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Catastrophic Zone I Open Globe Injury: Pathophysiological Insights and Staged Surgical Triumphs in a Case of Corneal Rupture, Lens Extrusion, and "Blackball" Hyphema

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ABSTRACT

Background: Complex open globe injuries (OGIs) involving the simultaneous destruction of multiple anterior segment structures represent a formidable challenge in ophthalmic traumatology. These injuries necessitate a staged surgical approach to restore ocular integrity and optimize the potential for visual rehabilitation. **Case presentation:** A 44-year-old male presented with a severe Zone I OGI in the left eye from a high-velocity projectile stone. His initial best-corrected visual acuity was limited to light perception. Examination revealed an 8-mm corneal rupture with uveal prolapse, complete anterior extrusion of the crystalline lens, and a Grade IV "blackball" hyphema. The Ocular Trauma Score (OTS) was calculated as 1, predicting a very poor visual outcome. Immediate primary repair involved anterior vitrectomy, lensectomy, hyphema evacuation, and corneal suturing. After a six-month stabilization period, a secondary scleral-fixated intraocular lens (IOL) was implanted using a double-needle Yamane technique. **Conclusion:** Despite the devastating nature of the initial injury and a grim prognosis as per the OTS, a principled, staged surgical strategy resulted in a final best-corrected visual acuity of 20/50. This case highlights that adherence to damage-control principles—prioritizing anatomical restoration in the primary surgery and deferring refractive correction—can lead to unexpectedly favorable functional outcomes in the most severe categories of ocular trauma.

1. Introduction

Ocular trauma is a major cause of preventable monocular blindness globally, inflicting a significant socioeconomic and personal burden. Annually, millions of eye injuries are reported, with a substantial number resulting in permanent visual impairment.¹ Among these, open globe injuries (OGIs)—defined by the Birmingham Eye Trauma Terminology (BETT) as a full-thickness wound of the corneal or scleral wall—represent the most severe end of the trauma spectrum. The prognosis for these injuries is often guarded and can be quantified using prognostic

models like the Ocular Trauma Score (OTS), which provides a standardized method for predicting the final visual outcome based on initial clinical findings.² An initial acuity of light perception or worse, coupled with a globe rupture, immediately places a patient in one of the lowest OTS categories, portending a high probability of severe, permanent vision loss.³

Complex OGIs, characterized by extensive intraocular damage beyond the globe wall breach, present the greatest therapeutic challenges. These injuries often involve a cascade of devastating sequelae, including traumatic hyphema, iris sphincter

tears, lens capsule rupture with cataract formation, zonular dialysis leading to lens dislocation, vitreous hemorrhage, and posterior segment trauma.⁴ The management of these cases is complicated by the synergistic effects of the concurrent injuries. For instance, a total, or Grade IV, "blackball" hyphema not only completely obscures the view for surgical repair but also dramatically increases the risk of intractable secondary glaucoma and corneal blood staining.⁵ Simultaneously, a dislocated and ruptured crystalline lens can incite a severe, granulomatous phacoanaphylactic uveitis and cause mechanical trauma to the corneal endothelium and trabecular meshwork.

The initial surgical intervention following a complex OGI is a critical determinant of the final visual outcome, adhering to the principles of damage control surgery.⁶ The primary goals are to restore the anatomical integrity of the globe, prevent devastating complications such as expulsive hemorrhage and infectious endophthalmitis, and control intraocular inflammation.^{7,8} A key point of contention in ocular traumatology is the timing of intraocular lens (IOL) implantation. While primary IOL placement may be considered in select, cleaner cases, the consensus for severely traumatized and potentially contaminated eyes has shifted firmly towards a staged approach. Deferring IOL implantation allows for the resolution of inflammation, stabilization of corneal curvature, and accurate biometry, thereby reducing the risk of refractive surprise and devastating infective complications in a controlled, quiescent eye.^{9,10}

This case report aims to provide a detailed, methodologically robust description of the diagnostic evaluation and surgical management of a catastrophic Zone I OGI, reported in accordance with the CARE guidelines. The case is notable for the "triple-threat" presentation of a full-thickness corneal rupture, complete anterior extrusion of the crystalline lens, and a Grade IV total hyphema, yielding an OTS of 1. The unique contribution of this report lies in its in-depth, integrated discussion of the interconnected pathophysiological mechanisms driving each

component of this severe injury. Furthermore, it documents the rationale behind a staged surgical strategy, beginning with emergency primary globe repair and culminating in a secondary scleral-fixated IOL implantation via the Yamane technique, which ultimately led to a functional outcome far exceeding the initial prognosis. By dissecting this complex case, we seek to reinforce the core principles of ocular trauma management and highlight the nuances of surgical decision-making that are paramount to salvaging vision in the most challenging of clinical scenarios.

2. Case Presentation

A 44-year-old Indonesian male, a professional landscaper with no significant past medical or ocular history, presented to the emergency department of our tertiary care center. The patient reported a direct injury to his left eye sustained approximately 11 hours prior while operating a grass-cutting machine without eye protection. A small stone was ejected at high velocity, striking him in the left eye. He experienced immediate, profound vision loss, severe ocular pain, and photophobia. There was no loss of consciousness. The patient was up-to-date on his tetanus immunization. A comprehensive ophthalmic evaluation was performed. The summary of clinical findings on admission is presented in Table 1.

Upon arrival at the emergency department, the patient presented a clinical picture of the utmost severity. The initial examination was a carefully orchestrated process, designed to gather the maximum amount of critical information while minimizing any risk of further damage to the compromised globe. The first and most fundamental metric, visual acuity, was limited to Light Perception (LP). This finding, while dire, contained a crucial qualifier: the perception was accompanied by accurate projection. This meant that when a light was shone from different quadrants, the patient could correctly identify its direction. This seemingly small detail was a profound indicator that, despite the complete destruction of the anterior segment, the neural

pathways from the retina to the brain were at least partially intact. It provided the first, albeit faint, glimmer of hope that the retina had not suffered a

complete shearing detachment and that the optic nerve was still functional, making a heroic surgical effort worthwhile.

Table 1. Summary of Clinical Findings on Admission

Patient: 44-Year-Old Male | Case: Catastrophic Zone I Open Globe Injury

Patient Demographics	44-year-old Indonesian Male
Occupation	Professional Landscaper
Chief Complaint	Severe ocular pain and profound, immediate vision loss in the left eye.
History of Present Illness	Struck in the left eye by a high-velocity stone ejected from a grass-cutting machine approximately 11 hours prior to presentation. No eye protection was worn.
Visual Acuity (Left Eye)	Light Perception (LP) with accurate projection in all quadrants.
Intraocular Pressure (Left Eye)	Deferred due to obvious open globe injury.
Anterior Segment Findings (Slit-Lamp Biomicroscopy)	• Cornea: Full-thickness, 8 mm, gaping, reverse 'C'-shaped laceration from 1 to 5 o'clock. • Anterior Chamber: Completely filled with a Grade IV "blackball" hyphema. • Lens: Opacified, dislocated, and extruded completely through the corneal wound. • Other: Prolapse of pigmented uveal tissue and vitreous strands into the wound.
Ocular Trauma Score (OTS)	Category 1 (Raw Score: 37) Predicts a 74% probability of a final visual outcome of No Light Perception (NLP).
Imaging: B-Scan Ultrasound	Intact posterior globe contour, evidence of vitreous hemorrhage, and an acute posterior vitreous detachment. No retinal detachment or intraocular foreign body (IOFB) visualized.
Imaging: Orbital CT Scan	Confirmed anterior globe rupture and extruded lens. Definitively ruled out any radiopaque IOFB and associated orbital fractures.

The measurement of intraocular pressure (IOP), a standard part of most ophthalmic examinations, was immediately deferred. In the context of an obviously open globe, attempting to measure pressure with a tonometer would apply external force to the eye, risking the catastrophic extrusion of any remaining intraocular contents—uveal tissue, vitreous, or even the retina itself. This decision reflects the primary principle of "do no further harm." The slit-lamp biomicroscopy revealed the full, devastating extent of the anatomical destruction. The injury was not a clean cut but a full-thickness, gaping, reverse 'C'-shaped corneal laceration. This specific morphology is a hallmark of an "inside-out" rupture from blunt force, as opposed to a linear cut from a sharp object. The laceration's significant length of 8 mm and its paracentral location implicated the visual axis, posing a direct threat to the final clarity of vision due to inevitable scarring. Through this wound, a chaotic admixture of internal ocular structures was prolapsing: the opacified, dislocated crystalline lens, proving it had been torn from its zonular moorings and catapulted forward; darkly pigmented uveal tissue, likely iris and ciliary body, indicating severe internal tearing; and translucent vitreous strands, confirming that the posterior segment's integrity was also breached. Compounding this structural collapse, the anterior chamber was not merely filled with blood, but with a dark, clotted "blackball" hyphema, a sign of massive hemorrhage from the highly vascularized ciliary body, which completely obscured any deeper view.

With the initial examination complete, the next step was to formally quantify the prognosis and complete the diagnostic picture with imaging. The Ocular Trauma Score (OTS) was calculated. This validated scoring system provides a statistical prediction of the final visual outcome based on initial clinical variables. The patient's initial visual acuity of Light Perception conferred a raw score of 60 points. However, the presence of a globe rupture—the most severe injury type—subtracted 23 points. With only these two factors applicable, the patient's raw score

was 37, placing them firmly in OTS Category 1. The statistical prognosis for this category is extraordinarily grim: a staggering 74% of patients in this category end up with a final visual outcome of No Light Perception (NLP)—complete and total blindness. This objective score underscored the monumental challenge ahead and framed the subsequent successful outcome as a significant triumph against overwhelming odds.

To peer beyond the opaque curtain of the blackball hyphema, B-scan ultrasonography was performed using a gentle, closed-eyelid technique. This was a critical step to assess the posterior segment. The scan provided invaluable information: the posterior globe contour was intact, meaning the scleral shell had not ruptured posteriorly. It confirmed the presence of vitreous hemorrhage, but, crucially, showed no evidence of a retinal detachment. It did, however, reveal an acute posterior vitreous detachment (PVD), a common finding after significant concussive force. Finally, orbital Computed Tomography (CT) with thin, 1 mm slices was performed. This confirmed the deformed anterior contour of the globe and the extruded lens, but its most vital role was to definitively rule out a retained intraocular foreign body (IOFB) or any associated orbital fractures, which would have necessitated a different and more complex surgical approach.

With a comprehensive diagnosis and a grim prognosis, the patient was taken for immediate surgical repair under general anesthesia. The philosophy guiding this primary intervention was not definitive visual rehabilitation, but meticulous damage control. The surgery began with the gentle insertion of a wire-lid speculum to achieve exposure. The prolapsed uveal tissue, though likely non-viable, was carefully repositioned into the globe to avoid excising tissue that could be crucial for forming a stable closure. The first and arguably most critical surgical maneuver was a thorough anterior vitrectomy. Using a high-speed (2500 cuts/min) automated vitrector introduced through the corneal wound, all vitreous strands were cleared from the anterior chamber and, most importantly, from the wound itself. Leaving

incarcerated vitreous is a cardinal sin in trauma repair, as it acts as a scaffold for fibrous ingrowth, leading to chronic inflammation, wound leaks, and devastating tractional forces on the retina.

Next, attention turned to the extruded and now-cataractous lens, which was removed in its entirety (lensectomy). This was followed by the meticulous evacuation of the organized "blackball" clot. This was achieved with a coaxial irrigation/aspiration (I/A) cannula, which gently flushed and aspirated the clotted blood. Throughout this process, a dispersive ophthalmic viscosurgical device (OVD) like Viscoat® was used to coat and protect the delicate corneal endothelium from the turbulence and instrumentation, preserving as much cellular integrity as possible for future visual clarity.

With the anterior chamber cleared, the final step of the primary repair was the anatomical closure of the cornea. The wound was painstakingly repaired with 16 interrupted 10-0 nylon sutures. This high number of sutures was necessary to re-approximate the gaping, irregular wound edges and create a watertight seal. Each suture was placed at approximately 90% stromal depth to ensure robust closure without perforating into the anterior chamber. Longer bites were taken peripherally to distribute tension across the wound, and all knots were carefully rotated and buried within the stroma to prevent them from causing irritation and acting as a nidus for infection. To conclude the surgery, a powerful combination of prophylactic medications was administered: intracameral Cefuroxime as a direct, intraocular antibiotic; and subconjunctival Dexamethasone and Ceftazidime to provide a depot of anti-inflammatory and antibiotic coverage in the critical immediate postoperative period.

The subsequent postoperative regimen was equally aggressive, involving hourly fortified Vancomycin and Tobramycin drops to prevent infection, a potent steroid (Prednisolone Acetate 1%) to control the severe inflammation, and a cycloplegic agent (Atropine 1%) to paralyze the ciliary muscle, reducing pain and preventing the formation of posterior synechiae.

Beginning three months after the initial repair, as the eye stabilized, corneal topography was used to guide the selective removal of sutures, a key strategy for managing the high degree of post-traumatic astigmatism and beginning the long journey toward visual rehabilitation.

Six months after the initial trauma, the eye was stable, quiescent, and free of inflammation. This crucial waiting period allowed the cornea to heal and its curvature to stabilize, making accurate biometric measurements for an IOL possible for the first time. The patient was now ready for the definitive rehabilitative step: secondary IOL implantation. Given the complete absence of the lens capsule and the significant iris damage, a standard IOL was not an option. The chosen procedure was the Yamane double-needle technique, a sophisticated method for scleral fixation of a posterior chamber IOL. A standard three-piece acrylic IOL was selected. The surgery involved creating two parallel scleral tunnels precisely 2 mm posterior to the limbus. The two flexible haptics of the IOL were then externalized through the sclera using 30-gauge thin-wall needles. The tips of the externalized haptics were then carefully cauterized to create small, mushroom-shaped flanges. These flanges were then tucked back into the scleral tunnels, providing an exceptionally stable and secure fixation without the need for any sutures, which can erode or degrade over time.

At the final one-year follow-up, the results of this meticulous, staged approach were clear. The patient's best-corrected visual acuity (BCVA) in the injured eye was 20/50. This outcome is nothing short of extraordinary when contrasted with the initial OTS prediction of a 74% likelihood of total blindness. The scleral-fixated IOL was perfectly stable and well-centered, and the cornea, despite the massive initial laceration, showed only a faint, well-healed scar that remained outside the central visual axis. With a modest spectacle correction, the patient was able to resume most of his daily activities, expressing profound satisfaction with an outcome that defied all initial expectations. This case stands as a powerful

testament to the principle that even in the face of the most catastrophic ocular trauma, a surgical strategy founded on the principles of immediate damage

control followed by patient, methodical rehabilitation can achieve a life-changing restoration of sight. The timeline of the case is detailed in Table 2.

Table 2. Timeline of Case from Initial Presentation to Final Follow-up
Tracking the patient's progress, interventions, and outcomes over one year.

Time Point	Clinical Findings / Intervention	Visual Acuity (OS)	IOP (OS)
Day 0 (Presentation)	Initial Injury: 8mm corneal rupture, lens extrusion, Grade IV hyphema. - Ocular Trauma Score (OTS) calculated as 1. Intervention: Emergency primary globe repair, lensectomy, & vitrectomy.	Light Perception	Deferred
Post-op Day 1	Formed globe, well-approximated wound, mild corneal edema, 1mm microhyphema.	Hand Motion	18 mmHg
Post-op Week 1	Cornea clearing, anterior chamber quiet, hyphema resolved.	Counting Fingers @ 1m	16 mmHg
Post-op Month 1	Quiet eye, intact sutures, patient aphakic. Corneal topography showed significant astigmatism.	20/400 (pinhole)	15 mmHg
Post-op Month 3	Selective suture removal initiated to manage astigmatism. Retina remained attached.	20/300 (pinhole)	14 mmHg
Post-op Month 6	Eye stable and quiescent. Corneal topography stabilized. Intervention: Secondary scleral-fixated IOL (Yamane technique).	-	-
Post-op Month 7	Stable, well-centered IOL. Mild post-operative corneal edema.	20/80 (pinhole)	16 mmHg
Post-op Year 1	FINAL OUTCOME: Clear cornea with faint scar, centered IOL. Healthy retina. Patient resumed most daily activities.	20/50 (BCVA)	15 mmHg

3. Discussion

The successful management of this catastrophic Zone I open globe injury, which resulted in a functional outcome vastly exceeding the predictions of the Ocular Trauma Score, is a testament to a management strategy deeply rooted in understanding the complex, integrated pathophysiology of the injury and adhering to the principles of staged, damage-control surgery.¹¹ The discussion will dissect the pathophysiological mechanisms, provide a detailed

rationale for the critical surgical decisions made, and contextualize this case within the existing literature.

The simultaneous presentation of a full-thickness corneal rupture, complete extrusion of the crystalline lens, and a total, or "blackball," hyphema is not a random collection of devastating injuries. Instead, it represents a direct and predictable, albeit catastrophic, biomechanical cascade of events, a violent domino effect initiated by a single, high-energy impact (Figure 1).¹² The blunt force delivered by the

projectile stone did not simply puncture the eye; it momentarily transformed the globe into a pressurized hydraulic system pushed far beyond its structural tolerances.¹³ Understanding this interconnected sequence is fundamental to appreciating the full extent of the damage and to formulating a surgical strategy that addresses not just the individual

injuries, but the complete failure of the ocular architecture. The following analysis dissects this cascade, from the initial shockwave to the final anatomical state, and elucidates the meticulous, staged surgical rationale required to salvage function from the brink of anatomical loss.¹⁴

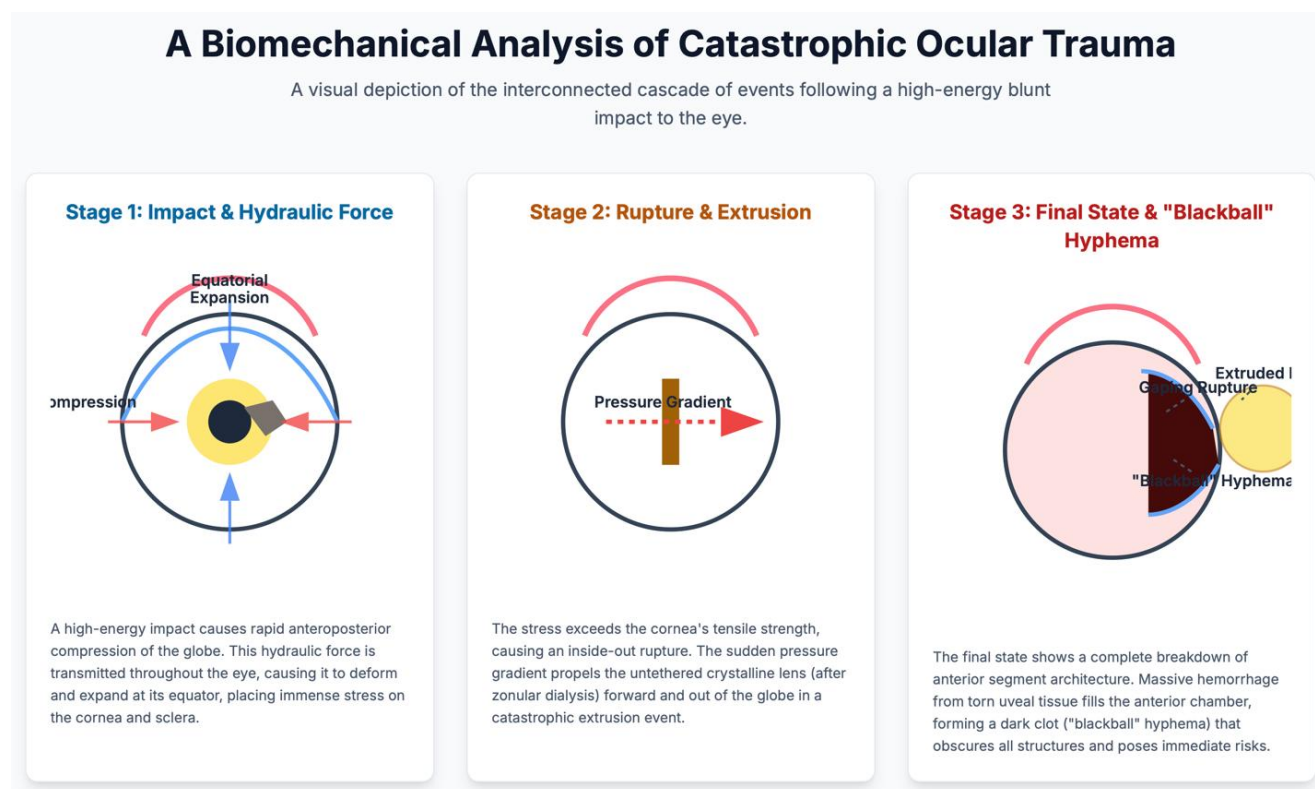


Figure 1. A biomechanical analysis of catastrophic ocular trauma.

The initial event in this cascade is the near-instantaneous transfer of kinetic energy from the stone to the globe. This triggers a classic coup-contrecoup phenomenon combined with a powerful hydraulic force transmission. As the stone strikes the cornea (the "coup"), it causes a rapid anteroposterior compression of the entire globe, flattening it along the visual axis. This compression forces the incompressible intraocular fluids—the aqueous and vitreous humor—to displace. According to Pascal's law, the immense pressure generated is transmitted equally and undiminished in all directions throughout

this closed fluid system.¹⁵

The globe, a resilient but ultimately finite viscoelastic sphere, is forced to deform. As it shortens along the anteroposterior axis, it must expand in its equatorial dimension. This equatorial stretching places an enormous amount of tensile stress on the collagenous lamellae that form the structural scaffolding of the cornea and sclera. The rupture, therefore, is not a simple tear from the outside in but rather an explosive failure from the inside out, occurring at the point where the biomechanical stress exceeds the tissue's tensile strength. While the limbus

is a common site for rupture due to the transition between the corneal and scleral curvatures, the paracentral cornea is also highly susceptible. It lacks the dense, highly interwoven, and reinforcing architecture of the limbus, making it a point of relative structural weakness. The resulting laceration, often presenting in a characteristic reverse 'C'-shape, is a physical signature of this internal bursting mechanism. This shape reflects the complex propagation patterns of shear stress forces radiating through the corneal stroma as the globe fails under the immense, hydraulically transmitted pressure.¹⁶

The very same compressive and equatorial expansion forces that lead to the corneal rupture are simultaneously transmitted directly to the delicate lens-zonule diaphragm. This structure, which suspends the crystalline lens in place, is subjected to an insurmountable shearing force as the globe violently expands. The delicate zonular fibers of Zinn, which tether the lens capsule to the ciliary body, are stretched beyond their breaking point. A complete, 360-degree rupture of these fibers, known as total zonular dialysis, occurs, resulting in a complete dislocation (luxation) of the crystalline lens from its anatomical position. The lens is now untethered, floating freely within the posterior segment.

In the instant the cornea ruptures, the globe is no longer a closed system. This breach creates a dramatic and immediate pressure gradient between the still-pressurized posterior segment and the zero-pressure extraocular environment. The compressed vitreous body, acting with the force of a hydraulic piston, surges forward, propelling the dislocated lens through the pupil, into the anterior chamber, and catastrophically, out through the gaping corneal wound. This event is more accurately termed extrusion, a phenomenon signifying a total and devastating breakdown of the anterior segment's architectural integrity. It is a far more severe injury than a simple anterior luxation, where the lens might dislocate into the anterior chamber but remain within the eye. Lens extrusion is a definitive marker of an injury of the highest magnitude, indicating that the

forces involved were sufficient to overwhelm all of the eye's internal structural barriers.¹⁷

The Grade IV, or "blackball," hyphema is the third component of this devastating triad, resulting from massive hemorrhage from the highly vascularized anterior uveal tissues. The same concussive shockwave and shearing forces from the impact cause widespread tearing and rupture of blood vessels within the iris and ciliary body. The primary source of such a massive bleed is typically the anterior face of the ciliary body and the major arterial circle of the iris, which contains relatively large-caliber vessels.¹⁸ Bleeding from these sources is notoriously profuse and can fill the entire anterior chamber with blood within minutes.

Once the anterior chamber is filled, the blood rapidly deoxygenates, turning from bright red to a dark, tar-like black, giving the "blackball" hyphema its name. This blood doesn't remain fluid; it quickly forms a dense, organized clot composed of fibrin and trapped red blood cells. This clot is not merely a passive occupant of the anterior chamber; it is an active pathological entity that poses several immediate and long-term threats to the eye's health and the surgeon's ability to repair the damage: (1) Mechanical obstruction and secondary glaucoma: the most immediate threat is a severe, acute rise in intraocular pressure (IOP). The dense, organized clot physically obstructs the trabecular meshwork, the eye's primary drainage structure, completely preventing the outflow of aqueous humor. This leads to a form of secondary glaucoma that can cause IOP to spike to dangerously high levels, potentially causing irreversible glaucomatous optic neuropathy and permanent vision loss within hours or days; (2) Surgical Obscuration: For the surgeon attempting the primary repair, the blackball hyphema creates an almost insurmountable obstacle. It completely blocks the view of any underlying structures, including the extent of iris damage, the status of the lens capsule (if any remnants exist), and the presence of vitreous in the anterior chamber. Performing a meticulous repair under these conditions is exceptionally challenging

and requires specialized techniques to carefully evacuate the clot without causing further damage; (3) Corneal Blood Staining: If the hyphema is left unresolved, hemoglobin from the red blood cells begins to break down into hemosiderin. These iron-containing pigment molecules can infiltrate the corneal stroma, migrating between the collagen lamellae. This results in a permanent, amber-colored opacification of the cornea known as corneal blood staining. This stain can take months or even years to clear, if ever, and can act as a significant secondary cause of profound vision loss, even after the primary injury has been repaired; (4) Potent Inflammatory Cascade: The presence of a large volume of blood in the anterior chamber is a powerful pro-inflammatory stimulus. It triggers the release of cytokines and other inflammatory mediators, attracting white blood cells and contributing significantly to the overall inflammatory burden in the traumatized eye. This intense inflammation can lead to the formation of pupillary membranes, synechiae (adhesions), and can complicate postoperative healing.

The successful management of such a multifaceted and catastrophic injury hinges on a disciplined surgical strategy predicated on a damage-control hierarchy.¹⁹ This philosophy, borrowed from general trauma surgery, prioritizes survival of the organ over definitive reconstruction in the acute phase. The goals are threefold and sequential: first, restore the anatomical integrity and watertight closure of the globe to prevent infection and further tissue loss; second, remove all sources of future inflammation and all scaffolds for fibrosis (namely, the ruptured lens and incarcerated vitreous); and only then, after a period of healing and stabilization, plan for long-term visual rehabilitation in a controlled, quiescent environment.

In this context, the decision to defer intraocular lens (IOL) implantation was the single most critical strategic choice. Attempting to place an IOL during the primary repair of such a severely contaminated and inflamed eye would have been fraught with an unacceptable constellation of risks. The arguments against primary IOL implantation in this setting are

overwhelming and based on fundamental principles of surgical safety: (1) Prohibitive Risk of Endophthalmitis: The nature of the injury—a high-velocity stone, likely contaminated with soil and organic matter—carries a high risk of bacterial or fungal inoculation. An IOL, being a foreign body, can act as a perfect nidus for microbial adhesion and biofilm formation, significantly increasing the risk of a devastating, sight-ending postoperative endophthalmitis; (2) Impossibility of Accurate Biometry: Accurate IOL power calculation is the cornerstone of modern cataract surgery, but it is utterly impossible in the setting of an open globe. The key measurements—axial length (impossible in a hypotonous, collapsed globe) and keratometry (meaningless with a gaping, edematous corneal wound)—are completely unreliable. Any IOL placed would be a guess, inevitably leading to a massive postoperative refractive surprise (a very high degree of near- or far-sightedness), negating the entire purpose of the lens; (3) Exacerbation of Post-Traumatic Inflammation: Every IOL incites a low-grade foreign body inflammatory response. Placing this foreign body into an eye already experiencing a maximal inflammatory cascade from the trauma and hyphema would be like adding fuel to a fire. This would dramatically increase the risk of severe postoperative inflammation, leading to the formation of dense pupillary membranes and intractable cystoid macular edema (Irvine-Gass syndrome); (4) Uncertain Final Anatomy: In a traumatized eye with a shredded iris, torn ciliary body, and no capsular support, the surgeon cannot predict the final anatomical position of the globe's internal structures after healing. An IOL placed acutely would have no stable support and would likely dislocate, requiring further surgery.

By adopting a staged approach, we allowed the eye to heal, the intense inflammation to resolve completely, the corneal wound to stabilize and develop a predictable curvature, and the globe to regain its normal dimensions. Only then could accurate biometric data be obtained. The secondary IOL could subsequently be placed in a quiescent, controlled

surgical environment, leading to a much more predictable, effective, and safer refractive outcome. This patient-first, safety-first approach is the undisputed cornerstone of modern ocular trauma management.²⁰

A thorough anterior vitrectomy is arguably one of the most important steps in any open globe injury repair. Vitreous that becomes incarcerated in the corneal wound acts as a scaffold for fibrous tissue ingrowth. This can lead to a cascade of devastating long-term complications, including chronic, smoldering inflammation, persistent wound leak, epithelial ingrowth into the eye, and the development of tractional forces that can distort the pupil, cause secondary glaucoma, and lead to tractional retinal detachment. The complete and unequivocal removal of all vitreous from the anterior chamber and the wound is therefore non-negotiable for long-term success.^{17,18}

Similarly, the decision for a complete lensectomy was unequivocal. The extruded lens was non-viable, and its ruptured capsule would have allowed lens proteins, which are normally sequestered from the body's immune system (a state known as "immune privilege"), to be exposed. This exposure can trigger a severe, delayed, granulomatous inflammatory reaction known as phacoanaphylactic uveitis, an autoimmune response where the body attacks its own lens proteins, which can lead to the chronic and irreversible destruction of the eye. By removing the lens and vitreous remnants entirely during the primary surgery, we eliminated the primary drivers of long-term postoperative inflammation and the biological scaffolds for fibrosis and failure.

Repairing a large, irregular corneal laceration invariably induces a high degree of postoperative astigmatism. Our strategy of using 16 precisely placed, interrupted 10-0 nylon sutures provided maximal control over wound apposition and subsequent healing. Unlike a single running suture, this technique allows for the selective removal of individual sutures postoperatively. Guided by serial corneal topography, which maps the curvature of the cornea, we were able to identify and remove the

"tightest" sutures—those inducing the most distortion. This allowed the cornea to relax along that specific meridian, gradually and controllably reducing the astigmatism from over 8 diopters initially to a manageable 2.5 diopters in the final spectacle refraction. This active and patient management of the corneal curvature was a key element in achieving high-quality vision.

Finally, six months after the primary repair, the eye was stable, quiet, and aphakic, but with significant iris damage and a complete absence of capsular support. This precluded the implantation of a standard in-the-bag IOL. Of the available options, scleral fixation was the clear choice. We selected the innovative Yamane double-needle, flanged IOL technique. This approach provides exceptional IOL stability by securing the lens haptics within carefully created intrascleral tunnels, avoiding the need for large scleral flaps or sutures that can erode over time. This minimally invasive yet technically demanding technique was ideal for achieving a stable, perfectly centered IOL, which was the final, critical piece in a long and complex puzzle of visual rehabilitation.^{19,20}

It is imperative to acknowledge the methodological limitations inherent in a single case report. The primary limitation is the inability to generalize the findings. The successful outcome in this patient cannot be extrapolated to all patients with similar injuries, as individual healing responses and other comorbidities play a significant role. Furthermore, this report describes an association between the staged surgical approach and a good outcome; it cannot establish causality. The absence of a control group prevents any definitive conclusions about the superiority of this specific management strategy over others. However, the purpose of this report is not to establish a new standard of care but to provide a detailed, transparent account of the successful application of established principles in an exceptionally severe case, thereby reinforcing their validity and contributing a valuable data point to the clinical literature.

4. Conclusion

This case of a catastrophic, multi-component open globe injury, with an initial Ocular Trauma Score predicting a minimal chance of functional vision, demonstrates that a favorable outcome is achievable through a systematic, principled, and patient surgical approach. Rapid diagnosis, meticulous primary repair focused on anatomical restoration, and the strategic deferral of intraocular lens implantation were instrumental in navigating the high-risk postoperative period and preventing devastating complications. The subsequent management of astigmatism and the choice of the Yamane technique for secondary IOL fixation were key to the final visual rehabilitation. This case serves as a powerful reminder that even in the face of the most severe ocular trauma, a staged, methodical approach that prioritizes safety and anatomical integrity above all else can overcome a grim prognosis and restore valuable, life-changing vision.

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