Updates on the Evaluation and Treatment of Orbital Fractures

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KEYWORDS

• Orbital fracture • Transconjunctival • Diplopia • Patient-specific implant • Intraoperative navigation • Microscopic • 3-D computed tomography

KEY POINTS

- *Evaluation*: Orbital fractures are typically evaluated with thin-slice computed tomography (CT) imaging, which delineates the extent of soft tissue herniation and bony displacement.
- *Surgical Approach*: Advances in surgical approaches for orbital fractures include transconjunctival and endoscopic techniques that minimize visible scarring and tissue trauma.
- *Technology*: Intraoperative CT and navigation, patient-specific implants, and microscopy enhance precision in reconstruction.
- *Outcomes*: Successful surgical intervention improves cosmetic and functional outcomes, reducing complications like persistent diplopia, enophthalmos, and visible scarring.

INTRODUCTION

Orbital fractures are some of the most common facial fractures, most frequently encountered after a blunt force trauma, such as in accidental injury, motor vehicle collisions, or assault. These fractures often involve the orbital rim, medial orbital wall, and orbital floor and occur as part of zygomaticomaxillary complex (ZMC) fractures.[1] As such, a detailed understanding of the orbital and midface anatomy is critical to anticipating the structures at risk during fracture repair. The orbital skeleton consists of the maxillary, palatine, lacrimal, ethmoid, sphenoid, frontal, and zygomatic bones (**Fig. 1**). The orbital roof is comprised entirely of the frontal bone and is typically involved in orbital fractures that also violate the frontal sinus or extend intracranially. By contrast, ZMC fractures and isolated orbital blowout fractures are more frequently encountered, with involvement of the orbital floor in both cases and the lateral orbital wall in ZMC fractures.[1] The orbital floor is most susceptible to fracture at its thinnest aspect medial to the infraorbital canal.[2,3] This article will focus on appropriate evaluation of the most commonly encountered isolated orbital fractures in adult patients and the latest approaches to surgical management.

ASSESSMENT

Clinical assessment of patients presenting with orbital fractures and other facial fractures typically requires a multidisciplinary approach. Evaluation by emergency medicine, trauma surgery, neurosurgery, and internal medicine may be required to stabilize any life-threatening injuries and/or optimize the patient before considering a repair. At a minimum, a basic visual acuity and eye examination should be performed by the consulting service. It is generally recommended that all patients with vision symptoms and operative orbital injuries also receive formal ophthalmology evaluation and baseline vision assessment before repair. However, severe ocular injuries are rare in patients with orbital fractures who are visually

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Facial Plast Surg Clin N Am 33 (2025) 291–301
https://doi.org/10.1016/j.fsc.2025.03.002
1064-7406/25/Published by Elsevier Inc.

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Abbreviations

CT	computed tomography
PSI	patient-specific implant
RCT	randomized control trial
SLA	stereolithography
VSP	virtual surgical planning
ZMC	zygomaticomaxillary complex

asymptomatic or only exhibit changes in visual acuity.[4,5] A complete history and physical is relevant to the patient's overall surgical candidacy and informs postoperative recovery. This includes a history of eye surgery, baseline vision status, medications, and comorbidities.

Initial assessment of all patients with orbital fractures may be divided into 3 subcategories: vision, soft tissue, and structural integrity of the orbital skeleton. Patients may report diplopia, blurred vision, orbital and facial pain, and/or paresthesia. Common signs associated with these injuries include periorbital edema and ecchymosis, chemosis, subconjunctival hemorrhage, and sensory deficits in the distribution of the infraorbital nerve. Gaze restriction may occur due to muscle impingement or soft tissue swelling causing localized pain. As such, interrogation with fine cut computed tomography (CT) imaging should be performed. Visual field testing, pupillary shape and light response, and visual acuity should be assessed by the surgical team. Palpable bony step-offs, hypoglobus or enophthalmos likely reflect bony displacement and should be correlated with imaging findings. Additional physical examination findings to note include disrupted color perception, which may reflect traumatic optic neuropathy, as well as hyphema, abnormal pupil shape, telecanthus, persistent oculocardiac reflex, and nasal deformity. Such findings may inform the urgency of ophthalmologic evaluation and

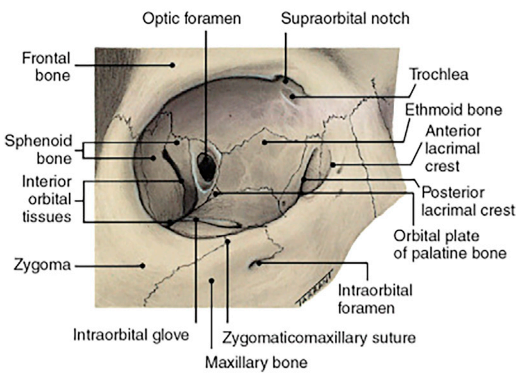

Fig. 1. The orbital skeleton. (*Reproduced from* Kanski JJ, Bowling B. Clinical ophthalmology: a systematic approach. 7th edition. Elsevier Health Sciences; 2011.)

intervention in these patients, typically within 24 to 48 hours.

Orbital fractures have been described based on the number of orbital walls involved (I-IV), the components of the fractured orbital skeleton with associated soft tissue or orbital volume compromise (ie, orbital floor fractures with associated inferior rectus muscle entrapment), and/or association with other craniofacial fractures.

Radiologic evaluation of orbital fractures includes thin-cut (1–2 mm slices) noncontrasted CT of the orbit, face and sinus. When available, three-dimensional reconstruction provides helpful perspective regarding the fracture pattern and scope of injury. If intraoperative navigation is used, CT images must capture the full facial skeleton, that is, vertex to menton and occiput to nasal tip. Indications for intraoperative navigation are discussed in later sections.

When assessing orbital fractures, different planes allow examination of each fracture location. The medial orbit is best assessed in an axial and coronal view, while the orbital floor is best assessed in coronal and sagittal views, with special attention to the medial strut and posterior ledge that are helpful intraoperative landmarks for plating. In all cases, special attention is paid to the integrity of orbital soft tissue contents with respect to these factures.

ORBITAL FLOOR FRACTURES

The orbital floor is made up of contributions from the palatine bone, along with the zygoma and maxilla that form the infraorbital rim (see **Fig. 1**). While this section will focus on isolated orbital floor fractures, early identification of concurrent medial wall involvement is critical for surgical planning, ensuring reliable landmarks and support for the implant.

Initial evaluation of patients with orbital floor fractures includes the aforementioned components, with particular attention to extraocular movement, enophthalmos, and diplopia due to changes in orbital volume. Vertical gaze restriction, specifically upward gaze restriction, may suggest entrapment of the inferior rectus muscle. Forced duction testing is helpful in distinguishing restriction due to pain and edema versus muscle impingement. Although typically a clinical diagnosis, radiographic evidence of muscle impingement or entrapment (the development of tissue ischemia due to incarceration) is best evaluated on coronal images and warrants urgent surgical exploration and repair.

While obvious deficits support operative repair, minimally displaced or asymptomatic orbital floor fractures may be treated conservatively. The latter group may benefit from observation over a period of 2 to 3 weeks, with subsequent evaluation after soft tissue edema has improved. However, there is no consensus regarding the optimal timing of surgical repair in these cases.[6] Some have commented that a delayed approach facilitates evaluation of globe position, residual diplopia, and surgical exposure without compromising surgical outcomes if operative repair is pursued. Still, many surgeons cite the recommendations of Michael Burnstine, who advocated for surgical repair within 2 weeks in patients with large orbital floor fractures, symptomatic diplopia, positive forced duction, and/or soft tissue entrapment, to prevent late complications.[7] CT findings generally supporting surgical repair include involvement of medial orbital wall, greater than or equal to 50% of the orbital floor, displaced soft tissue greater than 2 mm into the surrounding maxillary or ethmoid sinuses, and rounding of the inferior rectus to a 1:1 ratio of height-to-width on a coronal CT (**Fig. 2**).[8,9]

The objective of surgical repair of orbital floor fractures includes reestablishing orbital volume and correcting or preventing enophthalmos. Several approaches to the orbital floor have been described, with the goal of maximizing bony exposure while minimizing cosmetic and functional deficits for each fracture type and location. **Figs. 3** and **4** below illustrate the cross-sectional anatomy of the eyelid and the locations of these incisions in relation to one another.

The subciliary approach is a transcutaneous incision several millimeters below the lash line traditionally performed to expose the orbital floor and infraorbital rim (see **Fig. 4**; **Fig. 5**). The orbicularis oculi muscle is then divided either through direct dissection deep to the incision, or after several millimeters of dissection in a subcutaneous tissue plane toward the tarsal plate. While the subciliary incision provides more direct access to the infraorbital rim compared to other approaches, its major disadvantages include a visible scar and lid contracture leading to an increased risk of ectropion and scleral show.[10] In addition, the subciliary incision does not provide adequate exposure of the medial orbital wall if concurrent fractures are present.

By contrast, the transconjunctival approach has gained favor due to the hidden incision and reduced

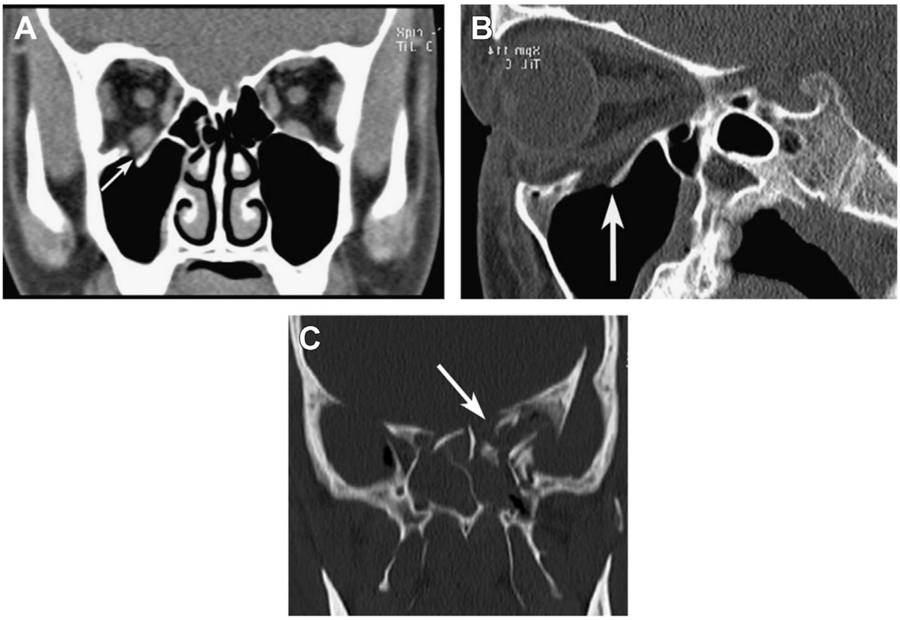

Fig. 2. Orbital fractures. (*A*) Coronal noncontrast-enhanced CT scan shows a depressed floor of orbit fracture with rounding of inferior rectus muscle indicating likely muscle entrapment (*arrow*). (*B*) Oblique sagittal bone window CT scan shows a depressed floor of orbit fracture (*arrow*). (*C*) Coronal bone window CT scan shows comminuted orbital fractures surrounding left optic canal with potential optic nerve impingement (*arrow*). (*Reproduced from* Goh PS, Gi MT, Charlton A, et al. Review of orbital imaging. Eur J Radiol 2008;66(3):387–95. https://doi.org/10.1016/j.ejrad.2008.03.031; and *Data from* Matic DB, Tse R, Banerjee A, et al. Rounding of the inferior rectus muscle as a predictor of enophthalmos in orbital floor fractures. J Craniofac Surg 2007;18(1):127–32. https://doi.org/10.1097/SCS.0b013e31802ccdc8; and Gabrick K, Smetona J, Iyengar R, et al. Radiographic predictors of FACE-Q outcomes following non-operative orbital floor fracture management. J Craniofac Surg 2020;31(4):e388–91. https://doi.org/10.1097/SCS.0000000000006356.)

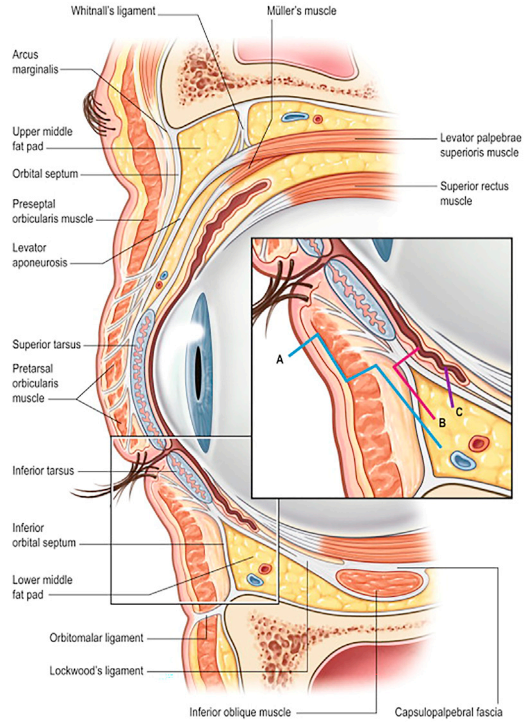

Fig. 3. Cross-sectional anatomy of eyelid. Inset box: surgical approaches to the lower lid fat pads. A, Subciliary skin muscle flap (step incision leaves pretarsal orbicularis oculi intact). B, Transconjunctival: preseptal. C, Transconjunctival: retroseptal. (*Reproduced from* Aston SJ, Steinbrech DS, Walden JL. Aesthetic plastic surgery. Elsevier Health Sciences; 2009.)

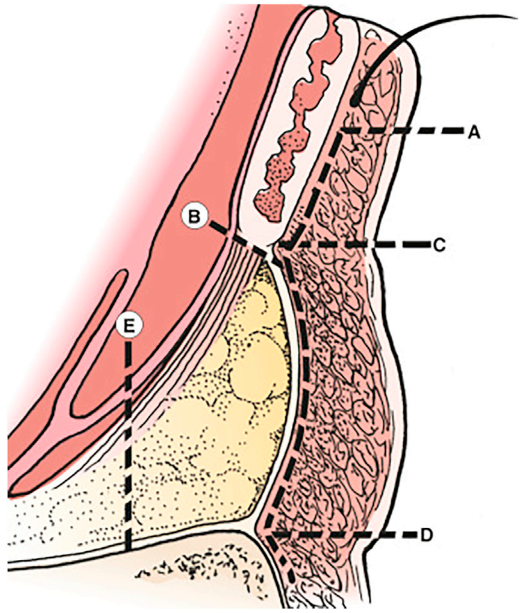

Fig. 4. The inferior anterior approaches to the orbit. The subciliary incision (A) and the subtarsal transconjunctival incision (B) end up at the same point and preserve the orbital septum. The skin crease incision (C) and rim incision (D) are not recommended, because they tend to leave a visible scar. The fornix approach (E) gives quick access to the orbital fat, but it can be difficult to control exposure because of fat prolapsing around retractors. (*Reproduced from* Nerad JA. Techniques in ophthalmic plastic surgery. 2nd edition; 2020.)

risk of scar contracture with resultant ectropion.[10,11] This involves creating an incision through the conjunctiva below the level of the tarsus to expose the orbital rim. Dissection may be carried out in a preseptal or postseptal plane, with or without the addition of lateral canthotomy and/or inferior cantholysis to improve exposure and minimize lid retraction intraoperatively. If this is performed, resuspension of the tarsal plate is performed with suture to the orbital periosteum and closure of the overlying skin. Closure of the conjunctiva with suture is not always required and, if performed, one may use a single fine suture with buried knots to prevent corneal irritation.[12] The senior author will often create a transconjunctival postseptal incision and will loosely approximate the conjunctiva with two to three 6-0 plain gut sutures. While this approach avoids external incisions, it is technically more challenging and carries the risk of entropion.[11] A properly placed incision is one that provides direct access to the preseptal or postseptal space and facilitates closure without disrupting the fornix to prevent entropion. Retropulsion of the globe and simultaneous inferior lid retraction promotes periorbital fat prolapse. A mean distance of 5 to 7 mm from the inferior tarsus to the tip of fat prolapse serves as a landmark for incision placement. An incision placed 0.5 mm posterior to this distance has been shown to facilitate dissection in the postseptal space.[13] On the other end of external transorbital approaches is the subtarsal incision (see **Figs. 4** and **5**). This approach carries the advantage of direct access to the orbital rim and floor fractures, but its effect on cosmesis remains an area of controversy.[6] It has been shown to carry a total complication rate of nearly 10%, with 1 author limiting its use for ZMC or combined ZMC and orbital floor repairs.[11]

Endoscopy offers the orbital surgeon improved visualization while limiting globe and lid retraction intraoperatively. Endoscopic assistance via a lid incision as well as endonasal and transantral endoscopic techniques to isolated orbital floor fracture repair have been described. In the transantral approach, an incision is made in the gingivobuccal mucosa followed by periosteal elevation to expose the anterior maxillary wall and infraorbital nerve. A Caldwell-Luc osteotomy is performed, and the maxillary sinus is entered. An angled

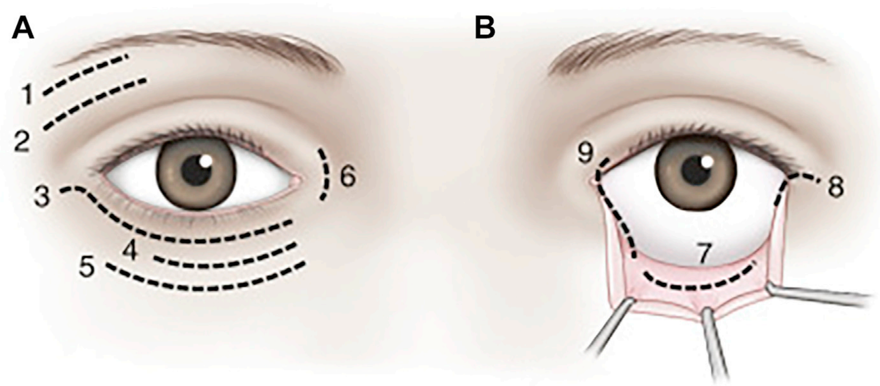

Fig. 5. (*A*) Transcutaneous approaches for exposure of the zygomaticofrontal suture (1, 2) and the lower orbit (3, 4, and 5). (*B*) The transconjunctival approach (7) with or without lateral canthotomy (8) is recommended for exposure of the orbital floor, lateral orbit, and infraorbital rim. 1, Brow; 2, upper blepharoplasty; 3, subciliary; 4, midtarsal; 5, subtarsal; 6, medial canthal (Lynch); 7, transconjunctival; 8, lateral canthotomy; 9, transcaruncular. (*Reproduced from* Brennan PA. Maxillofacial surgery. 3rd edition. Elsevier Health Sciences; 2016.)

scope is helpful for this technique, with the benefit of improved visualization of posterior orbital floor defects.[14] This approach has the added benefit of avoiding transcutaneous and transconjunctival incisions that carry the risk of scarring and ectropion. Some authors have suggested that this technique provides access to the internal orbital floor and reduction of herniated orbital contents without violating intraorbital vascular structures.[15] However, strong evidence to support the use of endoscopic approaches over traditional open techniques in isolated orbital floor defects is lacking.[14] This technique is not generally recommended for fractures involving in the infraorbital rim. The senior author uses the endoscope through a transconjunctival incision, which improves visualization of the orbital contents, serves as a teaching aid in surgical training, and confirms adequate reduction of orbital contents and plate placement.

IMPLANTATION

Previously described implantable materials include biologic and alloplastic materials. Historically, autologous bone and cartilage grafts were considered the gold standard for orbital floor reconstruction. Their major advantage was biocompatibility and long-term viability as a result. Calvarial bone grafts provided the rigidity and size needed to mold the implant, with the major disadvantage of donor site morbidity and risk of resorption.[16] Auricular, costal, and nasoseptal cartilage grafts provided malleable and avascular grafts with even better long-term viability compared to bone grafts.[17,18] While favorable outcomes are described for each of these graft types, the majority of these studies consist of small samples and case series.

Alloplastic materials have gained favor in recent years, as they have become highly customizable and offer long-term reliability. These are grouped into resorbable and nonresorbable implants. Examples of resorbable implants include a polymer of L-lactic acid and DL-lactic acid, polyglycolic acid, and polydioxanone.[19] These promote endogenous granulation and provide structural support during the initial healing period, with reduced long-term rates of graft infection and extrusion. However, they may not provide sufficient mechanical support due to their degradation, especially for larger fractures.[19]

Commonly used nonresorbable materials include titanium mesh and porous polyethylene. These are widely used in blowout fractures due to their long-term reliability, providing both malleability and rigid support.[6,19] Disadvantages of these implants include increased risk of fibrosis and adhesions to adjacent orbital tissue/muscle and implant-associated infection.[6] Limited evidence exists to suggest the routine use of one implant over the other.[20]

With the increased use of alloplastic plating systems, proper plate positioning is one of the most critical components of repair. Fractures that preserve the medial strut of the nasomaxillary buttress and the posterior bony ledge facilitate proper positioning of the plate, while fractures extending medially pose an added challenge to repair.[21] The design and placement of the implant must consider the natural S-shape of the orbital floor (**Fig. 6**). The angle of the orbital floor relative to the horizontal plane has been shown to be greater in males compared to females, and in children compared to adults. In addition, the lowest point of the orbital floor has been shown to shift

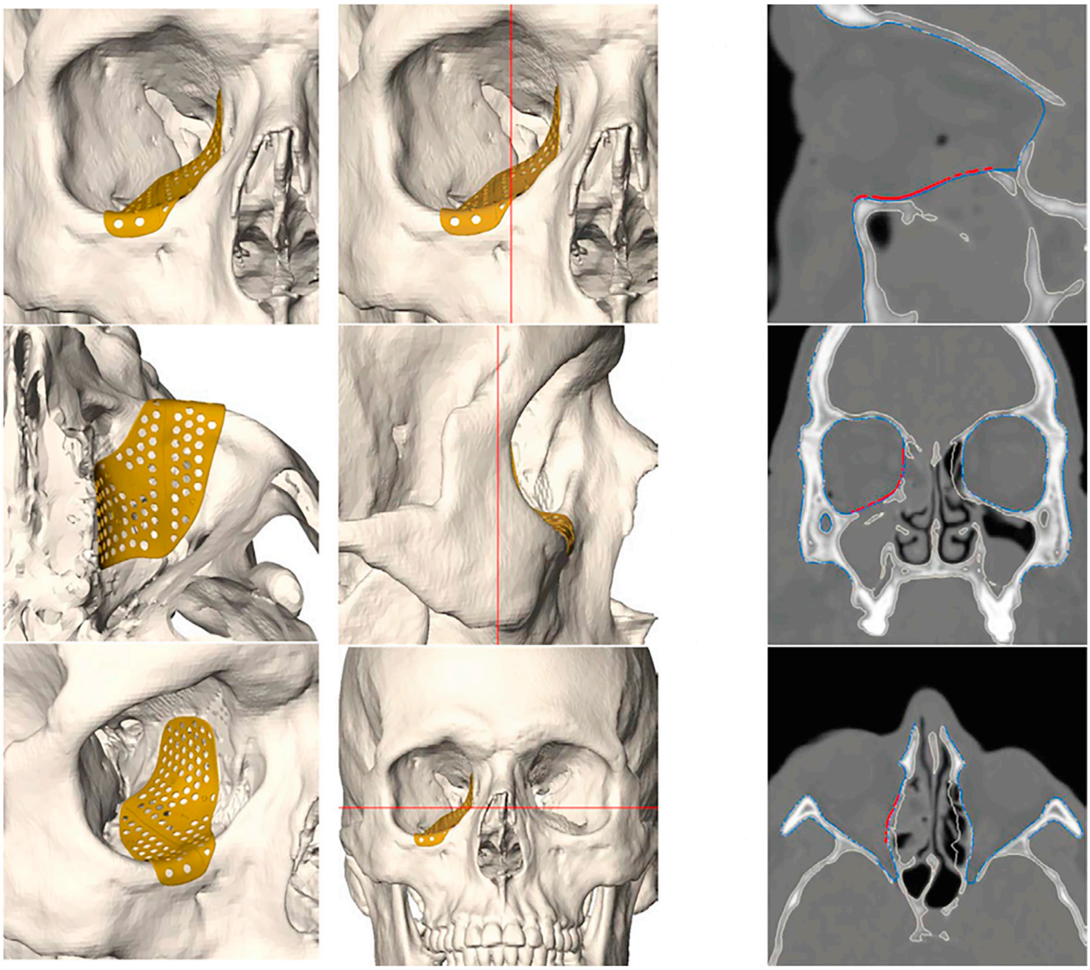

Fig. 6. VSP with PSI for a fracture involving the orbital floor and medial wall. The implant consists of titanium mesh 0.3 mm in thickness with two screw holes and a sterile bony host model. Measurements are mapped based on preoperative CT images in sagittal, coronal, and axial planes as well as 3D models. The sagittal view demonstrates the anatomic S shape of the orbital floor.

posteroinferiorly with age, generating a greater horizontal and vertical orbital floor depth.[22] This is consistent with the observation that the maxilla shifts downward with age, shifting the floor inferiorly, while bony remodeling over time raises the orbital floor and thus its angle. These findings impact surgical planning, as one can interrogate preoperative imaging to measure the extent of posterior dissection required to expose the posterior bony ledge and anticipated angle of the plate. This should be performed to prevent hypoglobus or enophthalmos and to avoid iatrogenic injury to surrounding structures, like the optic nerve posteriorly. A consistent landmark to guide plate placement intraoperatively is the superior posterior wall of the maxillary sinus.[21] This is because it typically remains intact in orbital floor and ZMC fractures. The author's experience supports that the distance of this landmark from the infra orbital rim serves as a reliable posterior limit to dissection and safe placement of the implant anterior to the optic canal.

MEDIAL ORBITAL WALL FRACTURES

The lamina papyracea of the ethmoid bone, the lacrimal bone, maxilla, and nasal process of the frontal bone form the medial orbital wall. The anterior ethmoid artery, posterior ethmoid artery, and optic foramina are found 24 mm, 36 mm, and 42 mm lateral to the anterior maxillary crest, respectively. The medial canthal tendon consists of 2 limbs that attach to the anterior and posterior lacrimal crest. Between these 2 limbs lay the lacrimal sac, which drains through the nasolacrimal duct into the inferior meatus.

Generally, early operative repair is pursued when functional deficit is present, usually due to medial rectus muscle herniation or entrapment. This can be evaluated radiographically and on forced duction testing. In cases of bradycardia and nausea from the oculocardiac reflex, decompression is emergent. Enophthalmos and resultant diplopia are also indications for early repair. Formal guidelines for late repair are lacking due to inadequate data to predict late enophthalmos functional deficits.[23]

The traditional approach to the medial orbit described by Lynch in 1921 involves a curvilinear transcutaneous incision medial to the medial canthus. This has fallen out of favor due to visible scars, risk of webbing, and injury to the lacrimal system. Transcaruncular and endonasal approaches to the medial orbit have largely replaced transcutaneous incisions due to the risk of scar contracture. The transcaruncular approach involves a 12 to 15 mm incision through the caruncle or just posterior to the semilunar fold to preserve Horner's muscle. This incision may be extended through the inferior conjunctiva to expose concurrent medial wall and floor fractures. Endonasal approach to the medial orbit involves medializing the middle turbinate to perform an uncinectomy, the maxillary os and ethmoid bulla are identified and the bulla is entered. Removal of anterior ethmoid cells exposes the lamina papyracea along with associated medial wall fractures. When combined with transorbital approaches to guide implant placement, this approach enhances visualization of medial wall defects with minimal morbidity. Depending on the approach used, an onlay versus inlay implant method may be used to reduce herniated orbital contents and reconstruct the medial wall.[24] Noncomminuted fractures may be reduced by segment and an inlay implant through the ethmoid sinus may be added for additional structural support to prevent recurrence.[24]

ORBITAL ROOF AND LATERAL ORBITAL WALL FRACTURES

The orbital roof is comprised mainly of frontal bone with small contributions from the lesser wing of the sphenoid posteriorly. Relevant to the orbital roof and lateral orbital wall are exposure of the zygomaticofrontal and zygomaticosphenoid suture lines (see **Fig. 5**). Both orbital roof and lateral orbital wall fractures may be accessed via the transpalpebral (upper blepharoplasty) approach. An incision is made in the natural supratarsal crease typically 7 to 10 mm above the ciliary line, extending just beyond the lateral canthus. To expose lateral wall fractures, preseptal dissection is carried to the lateral orbital rim and zygomaticofrontal suture. The periosteum is elevated to expose the fracture. This is cosmetically more favorable due to the reduced risk of visible scars and brow alopecia compared to a lateral brow approach for lateral wall fractures.

Extensive orbital roof defects may require a coronal approach. Exposing roof fractures may require extended dissection to the superolateral wall and zygomaticosphenoid suture. Medially, care must be taken to avoid injury to the anterior and posterior ethmoidal arteries. Anterolaterally, the lacrimal gland lies in the lacrimal fossa. Posteriorly, the roof extends to the superior orbital fissure and optic canal. As with other fractures of the orbit, there is limited evidence guiding the timing and indications for early surgical intervention versus observation, even in patients with displacement, visual deficits, or cerebrospinal fluid leak.[25] In a review of practice management for orbital roof fractures, Sandhu found most studies reported early intervention in cases with concomitant dural tears and/or multiple craniofacial injuries.[25] Rarely, delayed visual deficits presenting several months after initial injury have been reported, requiring surgical intervention.

EQUIPMENT AND MATERIALS

The use of microscope-assisted approaches to the orbit is limited in facial trauma literature. Park and colleagues described its application in a case of delayed pediatric orbital floor fracture repair. This was combined with a transantral approach, allowing for improved visual depth in a scarred wound bed, improved implant placement with a 2-handed technique, and uncomplicated postoperative recovery. While the efficacy of microscope-assisted techniques has not been examined in orbital fracture repair, the enhanced visualization, illumination, and control of the surgical field provided by microscopy is well-described in facial plastic surgery literature and microsurgery.[26] As such, further data to guide its application and feasibility should be investigated, especially in complex craniofacial injuries that carry higher operative risk (**Fig. 7**). The senior author primarily uses an operating microscope for his orbital fracture repairs due to the improved visualization and ability to more precisely contour the orbital implant that is afforded by the microscope.

Fractures involving the medial wall and/or orbital floor become significantly more challenging to repair when the inferomedial nasomaxillary buttress and the posterior bony ledge of the orbit are involved. In these cases, intraoperative image-guided navigation and personalized plate design

Fig. 7. Operating room set up for orbital floor fracture repair with CT navigation systems and microscope assistance. 3D C-arm (the left side of the room) can be used to check implant placement.

facilitate precise positioning to prevent complications and the need for revision surgeries. The growing availability of intraoperative navigation has allowed for complete visualization of these defects, thereby focusing soft tissue dissection to minimize risk of iatrogenic injury. Studies evaluating final plate positioning with and without the addition of intraoperative navigation have shown accuracy within 1 mm of the nontraumatized orbit, as well as significantly improved postoperative vision and globe position.[27,28]

Intraoperative CT has also become more widely used with the advancement of portable CT and the use of cone-beam radiation to reduce radiation exposure. One of the main utility measures associated with intraoperative CT is added operative time. In a retrospective review of 38 cases of routine or complex maxillofacial trauma repairs, Shaye and colleagues found intraoperative CT added 14.5 minutes of operative time, with surgical revision based on the CT findings in 24% of cases (8 of the 9 patients classified as having complex fractures).[29] While this technique requires an additional scan after each surgical adjustment, it eliminates the need for postoperative imaging and allows for immediate adjustment of malpositioned implants to minimize need for return to the operating room.

Combining intraoperative navigation and endoscopic techniques, reconstructive surgeons are able to more accurately address challenging fractures that disrupt landmarks typically used for plate positioning. A critical addition to this technology has been computer-aided design and printing as part of virtual surgical planning (VSP) to create orbit-specific implants with stark accuracy. Options for implant design include preformed implants, template contouring of a 3D model based on preoperative CT imaging as in stereolithography (SLA), and patient-specific implants (PSIs). Preformed implants have been developed based on standardization across several-hundred imaging datasets with accurate contours in both orbital floor and medial wall fractures.[6,30] For more extensive orbital injuries, Park and colleagues demonstrated the utility of rapid 3D prototype models of patient skulls in contouring titanium-reinforced porous polyethylene implants.[31] In their series of 104 patients, they achieved correction of orbital volume congruent with planned measurements with minimal morbidity.[31]

As one of the most recent technologies to revolutionize orbital fracture repair, PSIs are customized to the unique defect characteristics and mirror the contralateral unaffected orbit. These implants are typically secured to the infraorbital rim with a single screw (see **Fig. 6**; **Fig. 8**). In a systematic review and meta-analysis of traumatic orbital reconstruction in 560 participants, Saptarshi and colleagues found improved postoperative rates of enophthalmos with PSI compared to prebent implants, particularly for large defects.[32] However, a nonsignificant reduction in diplopia was seen with PSI and equivalent orbital volumes were seen with prebent implants. The literature is lacking in prospective randomized studies to inform indications for adaptation of these technologies. Moreover, significant variation in reported time and production costs associated with these implants exists, which may limit their application across health care settings.[33] In a recent systematic review of 28 randomized control trials (RCTs) on orbital fracture management, the overall fragility index of statistically significant dichotomous outcomes was 3.5.[34] In other words, a reverse outcome in just 3.5/100 patients would render a study's results statistically insignificant. This suggests poor stability of RCT findings, which are often considered the gold standard in influencing clinical decision-making.

POSTOPERATIVE CARE

Patients undergoing surgical repair for orbital fractures may be observed overnight to monitor for immediate complications, or surgery may be performed in the outpatient setting depending on surgeon preference. Postoperative CT is indicated if intraoperative CT is not used and/or there are concerns based on postoperative patient history and examination. Many surgeons do not routinely obtain postoperative imaging unless an issue arises. One to two Frost sutures may be placed in the lower lid conjunctiva and

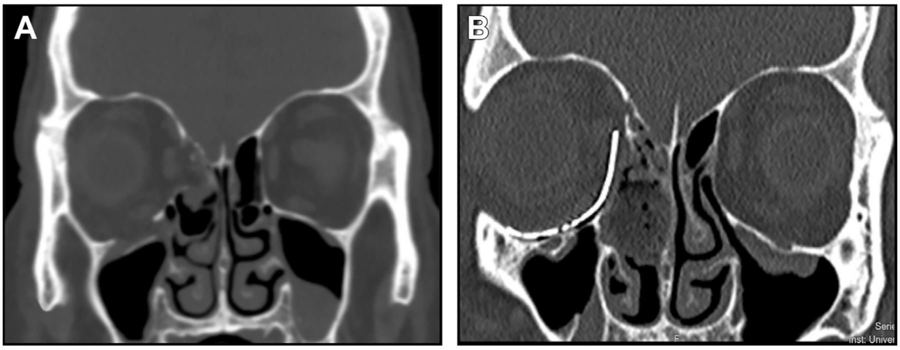

Fig. 8. (*A*, *B*) Preoperative and postoperative 1-mm thin-slice CT on coronal view demonstrating orbital floor and medial wall reconstruction with restoration of orbital volume after a naso-orbital-ethmoid fracture. The senior author used a titanium mesh PSI, design specifications detailed in **Fig. 6**. Concurrent limited maxillary antrostomy, middle turbinectomy, and ethmoidectomy with reduction of encephalocele and packing in place in right nasal cavity.

suspended above the brow to prevent ectropion, though criticisms of this technique include lack of evidence to correlate reduced rates of ectropion with its use, limited postoperative vision assessments, and theoretic risk of corneal abrasion.[35] The senior author typically suspends the sutures with tape to the brow, which allows for partial eye opening perioperatively. The senior author prefers to test visual acuity, extraocular motion, and light perception at 4-hour intervals, along with pain and blood pressure. Even in outpatient surgery, an initial postoperative visual assessment should be performed and documented. Increased postoperative pain out of proportion, proptosis, gaze restriction, or worsening visual acuity should raise suspicion for retrobulbar hematoma. Perioperative edema is treated with ice packs, and antibiotic and/or steroid ophthalmic drops are often used twice daily for up to 7 days.

SUMMARY

This article describes commonly encountered orbital fractures, their clinical assessment, and operative management. When possible, favorable surgical approaches are those that maximize exposure while minimizing visible scars and lid deformity. Similar principles used in cosmetic blepharoplasty may be applied to transcutaneous approaches to the orbit. Recent advancements in intraoperative imaging guidance facilitate endoscopic and microscopic approaches, with improved visualization for both surgical training and approximating preinjury orbital structure. PSIs are a key component of VSP, enhancing the surgeon's armamentarium in the face of more extensive injuries involving landmark structures. While these techniques have been reported to be safe and effective in case series and cohort studies, high-powered prospective studies to guide management remain limited across orbital fracture literature.

CLINICS CARE POINTS

- Limited prospective studies exist to support a consensus on optimal timing for operative repair. General guidelines support intervention in cases with concern for muscle impingement or entrapment, or radiologic evidence of significant bony displacement or soft tissue herniation.
- With recent advances in endoscopy and intraoperative navigation, surgeons have trended away from transcutaneous approaches where possible. Incision placement has shifted toward a combined transconjunctival and gingivobuccal approaches to the orbital floor or transcaruncular and endonasal approaches to the medial orbital wall.
- Fractures disrupting traditional surgical landmarks of the inferomedial nasomaxillary buttress and posterior bony ledge of the orbit pose increased risk for improper plate positioning, iatrogenic injury, and need for revision. Intraoperative image-guided navigation and personalized plate design have gained favor in approaching these cases.
- Intraoperative computed tomography has become more widely available and allows for immediate adjustment of malpositioned plates during a single operative visit, particularly for complex fractures.
- Improved postoperative rates of enophthalmos have been shown when patient-specific implants are used for larger defects, though no standard guidelines exist for their application based on current available data.

DISCLOSURES

The authors have nothing to disclose.

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