive at mean value measurements to important structures from stable landmarks:

• Midpoint of inferior orbital fissure to infraorbital foramen	24 mm
• Anterior ethmoidal foramen to anterior lacrimal crest	24 mm
• Superior orbital fissure to zygomaticofrontal suture	35 mm
• Superior orbital fissure to supraorbital notch	40 mm
• Optic canal (medial aspect) to anterior lacrimal crest	42 mm
• Optic canal (superior aspect) to supraorbital notch	45 mm

With this in mind, subperiosteal dissection may be safely extended 35 mm posterior to the inferior, lateral and superior orbital rim and the anterior lacrimal crest [3].

The infra-orbital subciliary approach was used in all 12 patients. After subperiosteal dissection and freeing the entrapped fatty-muscular tissue, and visualisation of the orbital floor defect (Fig. 3), the porous polyethylene implants (1.5 mm thick) were inserted below the

Fig. 1 Porous polyethylene implant

Fig. 2 Template

Fig. 3 Orbital floor defect

periosteum to reconstruct the defect (Fig. 4). The size and shape of the implants were adjusted intra-operatively according to size and shape of the defects using a template. The sheet was moulded in sterile saline solution. Each sheet was 2–3 mm wider than original defect and placed on healthy edges of the fractures (Figs. 1, 2). The implants were firmly fixed to the orbital rim using one or two 2 mm titanium screws (Fig. 5) under constant saline irrigation. Porous polyethylene is a radiolucent material so a screw used for fixation is well appreciated in radiographs.

Fig. 4 Porous polyethylene after shaping according to template

Fig. 5 Orbital floor reconstructed with porous polyethylene (indicated by arrow)

All patients were given 1.2 g of augmentin intravenously 2 h prior to the operation and continued to take the antibiotics every 12 h for 3 days after the operation. All patients were evaluated post-operatively on the first post-operative day, third post-operative day, first week post-operatively, second week post-operatively and sixth week, 6 and 12 months after operation, respectively.

Results

In our study over a duration of 1½ years 12 patients were chosen with orbito zygomatic fractures who consented for their inclusion in the study. Of these 12 patients one patient's follow up period was restricted to 6 weeks which was the minimal follow up period since the patient expired following second accident. One patient was evaluated for 6 months and rest of the patients for 1 year post-operatively.

The timing of surgery was from the day of accident to the day of operation and ranged from 4 days to 1½ years.

In all nine patients with pre-op enophthalmos were corrected post-operatively with p value = 0.000 which was

Fig. 6 Pre and post-operative evaluation of a patient both clinically and radiographically

CT scan (coronal), porous polyethylene implant indicated by the arrow.

statistically significant (statistical test used-Chi square test, using SPSS for windows-v16.0), diplopia in one patient was corrected. Persistence of double vision was noted in two patients, one in extreme upward gaze and other in extreme lateral gaze due to lateral rectus palsy as diagnosed by ophthalmologist, this error in the vision did not affect the patient's day to day activities. Restricted eye movements were corrected in all patients, dystopia was corrected in four patients but persisted in two patients. Paresthesia persisted in all three patients.

Controlled computed tomography was done post-operatively which showed that the porous polyethylene sheet was stable.

Post-operative ectropion was present in one patient which was resolved during the follow up period.

One patient develop epiphora post-operatively which was also resolved considerably over the period of 6 weeks follow up.

One patient developed infection in post-operative follow up after 1 year which was controlled by antibiotics.

Fig. 7 Assessment of diplopia

Fig. 8 Assessment of enophthalmos

Fig. 9 Assessment of infection

There was no inflammatory reaction and no implant extruded in any of the 12 patients. Pre and post-operative details of one patient is depicted in Fig. 6.

Discussion

The main aim of this study is to assess and evaluate the efficacy, long standing outcome and infection of porous polyethylene implants in treatment of orbital floor fractures (Figs. 7, 8, 9).

The ideal material for orbital reconstruction remains controversial. Ideal material should be chemically inert, biocompatible, non-allergenic and non-carcinogenic. If alloplastic, it should be cost effective and capable of sterilization without deterioration of its chemical composition.

The material should be easily cut and sized in the operating room, and it should be able to be shaped to fit orbital contours and retain its new form without memory. It should allow fixation to host bone by screws, wire, suture, or adhesive. It should not potentiate growth of microorganisms nor promote resorption of underlying bone or distortion of adjacent tissues. It should be radiopaque to allow radiographic evaluation. The material should be capable of removal without damage to surrounding tissues. The material should be permanently accepted. It should be readily available. To date, no single material has been universally successful in meeting every one of these criteria [6].

The more elastic materials are unable to withstand the dynamic stresses of large defects. Resorbable implants may be prone to foreign-body reaction, implant exposure, and having only fibrinous connective tissue remains after resorption. The disadvantages of autologous bone grafts include minimal contourability and a donor site defect. In addition, implant resorption can occur.

Chen et al. [18] in their studies conducted on orbital fractures state that fractures managed conservatively have shown to have complication rate as high as 40 %.

Porous polyethylene implants are widely used for orbital reconstruction. They are easily moulded and contoured according to the shape and size of the defect using a template. The porous structure of the material permits ingrowths of tissue, fibrovascularisation of the implant, and incorporation of the surrounding soft tissue and bone which prevent extrusion and migration and hence provide stabilization. Incorporation of the surrounding tissues prevents capsular formation and reduces the foreign body reaction in the long term. Fibrovascular ingrowth does not cause extraocular muscle restriction by soft tissue adherence to the implant [16]. We fixed the porous polyethylene sheets to the orbital rim with titanium screws.

Porous polyethylene has a density similar to the non-fat orbital tissue on a computed tomogram [16]. The sheets had not migrated and orbital contour was similar to the unaffected side. Porous polyethylene is not radiodense, so its position cannot be easily visualized on immediate post-op CT scan [6].

Potter and Ellis concluded that the selection of a bio-material for reconstruction of the orbit is academic discussion because there are so many easily available and user-friendly materials that give reliable outcomes for the repair of most injuries [19]. A number of materials such as polydioxanone (PDS), polyglactin 910 (Ethisorb), and porous polyethylene sheets have successfully been used to repair small defects of <2 cm in diameter or a maximum size of 2 cm × 2 cm (4 cm) [12, 14, 15]. The material must provide enough mechanical support to keep the internal orbital contents in their normal position. Thin porous polyethylene implants met or exceeded the

requirements for the support of the combined internal orbital contents [16].

In our study the most common mode of injury causing orbital wall fractures were associated with road traffic accidents (58.3 %), followed by self fall (33.3 %) and one case of orbital floor fracture following being attacked by a cow in the field.

Our study showed a male predominance with sample consisting of only male patients with a mean age of 31.25 years which is in agreement with earlier studies.

Majority of fractures involving orbit were caused by indirect forces associated with fractures of zygomatico maxillary complex of which 91.7 % of the study sample being orbital fracture of impure type which is in agreement with studies done by Prowse et al. [15].

Our study consisted of one patient with pure orbital blow out fracture.

Timing of Surgery

In our study 10 patients underwent surgery immediately following injury within 12 days and in two patients surgery was delayed. Minimum time lapse between trauma and surgery was 4 days and maximum period was 1½ years.

Time lags between injury and surgery ranging from 7 days to 2 years have been reported in some studies.

Post-operative Recipient Site Healing

Post-operative recipient site healed well in all patients in the 6-week follow up period. Our study showed one case with infection of the surgical site in follow up period of 1 year which was controlled with antibiotics.

None of cases showed any other complications associated with use of alloplastic materials like implant migration, extrusion of implant or hypersensitivity.

Ectropion was present post-operatively in one patient which resolved during the follow up period.

Epiphora was noted in one patient post-operatively on fractured side which resolved considerably over the period of 6 weeks follow up. None of the other patients gave any complaints of epiphora 1 year following surgery.

Studies done using resorbable materials have shown persistence of epiphora at the rate of 3.4 % [12].

Tuncer et al. [20] in studies to evaluate resorbable meshes for orbitozygomatic fractures report post-operative infections to be seen in 5.9 % of their patients.

Villarreal et al. [17] in their study with PDS implant have reported infection rate of 12.5 % and loss of vision in 3.1 % of subjects studied.

Mustafa et al. [16] in a study with porous polyethylene implant show infection in four patients (15.38 %) which was controlled with antibiotics given intravenously.

Lee et al. [21] studied 165 patients with orbital fractures with Medpor and reported loss of vision in one case (0.6 %) resulting from retrobulbar hematoma due to uncontrolled hypertension with rate of complications as high as 6.4 %.

Diplopia

The presence of pre-operative diplopia has been reported by some authors as 39.3 and 43 % which is seen in 25 % of our patients (three patients) in the study. All but one patient involved in the study showed correction of diplopia or double vision post-operatively in the 1 year of follow up.

Persistence of double vision was noted in two patients, one in extreme upward gaze and other in extreme lateral gaze due to lateral rectus palsy as diagnosed by ophthalmologist, this error in the vision did not affect the patient's day to day activities.

Buchel et al. [12] in his research using Ethisorb dura has reported diplopia in 5.7 % out of 87 patients involved in the study.

Medpor was used by studies by Lee et al. [21], Ozturk et al. [22] and Lin et al. [23] for orbital fractures and have reported rate of diplopia to be 3.5, 2.6 and 4.5 %, respectively.

Enophthalmos

Enophthalmos was seen in 75 % of patients included in the study pre-operatively. On the sixth week following surgery no patient showed signs of enophthalmos. Correction of enophthalmos was seen in 100 % of our patients when porous polyethylene implant was used to reconstruct the internal orbital wall contours. *p* value = 0.000 and result shows statistical significance (statistical test used-Chi square test, using SPSS for windows-v16.0).

Correction of enophthalmos has showed better results with Medpor as seen in studies by Lee et al. [21], Ozturk et al. [22] and Lin et al. [23] as 4.1, 7.9 and 14.3 %, respectively.

Buchel et al. [12] in their study with Ethisorb dura implant have recorded enophthalmos in 2.3 % of the patients.

Other materials like bioactive glass had recorded with enophthalmos in 10.7 % of the subjects [24].

Dystopia

Dystopia was present in six patients (50 %) pre-operatively which persisted after surgery in two patients and got corrected in four patients. The two patients presented with severe impure blowout fracture with comminuted ZMC fracture. The extent of the injury to the ZMC region with

loss of bone could be thought to be a reason for persistence of hypoglobus in the present study.

Studies with PDS by Iizuka et al. [25] have reported incidence of hypoglobus to be as high as 25 %.

Mustafa et al. [16] in a study with porous polyethylene implant shows hypoglobus rate of 30 % which was reduced post-operatively.

Restriction of Eye Movement

Restriction of eye movement was seen in two of the patients in our study and was corrected post-operatively.

Two of our cases showed obvious entrapment of the muscle cone on surgical exposure which was corrected and repositioned. Though orbital connective tissue and fat were noticed to be entrapped in the fracture site in few patients none of the cases showed any obvious restriction of globe movement except the two patients mentioned above.

Mustafa et al. [16] have done a study on 26 patient orbital floor reconstruction with porous polyethylene implants with 17 patients having restricted eye movement which was corrected in 16 patients.

Paresthesia

In our study 25 % of the patients reported numbness over the infraorbital and lateral part of the nose following trauma. The paresthesia persisted following surgery.

Patients showed no considerable improvement over 6 weeks of surgery.

Buchel et al. [12] have reported infraorbital paresthesia in 8 % of patients treated with Ethisorb dura patches.

Medpor has shown hypesthesia in 7.9 % of patients in a study conducted by Otzturk et al. [22].

Study done by Villarreal et al. [17] with PDS grafts have reported sensory disturbances in around 59 % of patients studied.

Autograft Versus Alloplast

The choice of a material to be used in orbital reconstruction has primarily been determined by the size and location of the orbital defect and the remaining structural support [26]. It also depends on the surgeon's choice. The treatment of choice to restore absent bone segments in facial skeleton is to replace with autogenous bone. Autogenous bone grafting has been the gold standard to provide framework for facial skeleton. However resorption of graft volume is obviously a concern for the long-term success of reconstruction using autogenous bone. Another disadvantage is patient morbidity which requires a second operative field and long duration procedure [6]. However considering the longer operative time and potential morbidity to the donor site,

porous polyethylene might be a better implant of choice although the autogenous graft will still have a role in places where cost is a major concern [26]. Porous polyethylene has the advantage of being easy to work with and not having sharp barbs on the edges after being trimmed. It has the disadvantage of being invisible on post-operative radiological imaging.

Titanium with porous polyethylene has the combined advantages of being more rigid than porous polyethylene alone, and being less likely to have sharp barbs on the edges. It is visible on radiographic post-operative imaging. A possible disadvantage is that drainage of orbital exudate may be compromised [27].

Conclusion

In view of orbital floor reconstruction our present study demonstrates that appropriate use of porous polyethylene implant can have good results, with low complication rates including acceptable low extrusion rate, and high patient satisfaction.

Our present study highlights the satisfactory stability of the implant and the ability of the material to correct post traumatic orbital sequelae including enophthalmos and diplopia.

Our experience was that reconstruction of orbital floor fracture using porous polyethylene implant is reliable, safe and effective and may be used for reconstruction of the orbital floor fracture with no donor site morbidity.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval This article does not contain any studies with animals performed by any of the authors.

Informed Consent Informed consent was obtained from all individual participants included in the study.

References

1. Rowe NL, Williams JL (1994) Fractures of zygomatic complex and orbit. In: Williams JL (ed) Rowe and Williams' maxillofacial injuries, vol 1, 2nd edn. Churchill Livingstone, London, pp 475–590
2. Rowe NL, Williams JL (1994) Ophthalmic injuries. In: Williams JL (ed) Rowe and Williams' maxillofacial injuries, vol 2, 2nd edn. Churchill Livingstone, London, pp 827–843
3. Leo FA, Cyrus JK (2007) Peri- and intraorbital trauma and orbital reconstruction. In: Booth PW, Schendel SA, Hausamen JE (eds) Maxillofacial surgery, vol 1, 2nd edn. Churchill Livingstone, London, pp 205–222
4. Gunarajah DR, Samman N (2013) Biomaterials for repair of orbital floor blowout fractures: a systematic review. J Oral Maxillofac Surg 71:550–570

5. Kontio R (2004) Treatment of orbital fractures: the case for reconstruction with autogenous bone. *Oral Maxillofac Surg* 62:863–868
6. Potter JK, Malmquist M, Ellis E III (2012) Biomaterials for reconstruction of the internal orbit. *Oral Maxillofac Surg Clin N Am* 24:609–627
7. Krishnan V, Johnson JV (1997) Orbital floor reconstruction with autogenous mandibular symphyseal bone grafts. *J Oral Maxillofac Surg* 55:327–330
8. Guerra MFM, Perez JS, Rodriguez-Campo FJ, Gias LN (2000) Reconstruction of orbital fractures with dehydrated human dura mater. *J Oral Maxillofac Surg* 58:1361–1366
9. Celikoz B, Duman H, Selmanpakoglu N (1997) Reconstruction of the orbital floor with lyophilized tensor fascia lata. *J Oral Maxillofac Surg* 55:240–244
10. Talesh KT, Babae S, Vahdati SA, Tabeshfar S (2009) Effectiveness of a nasoseptal cartilaginous graft for repairing traumatic fractures of the inferior orbital wall. *Br J Oral Maxillofac Surg* 47:10–13
11. Castellani A, Negrini S, Zanetti U (2002) Treatment of orbital floor blowout fractures with conchal auricular cartilage graft: a report on 14 cases. *J Oral Maxillofac Surg* 60:1413–1417
12. Buchel P, Rahal A, Seto I, Lizuka T (2005) Reconstruction of orbital floor fracture with polyglactin 910/polydioxanone patch (Ethisorb): a retrospective study. *J Oral Maxillofac Surg* 63:646–650
13. Ellis E, Tan Y (2003) Assessment of internal orbital reconstructions for pure blowout fractures: cranial bone grafts versus titanium mesh. *J Oral Maxillofac Surg* 61:442
14. Jank S, Emshoff R, Schuchter B, Strobl H, Brandlmaier I, Norer B (2003) Orbital floor reconstruction with flexible Ethisorb patches: a retrospective long-term follow-up study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endodontology* 95(1):16–22
15. Prowse SJ, Hold PM, Gilmour RF, Pratap U, Mah E, Kimble FW (2010) Orbital floor reconstruction: a case for silicone. A 12 year experience. *J Plast Reconstr Aesthet Surg* 63(7):1105–1109
16. Mustafa V et al (2007) Repair of fractures of the orbital floor with porous polyethylene implants. *Br J Oral Maxillofac Surg* 45:640–644
17. Villarreal PM et al (2002) Porous polyethylene implants in orbital floor reconstruction. *Plast Reconstr Surg* 109:877–885
18. Chen JM et al (1957) Early surgical intervention for orbital floor fractures: a clinical evaluation with lyophilized dura and cartilage reconstruction. *J Oral Maxillofac Surg* 39:20
19. Potter JK, Ellis E (2004) Biomaterials for reconstruction of the internal orbit. *J Oral Maxillofac Surg* 62:1280–1297
20. Tuncer S et al (2007) Reconstruction of traumatic orbital floor fractures with resorbable mesh plate. *J Craniofac Surg* 18:598–605
21. Lee S et al (2005) Porous high-density polyethylene for orbital reconstruction. *Arch Otolaryngol Head Neck Surg* 131:446–450
22. Otzturk S et al (2005) Long-term outcomes of ultra-thin porous polyethylene implants used for reconstruction of orbital floor defects. *J Craniofac Surg* 16:973–977
23. Lin IC, Liao SL, Lin LL (2007) Porous polyethylene implants in orbital floor reconstruction. *J Formos Med Assoc* 106:51–57
24. Kinnunen I, Aitasalo K (2000) Reconstruction of orbital floor fractures using bioactive glass. *J Cranio-Maxillofac Surg* 28:229–234
25. Iizuka T, Mikkonen P, Pauku P, Lindqvist C (1991) Reconstruction of orbital floor with polydioxanone plate. *Int J Oral Maxillofac Surg* 20:83–87
26. Wajih WA et al (2011) Hospital Universiti Sains Malaysia experience in orbital floor reconstruction: autogenous graft versus Medpor. *J Oral Maxillofac Surg* 69(6):1740–1744
27. Garibaldi DC, Iliff NT et al (2007) Use of porous polyethylene with embedded titanium in orbital reconstruction: a review of 106 patients. *Ophthal Plast Reconstr Surg* 23(6):439–444