Post-Traumatic Glaucoma

20

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Ocular trauma (both open globe and closed globe injury) is an important cause of secondary glaucoma that can manifest immediately or months to decades later. In open globe injuries, glaucoma can result from direct damage to angle structures, disruption of lens capsule, or from the reparative processes. On the other hand, closed globe injuries could have multiple mechanisms operating. The seven rings of trauma associated with blunt trauma are (1) sphincter tears, (2) iridodialysis, (3) trabecular meshwork (TM) tears, (4) angle recession, (5) cyclodialysis, (6) zonular dialysis, and (7) retinal dialysis. Advancing age, poor initial visual acuity, elevated baseline IOP, hyphema, lens injury, increased angle pigmentation, angle recession >180°, and a wider angle on ultrasound biomicroscopy (UBM) have been identified as early predictors of glaucoma following closed globe injury. The diverse mechanisms that could contribute to post-traumatic secondary glaucoma have been summarized in Fig. 20.1.

Inflammation associated with ocular trauma can manifest high intraocular pressure (IOP) by various ways. Trabeculitis and/or inflammatory clogging of TM remains the primary pathology in open-angle mechanism, while formation of posterior synechiae and peripheral anterior synechiae (PAS) contributes toward development of angle-closure glaucoma.

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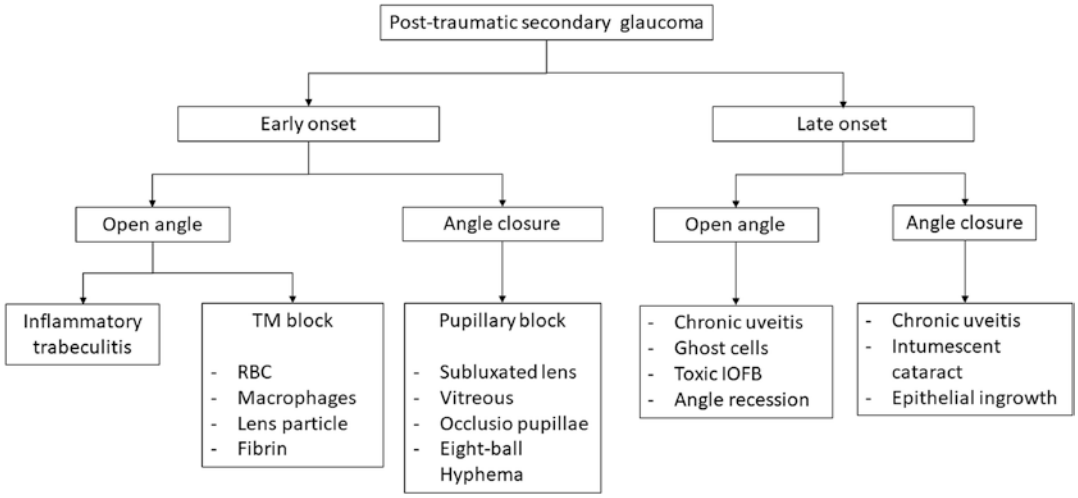

Fig. 20.1 Mechanisms of post-traumatic secondary glaucoma. *IOFB* intraocular foreign body, *TM* trabecular meshwork, *RBC* red blood cells

20.1 Case Examples

Case 20.1

A 16-year-old boy was brought to the casualty with complaints of sudden painful loss of vision and redness following trauma to the left eye by a cricket ball 3 hours ago. There was no history of any vomiting, loss of consciousness, or ear-nose-throat bleed.

Examination: Best-corrected visual acuity (BCVA) was 6/6 in right eye (RE) and perception of light with accurate projection of rays in left eye (LE). The LE upper lid showed ecchymosis, but on palpation, the orbital rim appeared intact with no subcutaneous emphysema or periorbital anesthesia. Ocular motility was full and free. The LE showed subconjunctival hemorrhage, clear cornea, and total hyphema (grade 4) (Fig. 20.2); RE examination was under normal limits, with a brisk direct and consensual pupillary reflex. Applanation IOP was 14 mmHg in RE and 40 mmHg in LE.

Investigations: (1) LE Ultrasound (USG) B scan showed echoes in the posterior segment suggestive of vitreous hemorrhage; retina was attached (2) X-ray face and orbit – no fractures were detected.

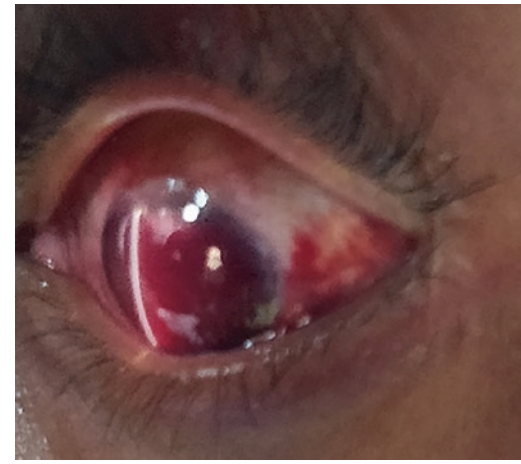

Fig. 20.2 Left eye of the patient showing subconjunctival hemorrhage and total hyphema

Diagnosis: LE total hyphema secondary to closed globe injury with secondary post-traumatic glaucoma

Differential diagnosis: Sudden hyphema in children without history of preceding trauma should raise the suspicion of the following:

- Retinoblastoma: A mass with calcification in the retina, with/without a positive family history is diagnostic.

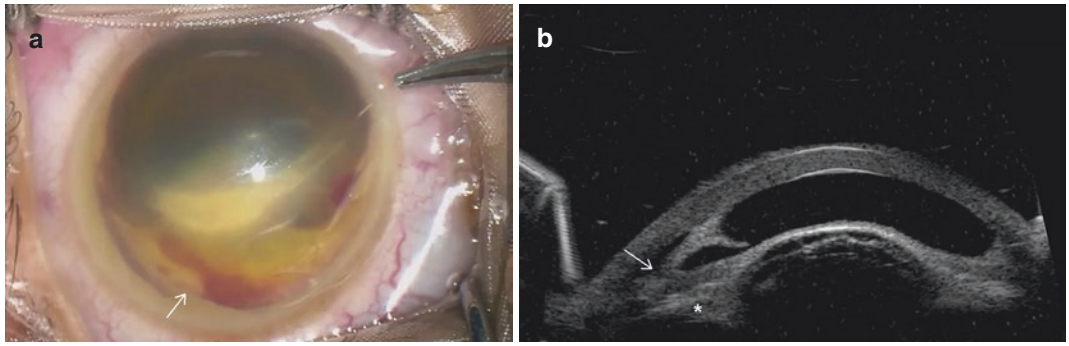

Fig. 20.3 A case of Juvenile Xanthogranuloma. (**a**) Intra-operative photograph showing a dense layered-hyphema at different stages due to recurrent hemorrhage (white arrow) (**b**) Ultrasound biomicroscopy showing dense inferior membranes in the angle (white arrow) and behind the iris (*) due to hemorrhage and mass lesion, causing secondary angle closure

- Juvenile xanthogranuloma (Fig. 20.3): A mass may or may not be detectable on clinical examination. UBM scan can identify a lesion in the iris.
- Systemic bleeding disorders: A full blood count, peripheral blood smear, and entire bleeding and clotting profile can identify inborn or acquired hematological disorders.
- Shaken baby syndrome: A discordant history and multiple tri-layered retinal hemorrhages could be a diagnostic feature.

Treatment

- Immediate treatment: Propped-up position. Intravenous mannitol 20% 1 g/kg and oral acetazolamide 500 mg stat dose, fixed-dose combination of brimonidine 0.2% + timolol maleate 0.5%BD, dexamethasone QDS, and homatropine 2% TDS.
- Definitive treatment: Anterior chamber (AC) washout followed by close monitoring for incidence of rebleeds and IOP status is required. If the IOP remains uncontrolled even after a thorough AC wash, an urgent trabeculectomy with mitomycin C (MMC) is warranted.

In young children with post-traumatic total hyphema and high IOP where serial monitoring would require examination under anesthesia each time, an anterior chamber irrigation aspiration along with trabeculectomy can be considered in the same sitting.

Other Examples: Figs. 20.4, 20.5

Learning Points

- Post-traumatic hyphema usually results from tearing of the major arterial circle vessels present at the iris base.
- Hyphema is graded as microscopic (suspended red blood cells), grade 1 (<1/3 of AC), grade 2 (1/3–1/2 AC), grade 3 (1/2–near total), and grade 4 (total/eight-ball hyphema).
- Indications for surgical intervention include:
  - IOP > 60 mmHg for 2 days, > 50 mmHg for 5 days, > 35 mmHg for 7 days, or near-total/total hyphema with IOP > 25 mmHg for 5 days
  - Failure of hyphema to resolve to <50% of anterior chamber volume by 8 days
  - Sickle cell disease/trait and mean IOP > 24 mmHg for ≥24 hours or IOP spikes repeatedly >30 mmHg
  - Preexisting glaucomatous optic neuropathy and unacceptable IOP
  - Corneal blood staining
- Rebleeding can occur in up to one-third of patients, frequently 2–5 days after injury.

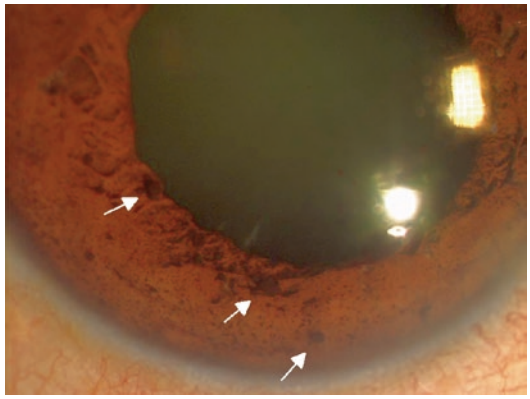

Fig. 20.4 Slit-lamp photograph of a post-traumatic eye with organizing hyphema showing blood clots on the iris surface (white arrows)

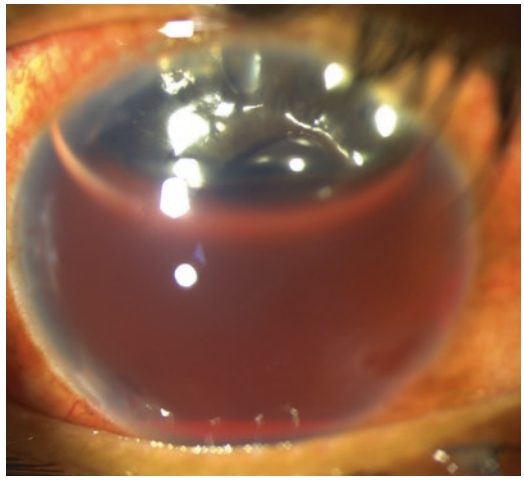

Fig. 20.5 Slit-lamp photograph of a case of iatrogenic hyphema following gonioscopy assisted transluminal trabeculotomy (GATT) procedure for pediatric glaucoma, creating a risk of secondary glaucoma. An anterior chamber wash out was performed

- The development and severity of glaucoma depend upon the amount of hyphema. About 10% of eyes with ≤50% hyphema develop glaucoma, while 25% with >50% hyphema do so. Total and eight-ball hyphema carry a risk of 50% and 100% of glaucoma development, respectively. Hence, it is advisable to perform simultaneous trabeculectomy at the time of hyphema drainage in the latter situation.

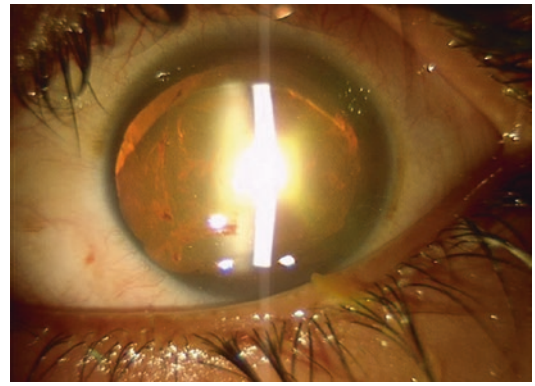

Fig. 20.6 Slit-lamp photograph showing an anteroinferiorly subluxated cataractous lens

Case 20.2

A 15-year-old boy presented with complaints of pain and progressive worsening of vision in his RE over the past 10 days, following injury to the eye by fist.

Examination: Unaided visual acuity (VA) RE 3/60; LE 6/6. Pupillary reflexes were normal both eyes (BE). On examination, RE had a clear cornea with irregular AC depth (deep superiorly, shallow inferiorly), cells 0.5+, no flare, sphincter tears+, and cataractous lens showing phacodonesis. The LE was within normal limits. Applanation IOP was 34 mmHg in RE and 14 mmHg in LE. Gonioscopy showed 180° angle recession in RE. On dilated examination, the RE cataractous lens was anteroinferiorly displaced with visible 180° zonular loss superiorly (Fig. 20.6). Indirect ophthalmoscopy examination did not show any retinal breaks or detachments, cup-disc ratio (CDR) was 0.3:1. Repeat applanation IOP after dilation showed RE 26 mmHg and LE 12 mmHg.

Investigations: (1) BE axial length, keratometry, and automated biometry (2) RE UBM to assess the true extent of zonular deficiency.

Diagnosis: RE post-traumatic subluxated cataractous lens with secondary angle-closure glaucoma.

Differential diagnosis:

- Microspherophakia: Small globular lenses with lax zonules can result in pupillary capture or

complete anterior dislocation leading to glaucoma. They could be an isolated ocular defect or be a part of Weil-Marchesani syndrome.
- Systemic syndromes with zonular weakness: Marfan syndrome, homocystinuria, hyperlysinemia, sulfite oxidase deficiency, etc. The subluxation in Marfan syndrome is typically superotemporal, while in homocystinuria, it is usually infero-nasal.

Treatment:

- Interim management: Rest in supine position. RE atropine 1% TDS and fixed dose combination of brimonidine 0.2% + timolol maleate 0.5% BD.
- Definitive management: RE lens aspiration aided with capsular support ring systems/Cionni ring fixation + posterior chamber intraocular lens (PCIOL) +/− anterior vitrectomy.

Other Examples (Figs. 20.7, 20.8, 20.9, 20.10, 20.11, 20.12, 20.13, and 20.14)

Learning Points
- Secondary angle closure glaucoma caused due to anterior lens displacement and subsequent pupillary block is a type of "inverse glaucoma" that improves with mydriatic cycloplegics (due to posterior displacement of the lens), in contrast to primary angle-closure disease. It causes phacotopic type of glaucoma.
- "Reverse pupillary block" is another mechanism observed in cases of pigment dispersion syndrome. In this scenario, due to a one-way valve effect at the plane of iris and lens, the communication of aqueous between the anterior and posterior chamber is blocked, leading to a relatively higher pressure in the anterior chamber and subsequent backward bowing of the peripheral iris. This effect can be relieved by creation of a peripheral iridotomy.
- The selection of capsular stabilization technique for displaced cataractous lenses, though is surgeon skill based, can be summarized depending upon the extent of zonular weakness:
  - 1 clock hour: Multipiece IOL haptic alignment ± capsular tension ring (CTR)
  - 1–3 clock hours: CTR
  - 4–6 clock hours: Single eyelet Cionni ring fixation
  - 7–9 clock hours: Bi-point fixation with double eyelet Cionni ring/CTR + capsular tension segment (CTS) or lensectomy with IOL (anterior chamber/iris claw/scleral-fixated intraocular lens). In eyes with pre-

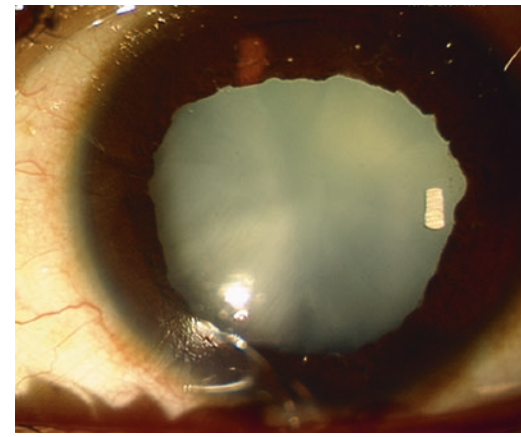

Fig. 20.7 Slit-lamp photograph of an eye with angle recession glaucoma showing additional signs of trauma such as post-traumatic cataract, traumatic mydriasis and multiple sphincter tears

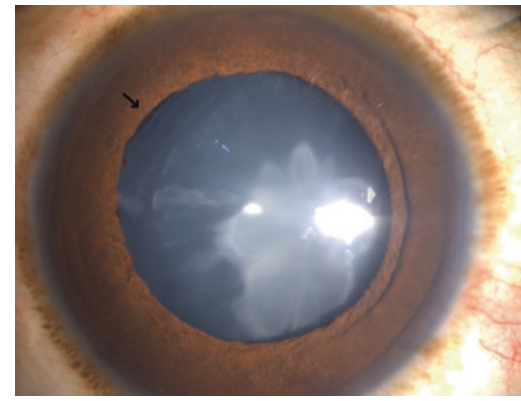

Fig. 20.8 Slit-lamp photograph of an eye showing post-traumatic rosette cataract with nasal subluxation. The black arrow indicates the region of zonular deficiency (2–3 clock hours)

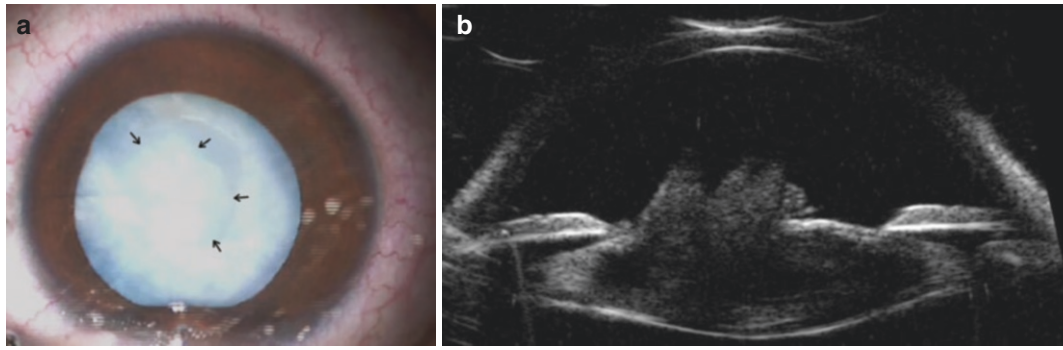

Fig. 20.9 (**a**) Photograph of an eye with post-blunt trauma white cataract with anterior capsular rupture and prolapsed lens matter into the anterior chamber (black arrows) causing secondary inflammatory glaucoma. (**b**) UBM examination of the eye delineated the extent of anterior capsular breach and confirmed the presence of an intact posterior capsule and taut zonules

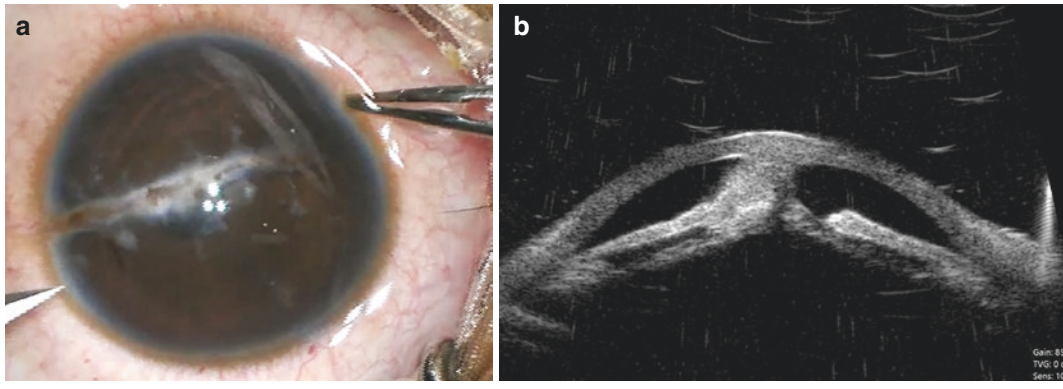

Fig. 20.10 (**a**) Intra-operative photograph showing an eye with healed repaired corneal laceration, non-dilating irregular pupil and an underlying traumatic cataract. (**b**) UBM of the eye showed a partially absorbed cataractous lens with formation of lenticulo-irido-corneal adhesions, causing secondary angle closure glaucoma

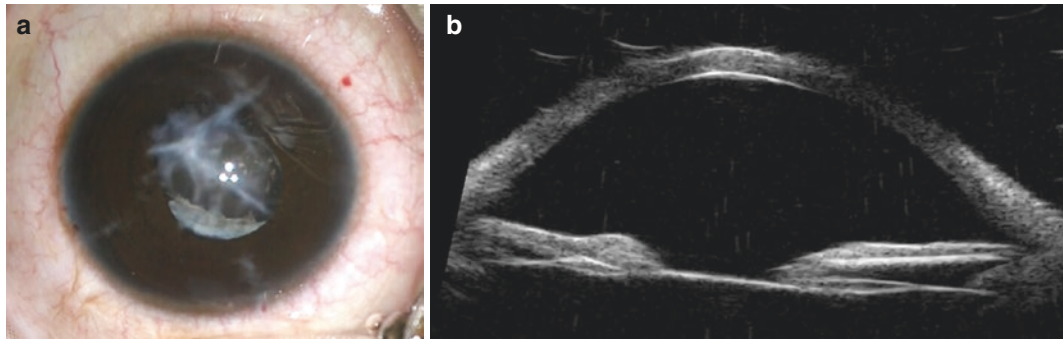

Fig. 20.11 (**a**) Intra-operative photograph showing a healed repaired tri-radiate corneal laceration, posterior synechiae, and a cataract. (**b**) UBM of the eye revealed a post-traumatic membranous cataract

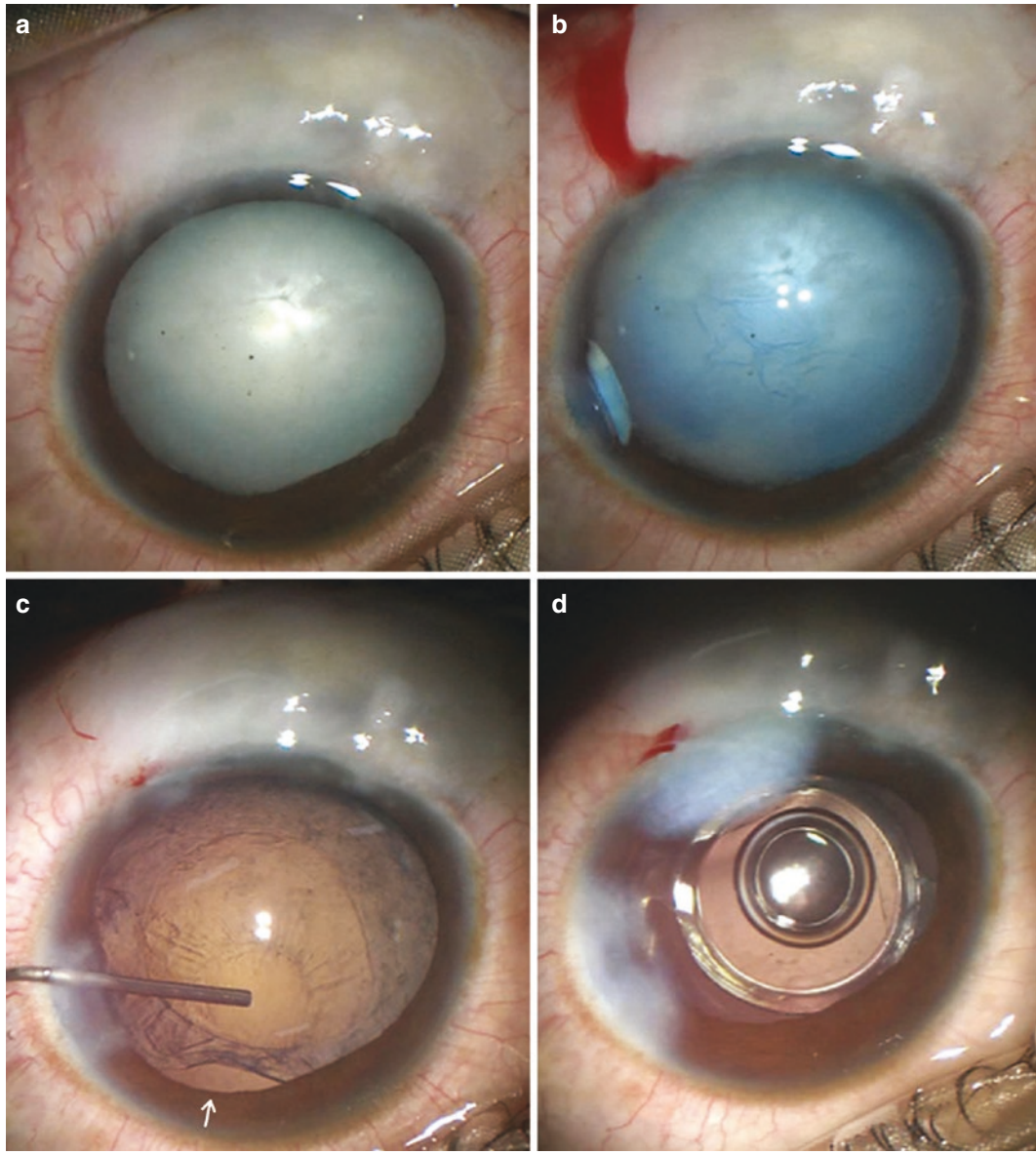

Fig. 20.12 (**a**) Post-traumatic white cataract in an eye with pre-existing trabeculectomy bleb. (**b**) Intraoperative trypan blue staining highlighted wrinkling of anterior capsule. (**c**) Two clock hours inferior subluxation was identified (white arrow). Posterior capsule also showed prominent wrinkling inferiorly. (**d**) The eye was successfully managed with a capsular tension ring and posterior chamber IOL

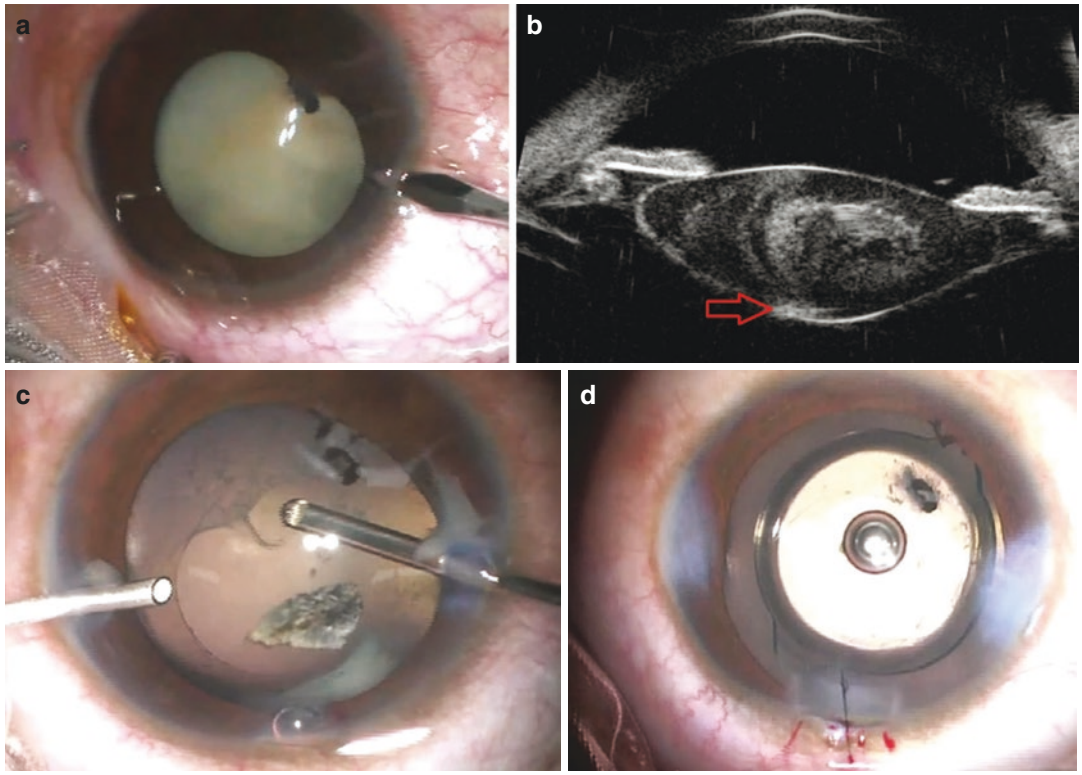

Fig. 20.13 (**a**) Post-traumatic white cataract and high intraocular pressures following an open globe injury. (**b**) UBM showed a hyperechoic structure near the posterior capsule (red arrow). (**c**) Following removal of the cataract, a retained metallic intraocular foreign body was identified. (**d**) The foreign body was removed using forceps, and a posterior chamber intraocular lens was inserted

existing bleb, avoid placing the Cionni suture fixation in the area of bleb.
  - > 9 clock hours: Pars plana lensectomy or intracapsular cataract extraction with anterior chamber/iris claw/scleral-fixated intraocular lens.
- Post-traumatic cataractous lenses with capsular disruption can result in inflammatory glaucoma or lens particle glaucoma.
- Most lens-induced glaucomas can be readily treated with lens extraction ± anterior vitrectomy, which tends to clear the pupillary block, relieve angle closure, and resolve the inflammation, thereby lowering the IOP. However, if the disease had been long-standing, TM damage could occur, necessitating a combined/sequential cataract + glaucoma surgery.

Case 20.3

A 17-year-old girl presented with complaints of dull eye pain and redness in RE for 1 year. There was a history of blunt trauma (shuttle cork injury) to the eye a year back, which was managed conservatively.

Examination: BCVA RE 6/12, LE 6/6. Applanation IOP: RE 44 mmHg and LE 16 mmHg. The RE showed mild corneal edema, a very deep AC as compared to the fellow eye, traumatic mydriasis, and a clear lens; the LE was within normal limits. On gonioscopy, RE showed irregular widening of the ciliary body band (CBB) (angle recession) over 6 clock hours, while the LE showed a normal open angle up to CBB all over (Fig. 20.15). Dilated fundus

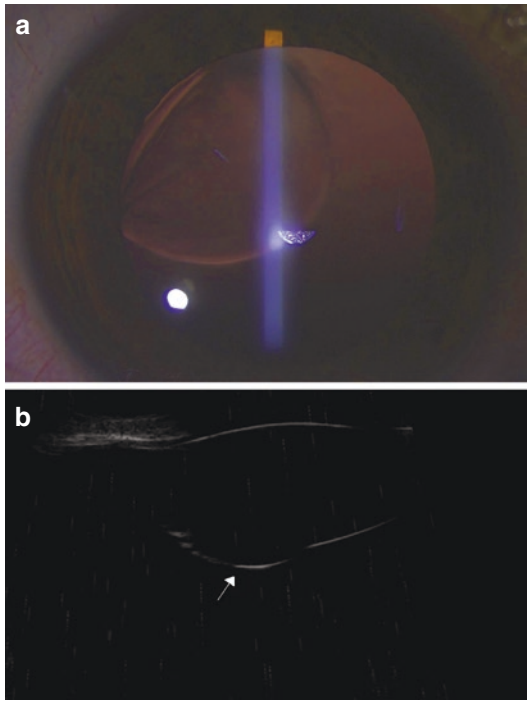

Fig. 20.14 (**a**) Slit-lamp photograph shows a post-traumatic posterior lenticonus with high pressures (**b**) UBM image confirms focal outpouching of the posterior lens capsule (white arrow) (Reproduced with permission from Desai A, Yadav MA, Gupta V, Gupta S. Wavefront analysis to diagnose blunt trauma-induced Weigert ligament dialysis: Isolated peripheral posterior lenticonus. J Cataract Refract Surg. 2018 Nov;44(11):1390–1393. doi: 10.1016/j.jcrs.2018.06.058)

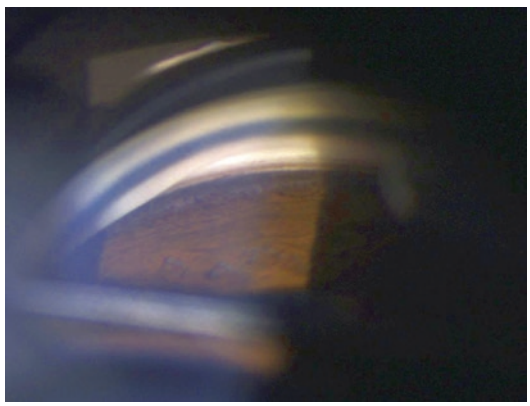

Fig. 20.15 Goniophotograph of right eye showing irregular widening of the CBB suggestive of angle recession

examination showed a CDR of 0.9:1 in RE and 0.3:1 in the LE; peripheral retina was normal BE.

Investigations: Humphrey visual field 30–2 SS of RE – arcuate scotoma

Diagnosis: RE post-traumatic angle recession glaucoma

Differential diagnosis:

- Pigmentary glaucoma: A densely pigmented angle could be confused with widened ciliary body band. The presence of Krukenberg spindle, concave iris configuration, and symmetry between the eyes may aid in differentiation.
- Uveitic glaucoma: Chronic inflammation may result in irregularly dense trabecular pigmentations that could be mistaken for angle recession. Keratic precipitates, AC cells and flare, posterior synechiae, and retrolental cells may aid in diagnosis. Unilateral, subtle uveitis with episodes of very high IOP can point to Posner-Schlossman syndrome.
- Steroid-induced glaucoma: History of topical steroid drops or ointments, periocular/intravitreal injections, nasal sprays, skin creams, and oral steroids should be elicited. A positive history along with a physiologically wide CBB could be a close mimic. Sometimes, a steroid response could exacerbate the severity of other glaucomas.
- Juvenile open-angle glaucoma (JOAG): Unilateral JOAG could be a differential diagnosis as nearly one-fourth may present with unilateral disease. A positive family history and careful gonioscopy will help in exclusion of the disease. Secondary glaucomas are more likely unilateral and should be ruled out before labeling it a case of primary glaucoma.

Treatment: Intravenous mannitol 20% 1 g/kg stat dose, oral acetazolamide 250 mg TDS, topical latanoprost HS, and fixed-dose combination of brimonidine 0.2% + timolol maleate 0.5% BD followed by listing for early trabeculectomy with mitomycin C RE if IOP remains uncontrolled.

Learning Points

- Comparison of gonioscopy findings with the fellow eye is important to identify abnormal and/or irregular broadening of the CBB, indicative of angle recession. Sometimes, a wide CBB may be physiological in both eyes.
- Angle recession can be seen in nearly 8% of eyes without glaucoma and 35% of eyes with glaucoma.
- The greater the extent of angle recession, the higher is the likelihood of glaucoma. 4–9% of patients with angle recession >180° can develop chronic glaucoma and therefore need long-term monitoring.
- More than 70% of eyes with traumatic hyphema may have angle recession. Gonioscopy is usually advised at least 2–6 weeks after injury when ocular inflammation/hyphema has resolved and pain has minimized.

Case 20.4

A 17-year-old boy presented with complaints of sudden blurring of vision in RE following a close-range firecracker injury.

Examination: Unaided VA of RE was 6/60, improving with pinhole to 6/18; LE 6/6. Goldmann IOP: RE 6 mmHg and LE 16 mmHg. Examination of RE showed Bowman corneal folds, normal AC depth, cells 0.5+ flare 1+, superotemporal iridodialysis, a D-shaped pupil, and a cataractous lens (Fig. 20.16). There was no phacodonesis. A gentle indirect gonioscopy

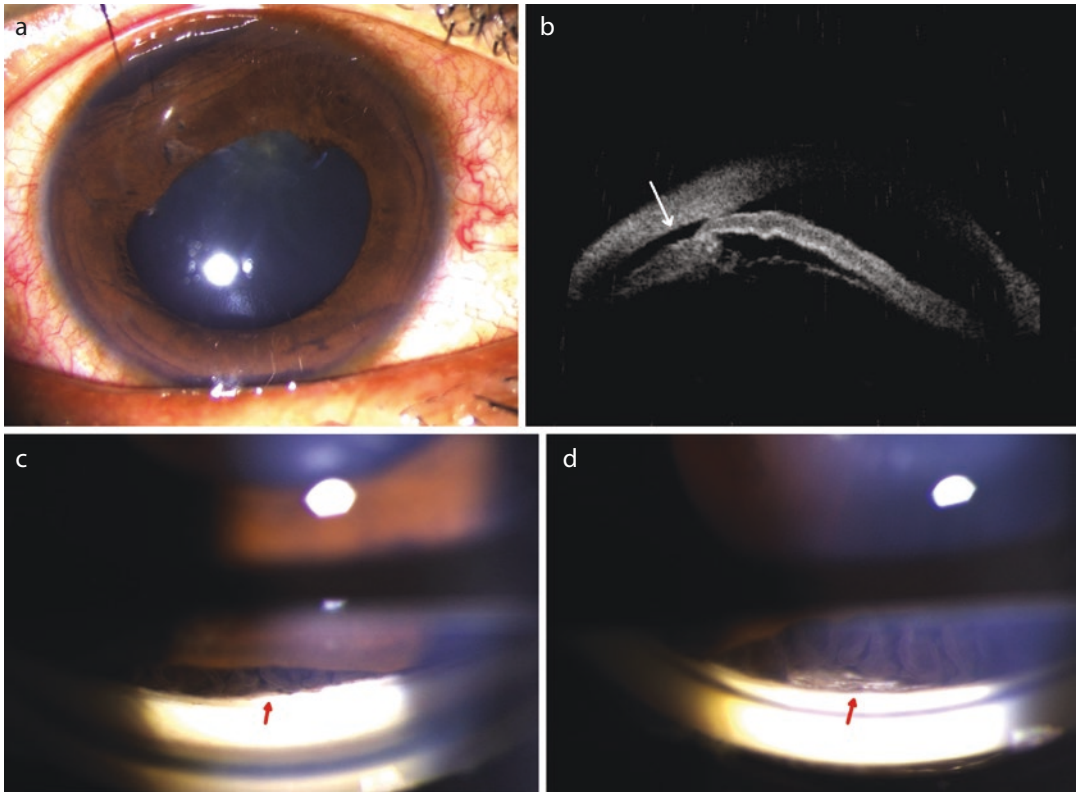

Fig. 20.16 (**a**) Clinical photograph showing superotemporal iridodialysis, D-shaped pupil, and cataractous lens (**b**) Ultrasound biomicroscopy (50 MHz, 85 dB) revealing cyclodialysis behind an intact iris (white arrow) that was undetectable clinically (**c**) Indirect gonioscopy in primary gaze showing an area of suspicious cleft (red arrow) (**d**) Dynamic gonioscopy opening up the maximum dimensions of the cleft like a rising crescent (red arrow) (Reproduced with permission from Gupta S, Selvan H, Agrawal S, Gupta V. Dynamic gonioscopy and ultrasound biomicroscopy for diagnosis of latent or low-lying cyclodialysis clefts. Clin Exp Ophthalmol. 2018; 46(8):960–962)

of RE showed a suspicious cleft in the superior quadrant. Dynamic gonioscopy opened the cleft spanning over 2 clock hours, and also identified an adjacent latent cleft of 2 more clock hours. Fundus examination showed a blurred disc margin with CDR 0.2:1, hypotonic maculopathy, and peripheral shallow choroidal detachments. LE examination was within normal limits.

Investigations: (1) Circumferential swept-source anterior segment OCT (SS-ASOCT) – Superior cyclodialysis cleft spanning over 5 clock hours. The apparently attached area between the two clinically identified clefts also had ciliary body detachment behind the intact iris, communicating on either sides (2) circumferential ultrasound biomicroscopy (UBM): findings same as SS-ASOCT. Additionally, shallow choroidal detachments were noted. (3) BE axial length (noncontact technique), keratometry, and biometry.

Diagnosis: RE post-traumatic cataract with iridodialysis and cyclodialysis

Differential diagnosis:

- Posterior scleral rupture: Post-traumatic hypotonic eyes without any identifiable cause could harbor a posterior globe rupture. A gentle USG B scan can clinch the diagnosis.
- Ciliary body shutdown: A severely injured eye with chronic inflammation may develop cyclitic membranes, resulting in hypotony and subsequent atrophic bulbi.
- **Treatment:** RE lens aspiration with IOL in bag + modified sewing machine endocyclopexy + stroke and dock iris repair.

Other Examples (Figs. 20.17 and 20.18)

Learning Points

- A cyclodialysis cleft should be looked for in an eye with chronic post-traumatic hypotony without other identifiable causes.
- Identifying the exact location, full extent and maximum dimensions of cyclodialysis clefts are crucial in planning their management.
- The surgical options for cleft repair include exocyclopexy, exocyclotamponade, endocyclopexy, and endocyclotamponade. The ab interno techniques are easier to perform, efficacious, and safer when compared to *ab externo* methods.
- Modified sewing machine technique of endocyclopexy can be performed in cases of coexisting posterior capsular rupture or zonular dialysis.
- In view of the transient hyperopic shift, IOL power calculation in hypotonic eyes is better based on their pre-injury measurements or the fellow eye biometry (if symmetric) to avoid postoperative refractive surprises.

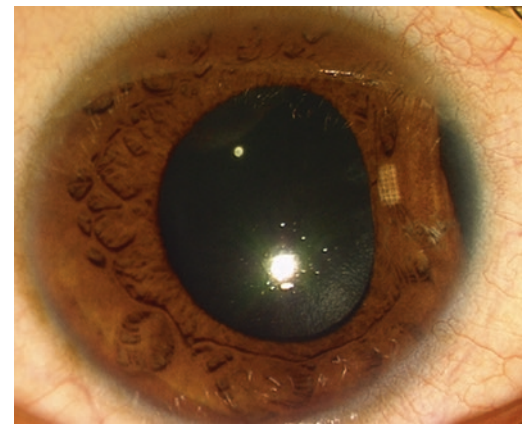

Fig. 20.17 Slit-lamp photograph of a case of isolated iridodialysis post blunt trauma

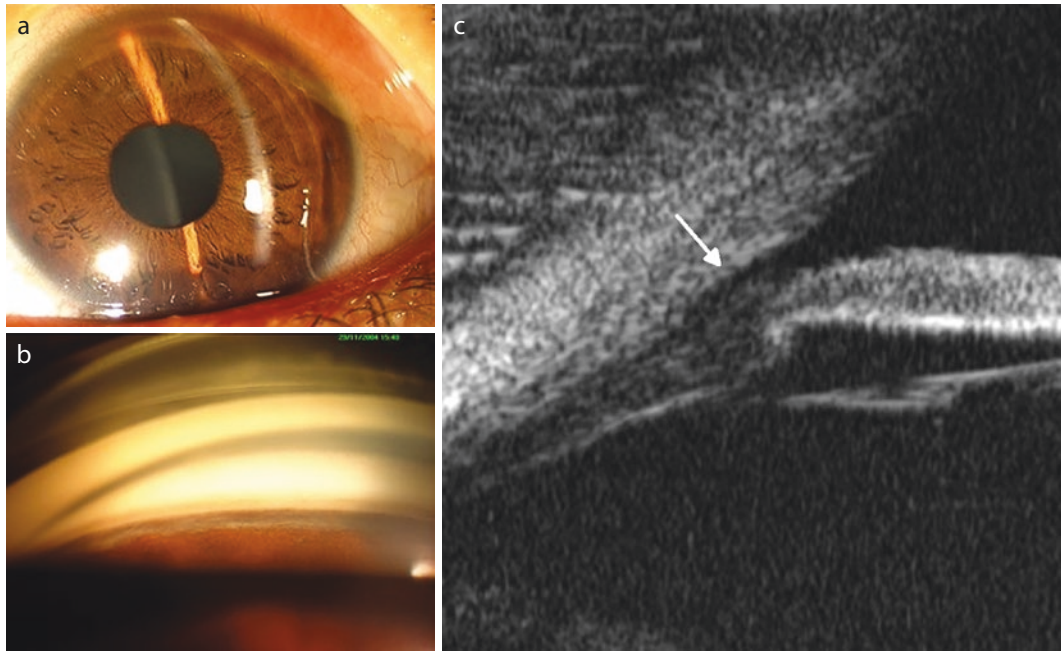

Fig. 20.18 A case of isolated cyclodialysis: (**a**) Slit-lamp photograph of anterior segment. (**b**) Goniophotograph showing the cleft (**c**) UBM image showing disinsertion of ciliary body from the scleral spur (white arrow)

20.2 Management Strategies (Figs. 20.19 and 20.20)

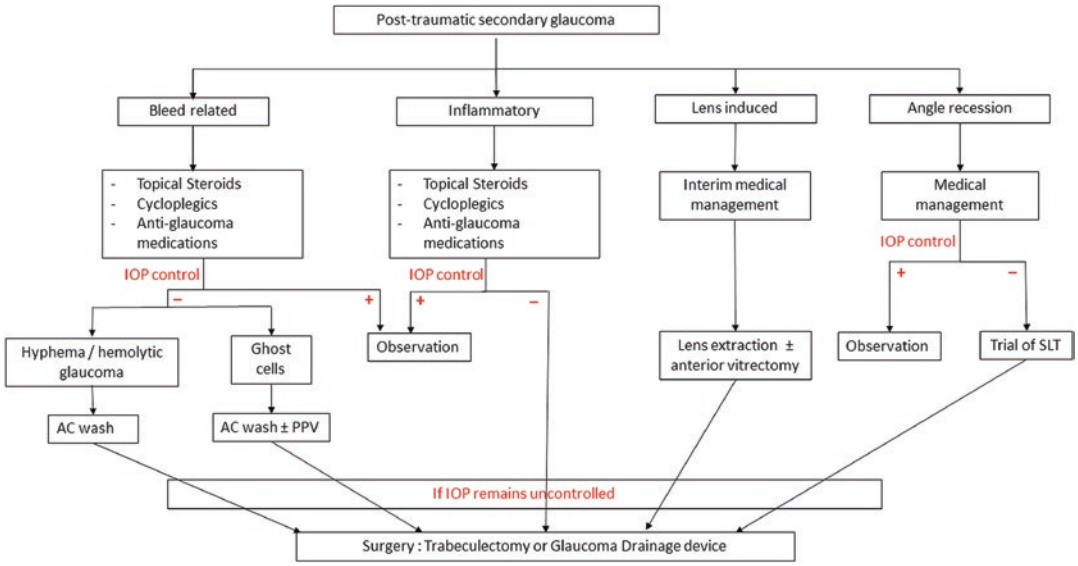

Fig. 20.19 Management strategies for post-traumatic glaucoma. *AC* anterior chamber, *IOP* intraocular pressure, *PPV* pars plana vitrectomy, *SLT* selective laser trabeculoplasty. + IOP controlled, - IOP uncontrolled

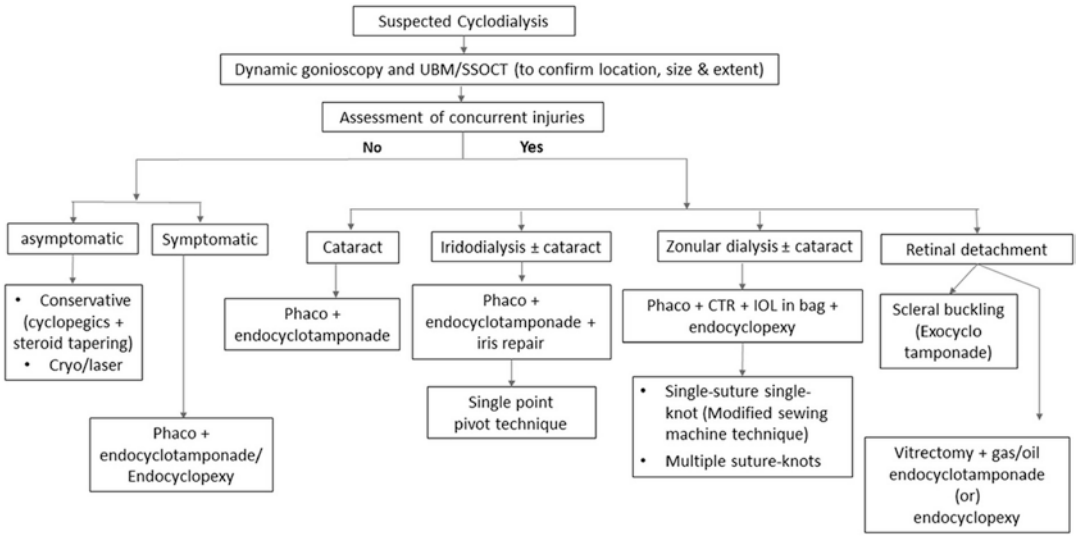

Fig. 20.20 Generalized management algorithm for cyclodialysis clefts. *CTR* capsular tension ring, *IOL* intraocular lens, *Cryo* Cryopexy, *Phaco* Phacoemulsification, *SSOCT* swept source anterior segment optical coherence tomography, *UBM* ultrasound biomicroscopy (Reproduced with permission from Selvan, H., Gupta, V. and Gupta, S. (2019), Cyclodialysis: an updated approach to surgical strategies. Acta Ophthalmol, 97: 744–751. https://doi.org/10.1111/aos.14210)

20.3 Conclusions

In conclusion, trauma is an important cause of secondary glaucoma. It may have multiple factors contributing and can occur at any time point. A detailed work-up, well-planned management, and life-long monitoring are crucial for optimal outcomes.

Suggested Reading

Girkin CA, McGwin G Jr, Long C, Morris R, Kuhn F. Glaucoma after ocular contusion: a cohort study of the United States eye injury registry. J Glaucoma. 2005;14(6):470–3. https://doi.org/10.1097/01.ijg.0000185437.92803.d7.

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