Lens Trauma in Children

21

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Abstract

Lens trauma is one of the most common types of pediatric ocular trauma, which usually results in traumatic cataract and traumatic lens dislocation. Pediatric lens trauma often has complex causes and a severe inflammatory response, which may also be complicated with other eye injuries and affect visual development. Because of inability of pediatric patients to cooperate, examination and diagnosis tend to be challenging. This chapter provides information on the classification, clinical features, examination, and precautions of pediatric lens trauma and also discusses its surgical management including the timing of surgery, surgical techniques, and benefits and risks of primary or secondary intraocular lens implantation.

Ocular trauma is one of the leading causes of unilateral blindness in developing countries. Based on whether the cornea or sclera has a full-thickness wound, the mechanical ocular injury is divided into two categories, namely, open-globe trauma and closed-globe trauma by the Ocular Trauma Classification Group. Both of them may lead to serious damage to the crystalline lens, such as traumatic cataracts, lens subluxation, or lens dislocation, which is one of the key reasons for post-traumatic blindness. The clinical features of pediatric lens trauma include the following:

1. Unclear of injury cause: Children may not be capable of making themselves understood and sometimes conceal the truth intentionally for fear of their parents' blame; thus, the cause of injuries cannot be determined.
2. Varying degree of injury severity: Pediatric lens trauma is often complicated by cornea, sclera, iris, and other ocular tissue damage, as well as intraocular foreign bodies or fundus injuries. Additionally, since the ocular structure in children is immature, the lens trauma may stimulate a severe inflammation and proliferation.
3. Unpredictability of visual outcomes: Lens trauma can seriously disrupt the eye structure and visual functions of children, and improper

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management may result in amblyopia or even blindness.

In clinical practice, mechanical ocular trauma is the principal cause of lens trauma in children. This chapter discusses the diagnosis and management of pediatric lens trauma caused by mechanical ocular injuries.

21.1 Classification and Clinical Features of Lens Trauma in Children

Lens trauma is commonly found among schoolchildren (mainly boys) aged 5–15 years. It is more common in rural than urban areas [1]. Unlike adult lens trauma, pediatric lens trauma largely results from accidental injuries during play caused by scissors, iron wires, needles, sticks, peashooters, or firecrackers [2, 3]. Depending on its clinical features, pediatric lens trauma can be classified as traumatic cataracts and traumatic ectopia lentis.

21.1.1 Traumatic Cataract

Traumatic cataract is one of the leading causes of acquired cataracts in children [4]. Lens opacification may occur immediately after trauma or develop slowly depending on the causes and severity of the trauma. Depending on the integrity of the eye wall following trauma, traumatic cataracts can be classified as cataracts caused by open-globe injury and cataracts caused by closed-globe injury, with the former more common and approximately three times the incidence of the latter according to published literatures [4]. These two types of cataracts have different clinical features.

21.1.1.1 Pediatric Cataracts Caused by Open-Globe Injury

Pediatric cataract caused by open-globe injury often results from the stab of a sharp object directly into the eyeball and the lens and may also occur after a heavy blow of blunt force. It is usually complicated by lens capsule rupture, which is associated with a more rapid onset and a more complex condition.

Traumatic Cataracts Complicated with Lens Capsule Rupture

Rupture of the lens capsule is often the result of direct trauma to the capsule. The aqueous humor flows into the lens through the ruptured capsule, causing lens edema and opacification. The size of the capsule rupture determines the progression and extent of lens opacification [5]. If the capsule rupture is small or there is an iris synechia to the capsule, the ruptured capsule may close up rapidly, often presenting as localized cortical opacification of the lens (Fig. 21.1a). If the rupture is large, it may result in rapid opacification and swelling of the whole lens, or even dislocation of the lens material into the anterior chamber (Fig. 21.1b) and/or the vitreous cavity.

Without proper and timely treatment, traumatic cataracts complicated by capsule rupture may induce secondary glaucoma, uveitis, and many other complications. The lens expansion caused by capsule rupture may lead to narrowing of the anterior chamber and pupillary block, which may induce IOP to increase rapidly. If the lens material prolapses into the anterior chamber, lens particle glaucoma could occur due to the elevated IOP induced by the obstruction of the trabecular meshwork with a large amount of lens cortex particles. It usually occurs several days after the lens capsule ruptures and may present as significant eye pain, redness, and vision loss. Slit-lamp examination may detect white cortex particles and/or capsule debris in the aqueous humor with a positive aqueous flare sign and deposition of loose lens material at the bottom of the anterior chamber as well as posterior iris synechiae. Gonioscopy findings often show an open anterior chamber angle, with large amounts of lens cortex debris adhered to the trabecular meshwork. The histologic examination demonstrates lens particles and macrophages in the aqueous humor. In addition, the exposure of lens proteins following capsule rupture may lead to the development of anterior uveitis. If the inflammation involves the trabecular meshwork, IOP elevation may be induced due to obstruction of aqueous outflow,

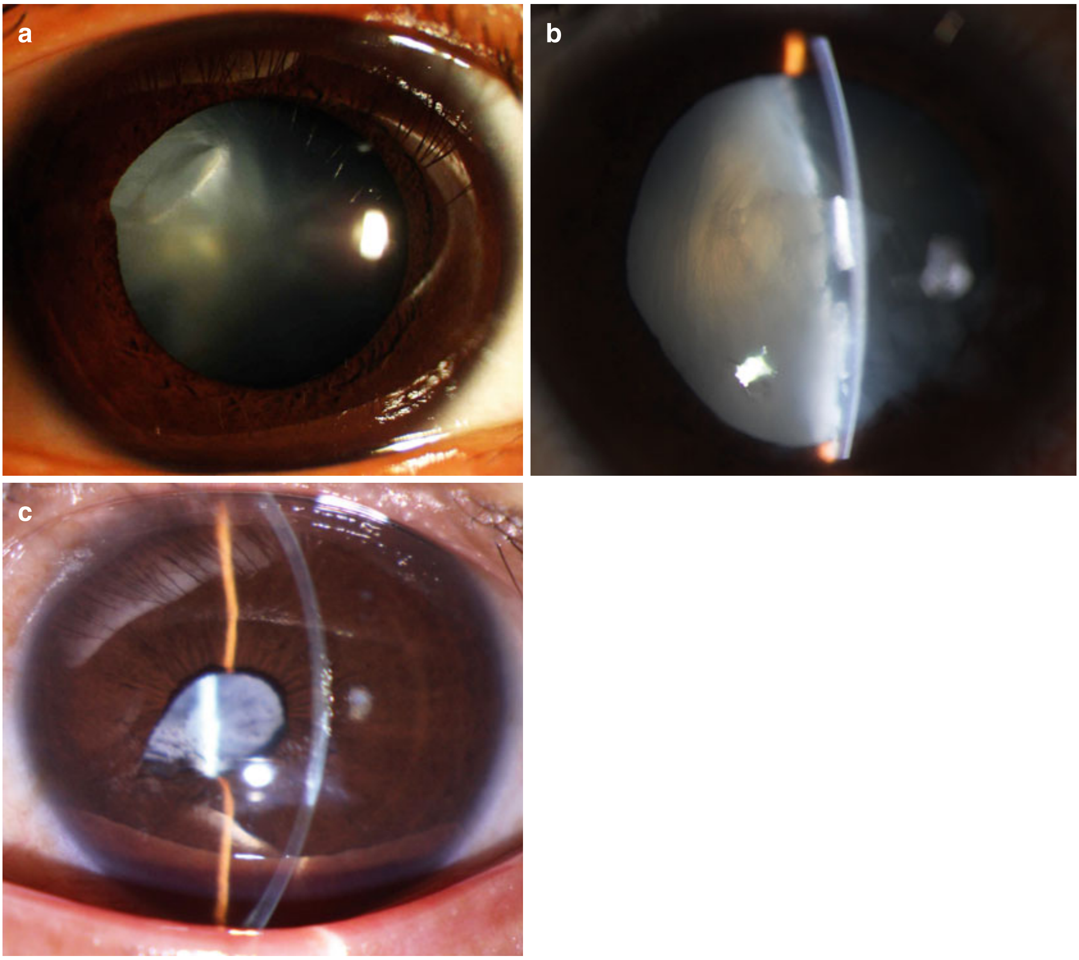

Fig. 21.1 Traumatic cataracts complicated with lens capsule rupture induced by open-globe injury. (**a**) Open-globe injury results in lens anterior capsule rupture and localized cortical opacity. A 7-year-old boy was stabbed in the right eye by a sharp blade 3 days previously. A 2 mm-long, self-sealed, full-thickness wound was observed in the mid-periphery of the temporal cornea. A long oval-shaped anterior capsule rupture was seen in the mid-peripheral region of the superior temporal lens, with exudative membrane adhering to the margin of the rupture and a localized opacity in the superior temporal lens. (**b**) Open-globe injury results in lens capsule rupture and cortex leakage. The right eye of a 6-year-old boy was injured by a metal wire 2 days before. The anterior chamber was shallow, with varying depths between the upper and lower parts of the anterior chamber. There was anterior capsule rupture, lens opacities, swelling, and loose cortex, part of which leaked into the anterior chamber. (**c**) Open-globe injury resulting in membranous cataract. A rural 12-year-old boy's left eye was injured by bamboo fragments 9 months previously. Because both his parents were migrant workers, he was left untreated after the injury. The image shows posterior iris synechia in the inferior nasal quadrant, pupillary distortion, extensive organization of the lens capsule, and partial absorption of the lens materials

which is called phacoanaphylactic glaucoma. Its pathognomonic sign is granulomatous inflammation of the lens, but its diagnosis is always difficult. Histology shows extensive lesions of polymorphonuclear cell, lymphocyte, macrophage, and epithelioid cell reactions around the lens cortex, which may help to establish the diagnosis.

If traumatic cataracts complicated by capsule rupture are left untreated for a long time, capsule organization may occur, and the lens material may be absorbed over time. Finally, only the organized capsule and a small amount of cortex are left, and this is defined as membranous cataract (Fig. 21.1c) [5]. It may also occur in patients with other types of traumatic cataracts. We observed that membranous cataract is more common in children with traumatic cataracts than in adults, with increased rigidity of the organized capsule, or even complicated with neovascularization.

Traumatic Cataracts Without Capsule Rupture

This condition is relatively rare in cases of open-globe injury. It may be caused directly by the trauma, but more often by indirect injuries including disruption of eye ball integrity, changes in the intraocular microenvironment, intraocular inflammation, and disturbance to lens metabolism. It may develop slowly after the injury, presenting as varying degrees of lens opacity.

Traumatic Cataracts Complicated by Intraocular Foreign Body

The usual mechanisms of intraocular foreign body-induced traumatic cataract are:

A. Mechanical injury by the foreign body: As the foreign body penetrates through the lens capsule, the aqueous humor enters into the cortex causing lens opacity (Fig. 21.2a).
B. Toxic reaction to the foreign body: Even without direct lens injuries, metal foreign bodies (e.g., iron and copper) retained in the eye for a long time may produce various chemical reactions and thereby result in cataracts. Examples include lenticular siderosis (Fig. 21.2b) and chalcosis.

21.1.1.2 Pediatric Cataracts Caused by Closed-Globe Injury

In the scenario of closed-globe injury, blunt forces per se or secondary factors may give rise to traumatic cataracts. Blunt forces on the crystalline lens may lead to capsule rupture, resulting in rapid opacification of the lens. Secondary factors after trauma, such as changes in the intraocular microenvironment, intraocular inflammatory responses, or metabolic disturbance to the lens, might cause slowly progressive lens opacity. Their clinical presentations may vary depending on the direction and intensity of the external force, but usually include a Vossius ring, rosette-shaped cataracts,

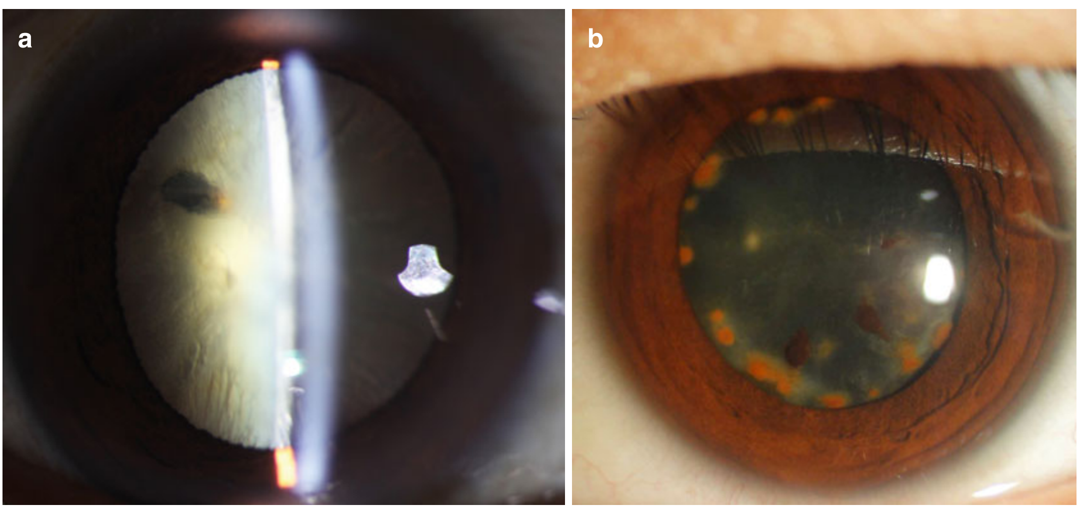

Fig. 21.2 Traumatic cataracts complicated by intraocular foreign body. (**a**) Lens foreign body. A 10-year-old boy complained of a small "stone" splashing into his left eye 2 days before. There were opacity and swelling of lens cortex and shallowing of the anterior chamber. A brownish black foreign body was seen in the mid-peripheral portion of the superior temporal lens, about 3 mm × 2 mm in size. (**b**) Siderosis. A 15-year-old boy presented with visual loss in the left eye for half a year. History taking revealed that his left eye was injured by "tiny iron sheets" when modifying a model car 1 year before, but he paid no attention to this. After pupillary dilation, multiple anterior subcapsular brown patches were seen in the mid-peripheral region of the lens, arranged in a circle, with mild lens opacities. A CT scan confirmed metal foreign bodies retained on the retinal surface of the left eye

punctate cataracts, and total cataracts. Besides, patients may have concurrent ocular injuries, such as iridodialysis (Fig. 21.3a), retinal breaks, and anterior chamber/vitreous hemorrhage.

Traumatic Cataracts Caused by Closed-Globe Injury and Complicated with Capsule Rupture

When the anterior ocular surface of the eye is hit with a blunt force, rapid anterior-posterior shortening of the eye occurs with simultaneous equatorial expansion. Severe equatorial stretching may result in capsule rupture, typically posterior capsule rupture (Fig. 21.3b). Then, opacities occur as the aqueous humor enters into the lens through the rupture. Hydration of the lens develops soon after opacification at the site of rupture, followed by formation of vacuoles and edema. Opacification would later extend to the periphery of the lens and, eventually, involve the entire lens (Fig. 21.3c). When the capsular rupture is small, however, the opacity may remain localized.

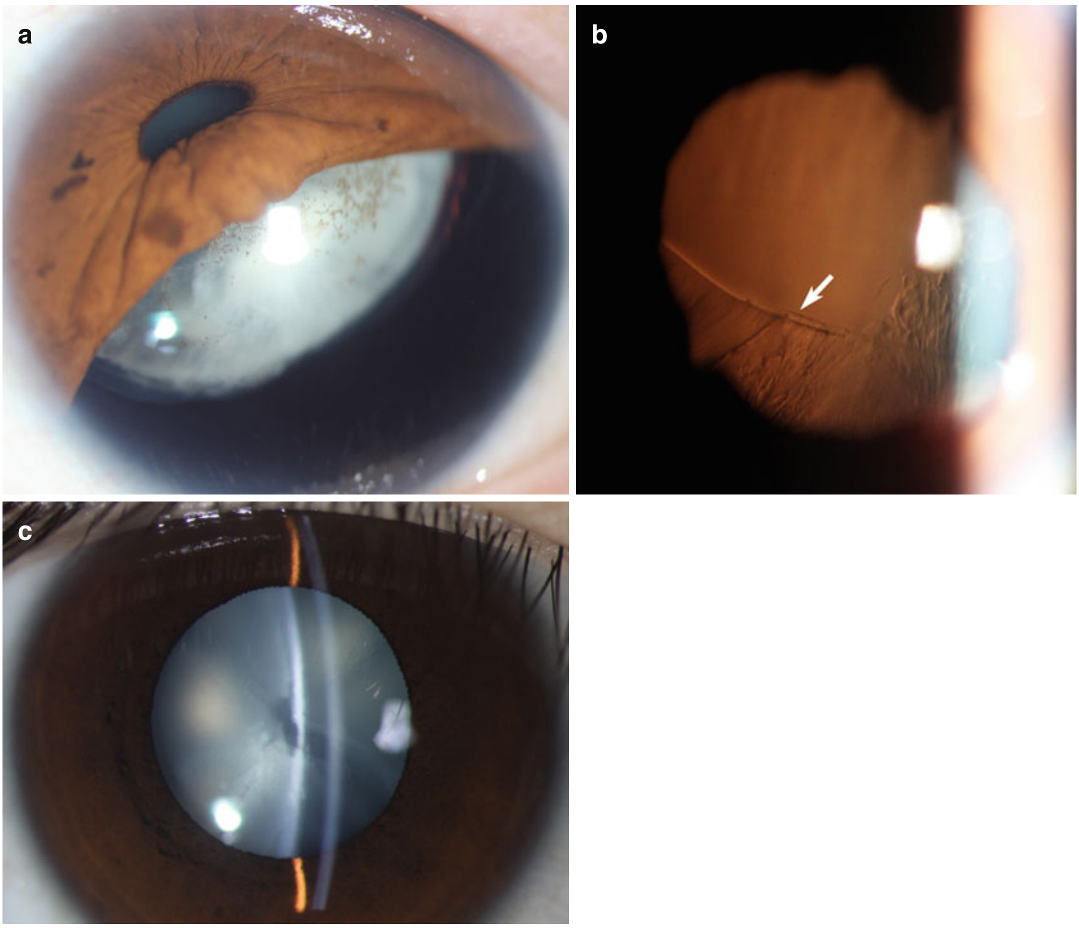

Fig. 21.3 Traumatic cataract caused by ocular contusion. (**a**) A 15-year-old boy presented 1 month after his right eye received a contusion after impacted with another player's head while playing basketball. The image shows an iridodialysis from 3 to 8 o'clock and white lens opacity, with the lens dislocated temporally and superiorly and a visible lens equator. (**b**) Posterior capsule rupture caused by ocular contusion. A 13-year-old girl presented 1 day after her left eye received a contusion after impacted with bicycle handlebars as she fell off. The image shows pupillary dilation, multiple tears at the pupillary margin, oval-shaped posterior capsule rupture, and localized cortical opacity surrounding the posterior capsule rupture. (**c**) Cataract caused by ocular contusion. A 12-year-old boy was hit with a fist 1 day before. No wound was observed on cornea or sclera. The lens rapidly opacified with cleft formation

Unless examined immediately after trauma, the posterior capsule rupture caused by closed-globe injury is often dormant, which may not be detected during a slit-lamp exam. But Scheimpflug imaging with a Pentacam has been reported to have been used to reveal posterior capsule rupture [6, 7].

Cataracts Caused by Closed-Globe Injury Without Capsule Rupture

1. Vossius ring: It appears as circular opacity in the lens anterior capsule. When the eye receives blunt trauma, the iris pigment epithelial cells at the pupil edge are shed off and imprinted on the surface of the anterior capsule in a circular pattern, which is referred to as a Vossius ring. In this case, anterior subcapsular opacities might occur.
2. Ectopia lentis: Cataracts caused by closed-globe injury are often combined with various degrees of zonular fracture, leading to ectopia lentis (Fig. 21.4a).
3. Rosette-shaped cataract: When the lens is impacted by an external force, the structure of lens fibers and sutures may be disrupted, and thereby fluid may flow into the intersutural and interlamellar spaces, forming rosette-shaped radial opacity (Fig. 21.4b). Such cataracts may occur within hours or weeks of an injury, and the opacities may be resolved spontaneously in some patients. In other cases, however, cataract may develop several years after the injury, and the opacity may be permanent.
4. Punctate cataracts: Lots of tiny opaque dots are formed beneath the subepithelial of the lens. They usually develop over a period of time following the injury and remain static and impact vision slightly.

21.1.1.3 Pediatric Cataracts Caused by Other Physical or Chemical Agents

Electric shock, heat, radiation, or chemical injury may also change the structure and transparency of the crystalline lens. Although most of these cataracts are rarely seen in children, electrical injury is relatively common.

Electrical Injury

Electrical injury includes electric shock and lightning strike. Electric shock in children is often caused by inadvertent touching of household appliances or a socket. The severity of an electrical injury depends on several factors such

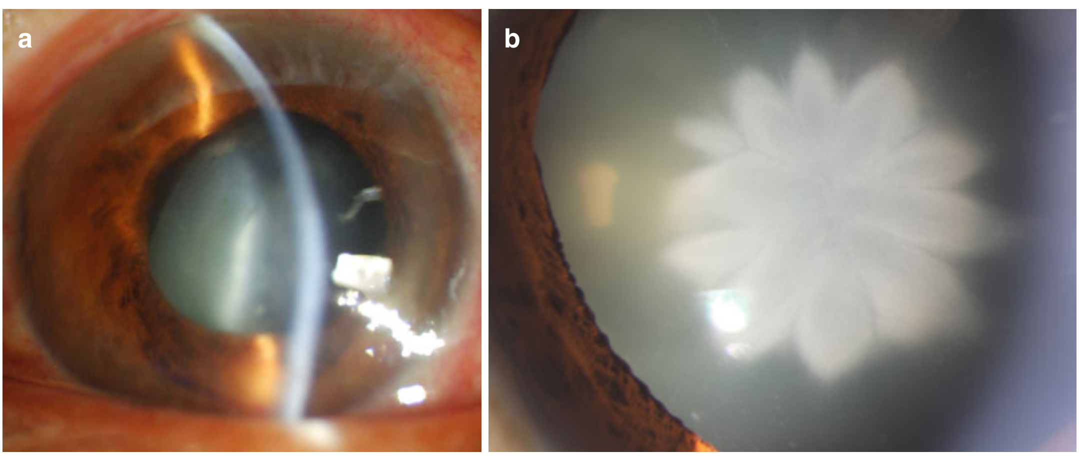

Fig. 21.4 Cataracts caused by closed-globe injury without capsule rupture. (**a**) Traumatic cataract caused by ocular contusion and complicated with ectopia lentis. A 16-year-old boy presented 5 days after being struck in the left eye with a badminton. A moderate degree of white lens opacity with intact lens capsule can be seen. There was zonular fracture from 9 to 1 o'clock, with the lens dislocated temporally and inferiorly. (**b**) Rosette-shaped lens opacities. A 15-year-old boy presented 7 days after his right eye received a blow with fist while fighting. Clefts can be seen between the lens fibers, arranged in a radial pattern, like rose petals

as the duration of contact, the strength of electrical current, the size of contact area, the part of body in contact, and the pathway the electrical current passes through the body. Cataracts caused by lightning strike often present as both anterior and posterior subcapsular opacities, while those caused by electric shock mainly present as anterior subcapsular opacities. Cataracts induced by electrical injury may be static or progressive. It may take several months or even years to form complete clouding of the lens in progressive cases. For a small number of patients, the lens opacities may be completely absorbed and become transparent. If an electrical injury-induced cataract is static and visually insignificant, observation is recommended; otherwise, surgical treatment should be considered. Favorable surgical outcomes can be achieved if not complicated with other ocular tissue injuries.

Chemical Injuries

Chemical-induced cataract is relatively rare in children, but if it occurs it is usually by alkali chemicals, such as lime. As alkali chemicals dissolve fats and proteins, they are more likely to penetrate into the eye causing lens metabolic disturbance directly or indirectly, which leads to various degrees of lens opacity. Milky white opacity of the entire lens may be detected in serious cases.

21.1.2 Traumatic Ectopia Lentis

Traumatic ectopia lentis often occurs following blunt trauma to the eye. A blunt force may cause compression and equatorial expansion of the globe and hence zonular dialysis, resulting in the lens tilting anteriorly or posteriorly. At the site of the dialysis, vitreous prolapse may occur (Fig. 21.5a), often with concurrent traumatic cataracts.

21.1.2.1 Lens Subluxation

The extent and presentation of lens subluxation may vary with the extent of zonular dialysis. Mild subluxation may be asymptomatic without any signs. A larger extent of lens subluxation is associated with more apparent clinical manifestations: (1) uneven anterior chamber depth (ACD) or changes in ACD (irregular ACD along different meridians in one eye); (2) iridodonesis and/or phacodonesis, a quivering of the iris and/or the lens on eye movement, accompanied with pupil displacement; (3) lens decentration, with a partially visible equatorial region of the lens after pupillary dilation; and (4) vitreous prolapse into the anterior chamber in serious cases.

21.1.2.2 Complete Lens Dislocation

1. Dislocated into the anterior chamber: The lens is typically seen at the pupillary zone, with the transparent lens looking like an oil drop (Fig. 21.5b), and white disc-shaped opacities may also be observed. The dislocated lens may cause corneal endothelial abrasion and Descemet membrane detachment, leading to corneal edema.
2. Incarcerated at the pupil: This may induce pupillary block and affect aqueous circulation, resulting in acute elevation of IOP and secondary glaucoma.
3. Displaced into the vitreous cavity: A transparent globule in the vitreous cavity is observed (Fig. 21.5c). Adhesion to the retina may occur over time. If the lens remains in the vitreous cavity for a long time, the soluble lens proteins may leak into the anterior chamber through the lens capsule, leading to phacolytic glaucoma.
4. The lens may become dislocated to the subconjunctival space or even out of the eye following severe trauma.

21.2 Examination of Children with Ocular Trauma

Due to the mental stress and eye pain after injury, most children are not cooperative for examination, making the diagnosis and treatment even more challenging. The ophthalmologist should be very patient and careful and try to earn the patient's trust and cooperation. For older children, the ophthalmologist should encourage them with patience and help them overcome their fear. As most children cannot cooperate for a long time, it is wise to let an experienced ophthalmologist complete the examination quickly. For children who fail to cooperate, in order to prevent

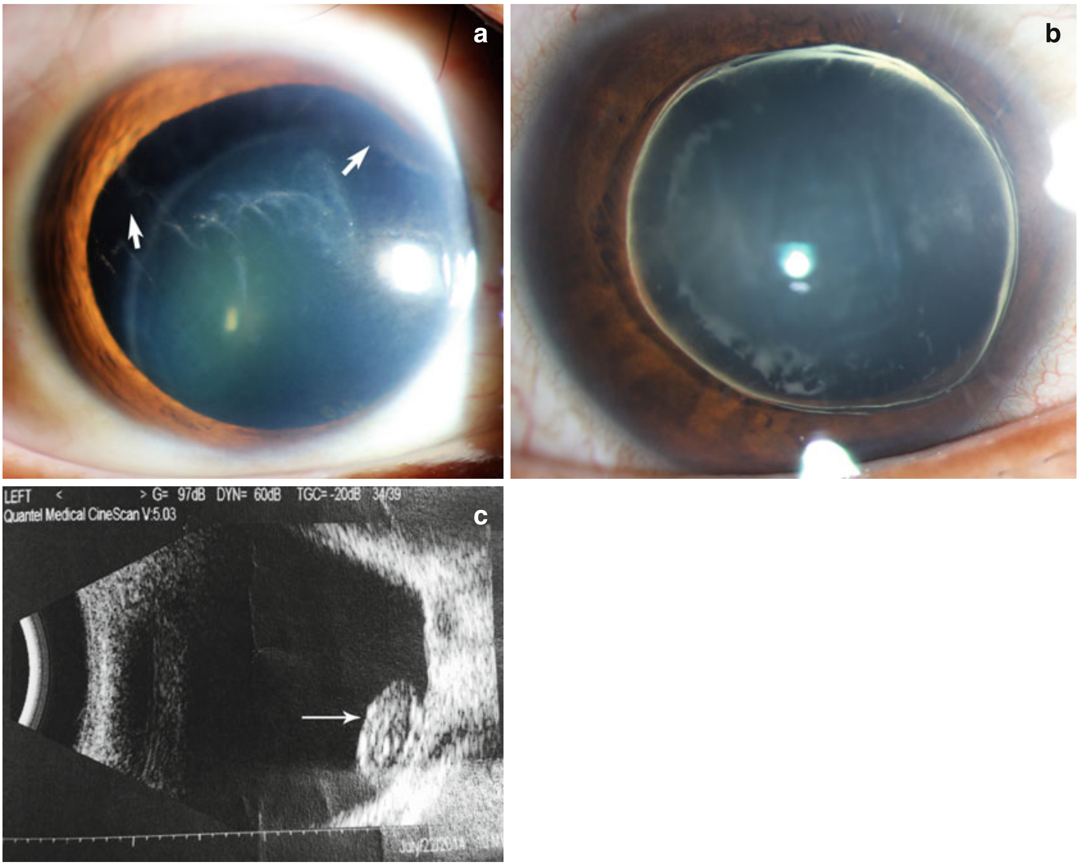

Fig. 21.5 Traumatic ectopia lentis. (**a**) Traumatic ectopia lentis with vitreous hernia. A 17-year-old boy presented 2 weeks after being hit in his right eye with a tennis ball. Zonular dialysis from 7 to 2 o'clock was seen in the right eye. The lens was displaced inferiorly and nasally, and the vitreous herniated into the anterior chamber through the dislocation area in the superior temporal quadrant (see *arrows*). The lens is mildly opaque. (**b**) Traumatic dislocation of the lens into the anterior chamber. A 10-year-old girl presented 2 days after her left eye received a blast injury from a firework during a wedding ceremony. The lens displaced into the anterior chamber, contacted with the corneal endothelium, where mild corneal edema could be seen. The dislocated lens is largely transparent, with the appearance of an oil drop. IOP in the left eye was 45 mmHg. (**c**) Traumatic dislocation of the lens into the vitreous cavity. A 10-year-old boy presented 3 months after a blow to the right eye with a rock. B-scan ultrasonography revealed the lens dislocated into the vitreous cavity (see *arrow*)

further injury, 10 % chloral hydrate at a dose of 0.6–0.8 ml/kg may be administered orally or rectally for sedation. In some cases, general anesthesia may also be considered. If the ocular trauma seems to be serious, life-threatening systemic injuries must be excluded.

21.2.1 Medical History

A detailed and accurate history is exceptionally important to determine the etiology, nature, extent, and severity of the ocular trauma, which may be quite helpful for diagnosis and treatment. The physician should make a detailed inquiry of the child, their parents, and even other witnesses about the traumatic event, including time of injury, the objects that cause the trauma and its nature, how (e.g., direction and distance) the event happened, as well as any initial management. In addition to the present history, information about the visual acuity of both eyes before the injury, past history of any ocular and systemic diseases, allergy to medications, and family history should also be obtained.

21.2.2 Examination

21.2.2.1 General Examinations and Precautions

For children with ocular trauma presented to an emergency department, their systemic condition must be assessed before any ophthalmic examination, so as to identify signs of shock, brain trauma, infection, or vital organ injury. If necessary, a consultation or referral should be considered immediately after brief treatment of the injured eye.

21.2.2.2 Visual Acuity Test

A visual acuity test of the injured eye is essential at the initial visit. This includes uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA). If there is a significant visual loss, then light perception and light projection should also be checked. For young children who are unable to cooperate, a test to check their ability to fix and follow a light is recommended. A visual acuity chart for children or other methods may be used as alternatives.

21.2.2.3 IOP Measurement

If there is no evidence of globe rupture, IOP measurement should be performed. A noncontact tonometer is the preferable option. For children who fail to cooperate, it is recommended to use a Tono-Pen tonometer under sedation or anesthesia. If a tonometer is not available, the IOP may be roughly estimated by finger palpation.

21.2.2.4 Slit-Lamp Examination

It is critical to avoid placing undue pressure on the globe during examination. Do not rush to clean the wound to avoid prolapse of intraocular contents. The slit-lamp examination helps to identify and document the location, affected area and depth of the anterior segment wound, the presence or absence of wound infection, as well as occult wounds. The transparency, position, and stability of the lens as well as the integrity of the lens capsule should also be observed. If the lens is found to be dislocated, areas of loss of zonular support and the presence of vitreous prolapse should also be carefully assessed. Besides, the ophthalmologist should be aware of the possibility of a retained intraocular foreign body.

21.2.2.5 Other Examinations

For patients with suspected orbital fracture or intraocular foreign body, orbital X-ray (sagittal and coronal views) or CT scan should be routinely performed. If the refractive media opacities prevent clear visualization of the fundus, then B-scan ultrasound is recommended. For patients with suspected lens dislocation, UBM may be used to examine the anterior eye segment (including the anterior chamber angle, ciliary body, lens, and zonules). When contact with the globe or applying pressure on the globe is necessary during examination (e.g., B-scan ultrasound or UBM), it is important to ensure the integrity of the globe before initiating the exam, so as to avoid extrusion of intraocular contents as well as causing iatrogenic intraocular infection.

21.2.2.6 Examination of the Contralateral Eye

The contralateral eye should be routinely checked to prevent the possibility of undetected injury. If primary intraocular lens (IOL) implantation is planned, parameters of the contralateral healthy eye have to be measured and documented, including keratometry, axial length, and so on.

21.3 Management of Traumatic Cataracts in Children

As the eyes and visual functions are still developing during childhood, opacities in the refractive media may result in arrested visual development and amblyopia. Hence, the basic principles of managing pediatric traumatic cataracts include restoration of transparency on the visual axis, visual rehabilitation, and prevention of complications. Due to the complexity of ocular trauma in children, a thorough, careful, and comprehensive analysis should be done according to the clinical features of pediatric traumatic cataracts, so as to formulate a rational and individualized therapeutic regimen [8].

21.3.1 Management of Pediatric Cataracts Caused by Open-Globe Injury

21.3.1.1 Indications for Surgery

The management of traumatic cataracts may vary with the object causing the injury, intensity of the external force, and degree of the injury. Whether surgery is needed and the timing of surgery depend on the location, size, density, and progression of the opacity, as well as the presence of severe complications [9]. For localized traumatic cataract, it may be managed with observation and regular follow-up, especially when the visual axis is not affected, expected progression is slow, and the cataract is visually insignificant. Once the cataract is progressive and significantly impairs vision, surgery should be scheduled soon.

The primary indications for surgery include:

1. Total opacification of the lens
2. Localized opacification ≥3 mm with visual axis involvement
3. Capsule rupture combined with cortex leakage
4. Presence of lens foreign body

21.3.1.2 Timing of Surgery

Early surgery is often advisable for children with traumatic cataracts; however, due to the complexity and variability of open-globe injuries, there is no evidence-based medical proof regarding the timing of surgery. Depending on the scenario, traumatic cataract surgery can be performed at the time of primary repair of open-globe injury, or later as a secondary procedure. Advantages and limitations of each surgical strategy are as follows [9–11]:

Cataract extraction at the time of primary repair of open-globe injury has the following advantages:

1. Visual recovery time can be shortened, which is associated with a lower risk of deprivation amblyopia.
2. Repeated surgeries and anesthesia can be avoided.
3. The lens cortex can be removed earlier, leading to lower risks of inflammatory response due to lens protein exposure as well as lens-induced glaucoma.
4. Opacities in the refractive media can be removed, which may facilitate visualization of the posterior eye segment.
5. Mixture of the lens cortex and vitreous can be avoided so as to prevent proliferative vitreous retinopathy and tractional retinal detachment.
6. For patients with financial concerns, primary cataract extraction and IOL implantation are helpful to reduce the total medical expenditure.

Nevertheless, primary cataract extraction also has its limitations: (1) the preexisting intraocular inflammation may become worse; (2) the edema and instability of the corneal wound may lead to surgical difficulties and thereby a prolonged duration of surgery, or even iatrogenic injury to the traumatized eye, such as posterior capsule rupture and vitreous loss during surgery. By contrast, secondary cataract surgery, which is conducted after the wound is sealed and the traumatized eye is stabilized, is usually associated with lower risks of postoperative inflammation and other complications.

When complicated with retinal detachment or serious posterior segment injury, pars plana vitrectomy and lensectomy should be performed as soon as possible [9].

It is generally accepted that the risk of postoperative complication is lowered if the surgery is done when the intraocular inflammation has subsided, usually about 2–3 weeks after the trauma. A prospective, large-scale, cohort study led by Shah et al. [12] showed that patients with traumatic cataracts had a better visual outcome if the surgery was performed at 3–30 days after the trauma, of whom 44.6 % were children. As this study was prospectively designed with a large sample size, and the Ocular Trauma Classification System was used for data collection, these findings are considered more reliable than those from smaller retrospective studies.

We believe that there is no "one-size-fits-all" approach to decide whether to perform primary or secondary cataract surgery. A number of factors, such as patient age, expertise of the surgeon, availability of surgical equipment, severity of the lens injury, as well as the vitreous and retinal status, should be taken into consideration. For young emergency physicians who lack surgical experience, especially with inadequate equipment at nighttime, it is suggested that extreme caution be exercised, and only necessary management be performed.

21.3.1.3 Timing of IOL Implantation

There are still controversies regarding primary versus secondary IOL implantation following traumatic cataract extraction in children [9–11, 13]. Primary IOL implantation expedites visual rehabilitation, eliminates the need for repeated surgeries and anesthesia, prevents capsule adhesions that may be encountered in a secondary procedure, and reduces medical cost. However, primary implantation is associated with a higher risk of postoperative inflammation, and refractive error may occur because IOL power calculation may be difficult soon after injury. By contrast, due to the stabilized refraction at the time of secondary IOL implantation, calculation of IOL power and prediction of visual outcomes can be much more accurate. Moreover, the surgeon may get a better visualization of the peripheral fundus if vitreous surgery is required for managing posterior segment lesions. But secondary IOL implantation may delay visual recovery, and exacerbated inflammation, along with a series of other complications, may be triggered by separating iris synechia.

Therefore, there is an ongoing debate on the timing of IOL implantation. Based on the morphological characteristics of traumatic cataracts and the zone classification system established by the Ocular Trauma Classification Group (Fig. 21.6), Shah and Turalba [14] proposed an algorithm to determine the appropriate timing of cataract extraction and IOL implantation (Fig.21.7).

As shown in the algorithm, (1) if there is no capsule rupture and no obvious opacities on the visual axis, cataract surgery is not recommended unless the cataract becomes visually significant. (2) If capsule rupture is present, the penetrating injury should first be classified by zone. For lacerations in Zone III, repair of the primary wound and removal of the lens are recommended to prevent lens related complications, and the injured eye is left aphakic until the secondary procedure. For Zone I and II injuries, primary or secondary in-the-bag or ciliary sulcus IOL fixation can be considered based on the stability of the lens capsule. (3) Significant posterior segment trauma (e.g., exit wounds and retinal detachments), evident infection, unstable capsule, ruptured zonules, severe iris damage, or botanical injury is an exclusion criterion for primary IOL implantation. Under emergency circumstances, this algorithm may be used to guide the decision-making on whether or not to perform primary cataract extraction.

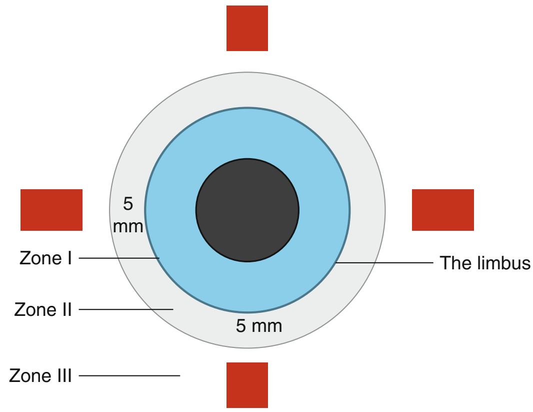

Fig. 21.6 Zone classification of open-globe injury. *Zone I* confined to the cornea and limbus, *Zone II* 5 mm or less posterior to the limbus, *Zone III* greater than 5 mm posterior to the limbus

But there are controversies about whether this algorithm is also applicable to children, mainly because the zone classification system is designed for adults. The anatomical structure of the eyes is under rapid development before the age of 5 years. For example, the length of the pars plana is about 1.8 mm in newborns, 3 mm at the age of 1 year, and up to 5 mm at the age of 5 years. Thus, it may not be advisable to use the adult-based zone classification system to assess ocular trauma in children. A comprehensive consideration should be given when deciding on the timing of IOL implantation. Do not rush to implant an IOL without careful planning, especially when intraocular inflammation is not controlled, the status of the posterior segment is unclear, or the IOL power is not accurately determined.

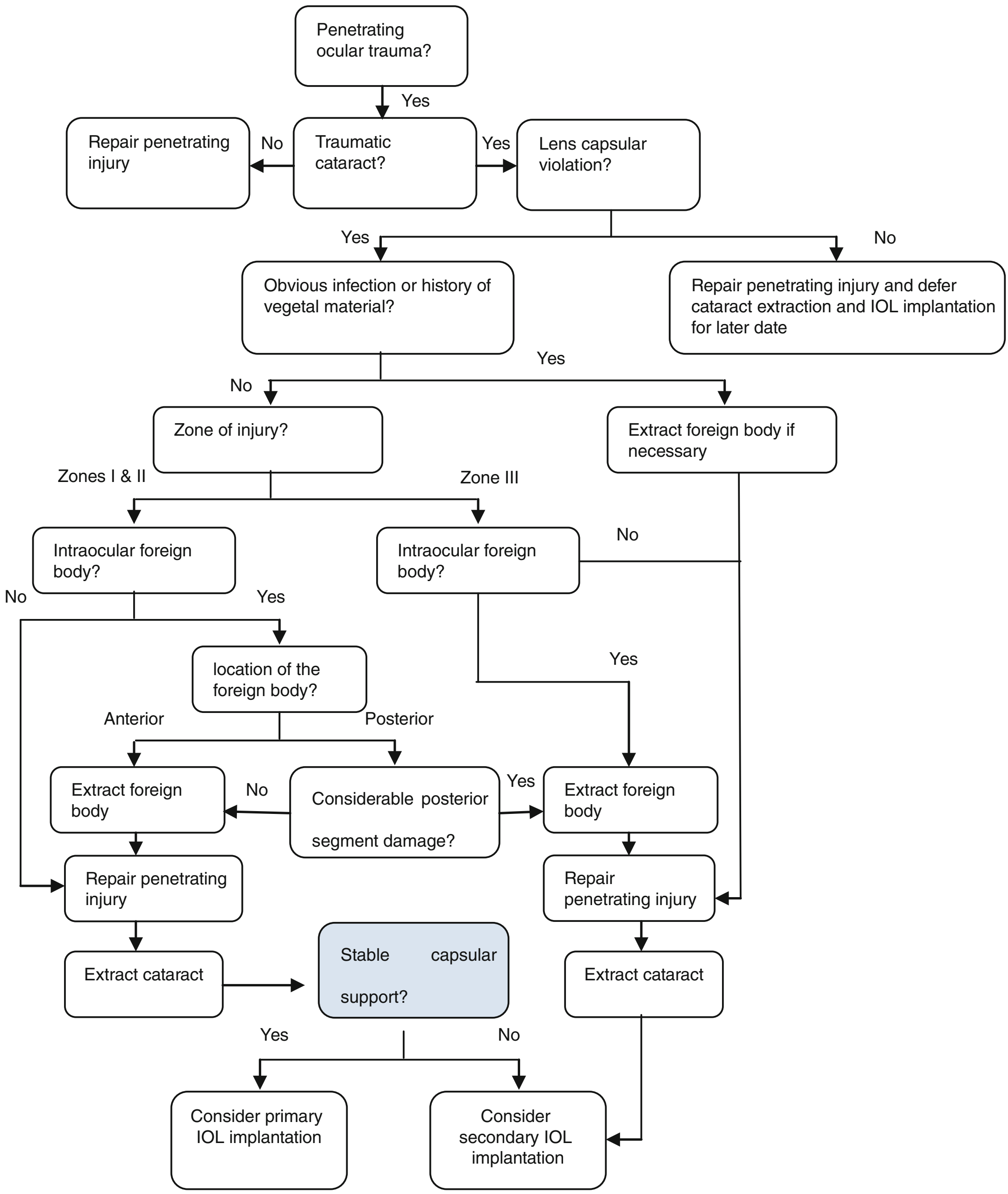

Fig. 21.7 An algorithm to determine the management of traumatic cataracts suggested by Shah and Turalba (Reproduced with permission from Shah and Turalba [14])

21.3.1.4 Surgical Techniques

The surgical principles for managing cataracts caused by open-globe injury mainly include avoiding further injury to ocular structures, trying to preserve the lens capsule for IOL placement and restoration of refractive status, controlling astigmatism, and preventing or reducing surgery-related complications.

1. Incision: Due to the complexity of traumatic cataracts and the discrepancy between preoperative evaluation and intraoperative findings,

a modified scleral tunnel incision should always be attempted. The incision should be constructed away from the corneal wound and the site of zonular disruption. If posterior segment injury is presented with severe corneal damage obscuring the surgical view, but the lens still has to be managed immediately, then the pars plana approach may be considered in this situation.

2. Lens capsule management: It has been reported that in children with traumatic cataracts, in-the-bag IOL implantation is associated with a better visual outcome than ciliary sulcus fixation [15]. Thus, the surgeon should preserve as much capsule as possible in order to support an IOL. The capsulorhexis should cover the anterior capsule rupture, allowing for a continuous and smooth opening. If the capsule has already been organized, capsulorhexis by radiofrequency diathermy may be considered. In the presence of significant anterior and posterior capsule defects, the peripheral capsule should be preserved as much as possible. Because of the high proliferative capacity of the lens epithelial cells during childhood, preservation of an intact posterior capsule is associated with an incidence of posterior capsule opacification after surgery of almost 100 % [10, 16]. It has been shown that primary posterior capsulotomy in the visual axis area may result in a better visual outcome [16]. Hence, in order to prevent posterior capsule organization and opacification after surgery, posterior curvilinear capsulorhexis involving the axis area should be performed based on the capsule integrity, which may be combined with anterior vitrectomy if necessary.
3. Lens material management: As the lens nucleus is relatively soft in children, irrigation and aspiration (I/A) or low-energy phacoemulsification is appropriate. In the presence of vitreous prolapse before surgery, the dislocated vitreous in the anterior chamber should be removed before lens aspiration. During I/A or phacoemulsification, the noncontinuous anterior capsule should be avoided. Eliminate the lens materials completely and any foreign body in the lens must be removed.
4. Anterior vitreous management: There are two circumstances requiring anterior vitreous management in pediatric traumatic cataract surgery, i.e., planned anterior vitrectomy for prolapsed vitreous that already exists before surgery and unplanned anterior vitrectomy for prolapsed vitreous that occurs during surgery. The former is the more commonly seen. It is preferable to perform anterior vitrectomy in a closed system and use a non-coaxial vitrector that separates irrigation from vitreous cutting, with a low bottle height (<50 cm), a high cut rate (600–800 cpm), and a moderate vacuum (150–200 mmHg). Using a high cut rate can minimize vitreoretinal traction. The surgeon can insert the vitrector tip behind the posterior capsule through the posterior capsule rupture and cut the prolapsed vitreous located at the posterior capsule rupture. Then high-speed cutting can be initiated behind the posterior capsule with the cutting port facing upward and away from the posterior capsule and always clearly visible. The prolapsed vitreous is drawn posteriorly and cut. After that, place the vitrector tip back into the capsule and remove the remaining lens cortex, with a lower cut rate at 300 cpm and a higher vacuum. Complete removal of vitreous from the anterior chamber is required. Finally, make sure no vitreous is retained in the incision.
5. IOL implantation: The fixation site of an IOL depends on the integrity of the lens capsule and the residual capsular support. In-the-bag implantation and ciliary sulcus implantation are commonly used in clinical practice. It has been demonstrated that ciliary sulcus fixation of an IOL is also safe in children. An iris clip anterior chamber IOL is not recommended for children.

21.3.2 Management of Pediatric Cataracts Caused by Closed-Globe Injury

The visual outcomes of cataracts caused by closed-globe injury are generally better than those caused by open-globe injury [10].

The indications for surgery are listed as follows:

1. For patients with a Vossius ring, the opacities rarely progress or affect vision, and thus surgery may not be needed.
2. For patients with capsule rupture, if the rupture is large and the lens rapidly opacifies, surgical treatment is usually required. Conversely, if the rupture is small and the opacity is localized without visual axis involvement, observation is recommended.
3. For patients with rosette-shaped cataracts, the opacities can be resolved spontaneously in some patients, and conservative management is generally recommended. But if significant visual impairment occurs, surgical treatment should be considered.
4. For patients with punctate cataracts, the opacities are usually static and visually insignificant. Therefore, observation is recommended.

21.3.3 Management of Pediatric Cataracts Caused by Other Factors

For cataracts caused by other physical or chemical factors, observation is recommended if there is no significant visual impairment; otherwise, surgical treatment should be considered which is similar to congenital cataract surgery.

21.4 Management of Traumatic Ectopia Lentis in Children

See Chap. 17 for the management of traumatic ectopia lentis in detail.

21.5 Summary

Open-globe or closed-globe trauma might result in injury to the crystalline lens. Children are unable to provide a detailed history and are uncooperative to examinations, which raises challenges for evaluation, diagnosis, and treatment of lens trauma. Traumatic cataracts are often accompanied by rupture of the capsule, zonular injury, and intraocular foreign bodies; and trauma-induced inflammatory response in children is severe, with rapid progression of related pathologies, which makes the management in pediatric cases more difficult. Decisions should be made on the timing of cataract extraction after trauma, surgical techniques, and timing of IOL implantation, which warrants a thorough consideration of patient age, experience and skills of the surgeon, surgical devices, severity of the lens trauma, and vitreoretinal condition.

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