Orbital Floor Fractures: A Retrospective Review of 45 Cases at a Tertiary Health Care Center

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ABSTRACT

The purpose of this retrospective study was to investigate treatment options for orbital floor fractures at a Level 1 Trauma Center in Southern California. A review of 45 cases of isolated orbital floor fractures treated at the University of California at Irvine between February 2004 and April 2007 was done. Patients were retrospectively analyzed for gender, age, mechanism of injury, associated facial injuries, presenting symptoms, method of treatment, and postoperative complications. Thirty-six male patients and nine female patients were treated. Motor vehicle collision (26/45) was the most common cause of injury, and the mean age of the patients was 35.5 years (range: 15–81 years). Ecchymosis surrounding the orbital tissue was the most common presentation (38/45). Diplopia was present in 8 of 45 patients, with 1 patient requiring urgent decompression for retrobulbar hematoma. Forty-three patients underwent surgical repair; 40 underwent transconjunctival approach with lateral canthotomy; 17 underwent reconstruction with porous polyethylene Medpor (Porex Surgical, Inc., College Park, GA.); and 26 underwent reconstruction with a titanium mesh plate. Immediate postoperative complications included 12 patients with infraorbital numbness, 3 with diplopia, 1 with cellulitis, and 1 with ectropion with a subciliary approach. Average timing of surgery of our study was 4.94 days (range, 1–20 days). Orbital floor fracture management has changed significantly over the past few decades with the introduction of new internal fixation methods and new materials for reconstructing orbital floor defects. Recommendations for surgical intervention on orbital floor fractures mostly depend on clinical examination and imaging studies. Consequences of inadequate repair of orbital floor fractures can lead to significant facial asymmetry and visual problems. Both porous polyethylene and titanium plates are effective tools for reconstructing the orbital floor. Our review demonstrates that orbital floor fractures can be repaired safely with minimal postoperative complications and confirms that transconjunctival approach to orbital floor is an effective way for exposure and prevention of ectropion that can be seen with other techniques.

KEYWORDS: Orbital floor fractures, review, treatment options

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Figure 1 Bones of the orbit.

The treatment of orbital floor fractures is a demanding aspect of craniofacial fracture management. Consequences of inadequate or improper orbital fracture management, such as enophthalmos, ocular motility restriction, and ocular or orbital dystopia, present cognitive and functional problems that are difficult, if not impossible, to correct.

The evolution of treatment involving the orbital skeleton has undergone substantial change in the past century. Closed reduction, external fixation, antral packing, and Kirschner wires were all used until open reduction with internal wire fixation was introduced in the 1940s becoming widely adapted by the 1950s.¹ Introduction of rigid fixation to craniofacial fracture management revolutionized the treatment of orbital injuries.²

Orbits are pear-shaped pyramids at the center of the craniofacial region, in which the eyes are protected by the bony orbital walls. Zygomatic bone, maxilla, frontal bone, ethmoid bone, sphenoid bone, lacrimal bone, and palatine bone are all part of the walls (Fig. 1). The orbit is particularly susceptible to fractures due to its exposed position and thin bones. External impact to this area can cause a blowout fracture or nonblowout fracture, both of which could be accompanied by orbital floor defects.

Diplopia is the most common complication caused by orbital defects. Others include ocular movement restriction, infraorbital nerve numbness, enophthalmos, and reduced vision. When the orbital floor is fractured, the enlarged capacity of the posterior part of the orbital bony cavity plays a major role in causing enophthalmos.

The aim of this article is to review our surgical experience, with special attention to surgical technique, method of repair, and postoperative complications. In addition, this article will discuss current thoughts on isolated orbital floor fractures.

PATIENTS AND METHODS

Forty-five patients fulfilled the following inclusion criteria: (a) clinical diagnosis of orbital floor fractures, (b) imaging studies demonstrating orbital floor defects, and (c) no previous surgical treatment.

Forty-five patients treated at the University of California at Irvine Hospital from February of 2004 to April of 2007 were selected for this study (Table 1). All patients were retrospectively analyzed for gender, age, mechanism of injury, presenting symptoms and signs, associated facial injuries, treatment methods, timing of surgery, and postoperative complications (Tables 2–5).

Table 1 Patient Demographics with Orbital Floor Fractures

Number of patients	45
Age	Mean age: 35.5 years (range: 15–81 years)
Sex	36 males, 9 females
Causes of injury	Motor vehicle collision: 26 Assault: 8 Fall: 6 Sports-related: 1 Other: 4

Table 2 Primary Preoperative Signs or Symptoms

Diplopia	8
Ecchymosis	38
Enophthalmos	5
Conjunctival hemorrhage	30
Herniation of tissue in orbital floor	24
Limited upward gaze	9
Retrobulbar hematoma	1

Table 3 Associated Fractures with the Orbital Floor Injuries

Lefort I	1
Lefort II	2
Lefort III	2
Maxilla	
Anterior	19
Lateral	20
Medial	10
Posterior	3
Pterygoid plate	5
Zygomatic bone	17
Anterior-wall frontal sinus	6
Mandible	5
Temporal bone	3
Sphenoid bone	6

Table 4 Number of Patients Undergoing Operative Treatment, Timing of Surgery, Surgical Exposure, and Method of Reconstruction

Open reduction and internal fixation	43 of 45 cases
Conservative treatment	2 of 45
Timing of surgery	4.94 days (range: 1–20 days)
Transconjunctival Incision with lateral canthotomy	40/43
Subciliary Incision	3/43
Reconstruction with porous polyethylene	17/43
Reconstruction with titanium mesh plate	26/43

Table 5 Postoperative Symptoms at Initial Follow Up

None	26
Infraorbital numbness	12
Diplopia	3
Ectropion	1
Cellulitis	1

DISCUSSION

The orbit is made of seven facial bones, which provide support and protection for the eye. The orbital depth is 50 mm, the height is 40 mm, and the width is 35 mm with an average volume of 30 mL. Cross-sectional anatomy of the lower eyelid can be seen in Fig. 2. Any subtle loss or gain in volume results in aesthetic or functional deficits. Restoration of orbital architecture

and volume can be challenging, even for the most experienced surgeons.

An evidence-based analysis by Burnstine et al³ on clinical recommendations for repair of isolated orbital floor fractures was recently published (Table 6). None of our patients met the criteria for immediate repair. There was no evidence of oculocardiac reflex, and the one patient younger than 18 years did not have evidence of “white-eyed blow-out fracture.” All patients treated surgically had evidence of

Figure 2 Cross-sectional anatomy of the lower eyelid.

Table 6 Clinical Recommendations for Repair of Isolated Orbital Floor Fractures

Immediate	Diplopia present with CT evidence of an entrapped muscle or periorbital tissue associated with a nonresolving oculocardiac reflex "White-eyed blow-out fracture": young patients (aged < 18 yr), history of periocular trauma, little ecchymosis or edema (white eye), marked extraocular motility vertical restriction, and CT examination revealing an orbital floor fracture with entrapped muscle or perimuscular soft tissue
Within 2 weeks	Symptomatic diplopia with positive forced ductions, evidence of an entrapped muscle or perimuscular soft tissue on CT, and minimal clinical improvement over time Large floor fracture causing latent enophthalmos Significant hypophthalmos Progressive infraorbital hypesthesia
Observation	Minimal diplopia (not in primary gaze or downgaze), good ocular motility, and no significant enophthalmos

CT, computed tomography.

nonresolving diplopia, significant orbital floor defect, entrapment of soft tissue, or limited gaze on examination.

In our study, 40 patients underwent preseptal transconjunctival incision for exposure of the orbital floor, with only 3 patients undergoing the subciliary incision approach (Figs. 3 and 4). Advantages of the transconjunctival approach for orbital access are minimal scarring, excellent patient acceptance, and decreased chance of eyelid retraction or ectropion when compared with other methods. Barbon et al⁴ found a 20% incidence of ectropion associated with the subciliary approach versus 0% for the transconjunctival approach. Barbon et al⁴ also found an increased 22% incidence of epiphora in the transconjunctival approach, compared with 13% in the subciliary approach. Factors predisposing to eyelid retraction and ectropion after orbital fracture repair include hematoma, eyelid edema, adhesions of the orbital septum, and scar contracture.⁵ This is evidenced by one patient in our review who had ectro-

pion postoperatively and underwent a subciliary incision that required corrective surgery. Golberg⁶ stated that an indication for the subciliary approach include the presence of severe conjunctival disease (conjunctivitis, burns). The choice of transconjunctival versus subciliary approach in our study was surgeon dependent. There are two different transconjunctival approaches: (1) preseptal transconjunctival approach takes more time for exposure of the orbital floor, and (2) postseptal transconjunctival approach. Although this method is faster, it is burdensome to deal with the herniated orbital fat.

Controversy exists with respect to closing the transconjunctival incision. Studies have concluded no substantial difference in eyelid margin position when the conjunctival incision was left open.⁷ Other surgeons believe that leaving the incision unsutured may be helpful in preventing hematoma formation by allowing the wound to drain.⁸ It is thought that not closing the conjunctiva may effectively weaken the lower eyelid

Figure 3 Transconjunctival surgical approaches to the inferior orbit. The solid line represents the preseptal approach, and the dashed line represents the postseptal approach.

Figure 4 Subciliary surgical approach to the inferior orbit. The solid line represents a skin flap or preorbicularis approach; the dashed line represents a stepped, postorbicularis approach; and the dotted line represents a nonstepped, postorbicularis approach.

Figure 5 Example of titanium mesh.

retractors; however, this weakening has been noted to exist only temporarily.^{7,8} Linden et al⁹ concluded that repair of orbital blowout fractures through a transconjunctival approach without closure of the incision can give excellent cosmetic and functional results and allow shorter operative times. All our incisions were loosely approximated with fast-absorbing sutures. Our preference is to approximate the transconjunctival incision with 5 to 0 fast-absorbing suture with buried knots.

Once the defect has been defined, the surgeon must choose an implant for reconstruction. Although there are many proponents for bone grafts, particularly calvarial, there are substantial disadvantages. In addition to the added incision and potential morbidity of harvesting cranial bone, there is the issue of potential resorption. This issue must be considered when bone is layered in the orbit to correct for volume deficiency. Synthetic options that are popular may include titanium mesh (Fig. 5) and porous polyethylene (Fig. 6). Titanium mesh comes in a variety of shapes and allows easy contouring to fit orbital defects of any size. The primary disadvantage of these implants is the occasional difficulty experienced during implantation. Fig. 7 demonstrates

Figure 6 Example of porous polyethylene for orbital floor reconstruction.

titanium mesh for reconstruction of the orbital floor. Other popular options include high-density porous polyethylene. Unlike titanium mesh, which often becomes caught on the periorbital, these implants can be used with relative ease. They can be cut precisely to the desired size. Kelly et al¹⁰ concluded that use of foreign materials in orbital reconstruction may be indicated for complex and small defects, when limited cranial bone is available, or when a patient does not wish to have cranial bone harvested. In addition, in their review, most inflammation and infections have been related to the use of foreign materials. Rubin et al¹¹ advised cautious use of porous polyethylene or complete abandonment of it, if the extraocular muscles are exposed. A recent advancement has been to incorporate titanium mesh with porous polyethylene. With the advantages of both titanium and polyethylene, these are likely to be suitable for more defects. In our study, 17 patients had reconstruction with porous polyethylene and 26 patients with titanium mesh. Selection of the implant was the surgeon's choice.

After exposure of the defect, attempt should be made to elevate the prolapsed periorbital. Failure to do so may result in dissecting through the periorbital and injuring the extraocular muscles. One should remember to dissect posteriorly in an upward direction, in keeping

Figure 7 Titanium plate mesh for reconstruction of the orbital floor defect.

with the superior inclination of the orbital floor. In particularly large defects where the posterior stable edge is difficult to find, it may be helpful to place the periosteal elevator straight back and contact the posterior wall of the maxillary sinus. This may help with locating the posterior edge of the defect. The importance of dissecting superiorly cannot be overstated. The most common mistake in approaching orbital fractures is to dissect directly posteriorly and place the implant into the maxillary sinus rather than inclined upward along the orbital floor (Fig. 8). Surgeons frequently worry about damage to the optic nerve from the dissection. It must be remembered that, typically, this is in the order of 45 mm from the orbital rim and in a superior and medial location.

Most surgeons recommend that all implants should be fixed.¹² Titanium mesh plates can be cut to allow extra holes to drape over the infraorbital rim on the superior aspect and anchored. Fixating the mesh on the superior aspect of the infraorbital rim avoids palpation of the screws and the mesh. When porous polyethylene was used, the implant was not fixated. Ho et al⁹ found in their study of 26 cases that nonfixed porous polyethylene provided an excellent functional and cosmetic result.

There have been many recommendations for the timing of surgery for orbital floor fractures. In 1982, Koornneef suggested a conservative approach to blow-out fractures.¹³ In 1983, Hawes and Dortzbach and Leitch et al in 1990 advocated surgery for orbital floor fractures, preferably within 14–21 days after trauma, respectively.^{14,15} In 1984, De Man et al¹⁶ suggested that a floor fracture with an intake periorbital does not require surgery. Early exploration of the orbital floor was advocated by Thaller and Yvorchuck in 1990, to reduce the incidence of posttraumatic complications.¹⁷ It is important to remember that orbital floor fractures are rarely emergent with few exceptions, like the situations in which the extraocular muscles are compromised. The classic example is the pediatric trap-door fracture, in which a defect opens on the floor and due to the green-stick nature of the fracture subsequently closes again. If extraocular muscles are entrapped in the fracture site, it can become ischemic. One thing to remember about orbital floor fractures is that we are not concerned with

fracture union but are trying to support the globe to prevent facial asymmetry. Therefore, delaying of surgery as recommended in Table 6 is beneficial to the surgeon because the orbital swelling will be relieved and thus facilitate exposure in the course of time. Cole et al¹⁸ stated that they routinely wait 1 to 2 weeks for surgical intervention. However, waiting for longer periods have demonstrated increased postoperative complications. Hawes and Dortzbach¹⁹ found the incidence of diplopia to be 38% when surgery was done 2 months or longer after surgery and only 7% if surgery was done in less than 2 months postinjury. In addition, Dullely and Fells²⁰ demonstrated that 72% of patients who had surgical intervention after 6 months had enophthalmos compared with 20%, if surgery was conducted within 2 weeks of injury. The average time of surgical intervention in our study was 4.94 days, with a range from 1 to 20 days.

Common complications after orbital floor fractures include ectropion, diplopia, and enophthalmos. The risk of postoperative ectropion can be minimized with use of the transconjunctival approach. In the event of lid retraction postoperatively, aggressive lower-eyelid massage and forced eye-closure exercises should be instituted. Unless significant corneal exposure and irritation are encountered, early operative intervention should be avoided. Operative correction should be performed if there is no improvement after 4 to 6 months of conservative therapy. One patient in our review who had postoperative ectropion required surgical intervention to correct the defect.

Diplopia in the postoperative setting can be a result of extraocular muscle deficits. A normal forced-duction test at the end of the surgery should effectively rule this out. Frequently, periorbital swelling or muscular contusion and edema may be the underlying cause. Diplopia is more problematic when in the primary field or in downgaze, which may interfere with walking. When the deficit appears first after surgery, a computed tomographic scan should be performed to determine whether the implant is causing interference with the extraocular muscles. If the implant is well positioned, then the patient should be followed conservatively, as the majority of these cases resolve without intervention.

Postoperative enophthalmos is one of the most distressing and common problems seen with orbital floor fracture management. The majority of cases are a result of persistent orbital-volume enlargement secondary to nonanatomic restoration of the orbital cone. The initial evaluation of postoperative enophthalmos should include a computed tomographic scan to determine implant location and characterize intraorbital volume.²¹ In some cases, the existing implant may be repositioned, which can be difficult due to scarring of the periorbital. In these cases the implant should be elevated with the periorbital and a second implant should be placed. If this does not result in an appropriate globe position,

Figure 8 Correct placement of implant for orbital floor reconstruction.

additional volume should be added to the orbit in a posterolateral location.

The most common subjective complaint in our review was infraorbital nerve paresthesia in 12 patients. Postoperative diplopia in one patient resolved with time, and another developed cellulitis that resolved with antibiotic therapy.

CONCLUSION

Orbital floor fracture management has changed significantly within the last several decades with the introduction of new internal fixation methods and new materials for reconstructing the orbital floor defect. New methods and new implant materials are constantly being introduced to improve the results of orbital floor fractures. Recommendations for surgical intervention on orbital floor fractures mostly depend on clinical examination and imaging studies. Inadequate repair of orbital floor fractures can lead to significant facial asymmetry and visual problems. In our study, we have shown that preseptal transconjunctival approach with either titanium mesh or porous polyethylene can give good results when it comes to orbital floor reconstruction.

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