Review Article

Posterior capsular rent: Prevention and management

Arup Chakrabarti, Nazneen Nazm[1]

This review article deals with a potentially sight threatening complication – rupture of the posterior capsule – during cataract surgery. Cataract surgery is the most commonly performed surgical procedure in ophthalmology and despite tremendous technical and technological advancements, posterior capsular rent (PCR) still occurs. PCR occurs both in the hands of experienced senior surgeons and the neophyte surgeons, although with a higher frequency in the latter group. Additionally, certain types of cataracts are prone to this development. If managed properly in a timely manner the eventual outcome may be no different from that of an uncomplicated case. However, improper management may lead to serious complications with a higher incidence of permanent visual disability. The article covers the management of posterior capsular rent from two perspectives: 1. Identifying patients at higher risk and measures to manage such patients by surgical discipline, and 2. Intraoperative management of posterior capsular rent and various case scenarios to minimize long-term complications.This review is written for experienced and not-so-experienced eye surgeons alike to understand and manage PCR.

Key words: Cataract, cataract surgery, complications, posterior capsule, posterior capsule rent

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The outcome of uncomplicated phacoemulsification in the present scenario is excellent. However, despite the advances in the field of cataract surgery, surgical complications still occur. Posterior capsular rent (PCR) is the most common potentially sight-threatening intraoperative complication during cataract surgery. PCR may call for additional surgical procedures, increased postoperative follow-up visits, and a higher incidence of postoperative complications which may impair final visual outcome. However, today, the control rendered through closed chamber modern surgical techniques may allow for a final visual outcome similar to an uncomplicated case. It is desirable to be better prepared for this complication to prevent it or manage it well. An improperly managed PCR, with or without a vitreous loss (VL), can adversely impact the excellent outcome associated with routine cataract surgery. Although each patient with PCR is unique several basic surgical principles apply universally, and every cataract surgeon should learn these fundamental principles to avoid and manage the long-term sequelae. With this thought, this review focuses on prevention and management of PCR.

Incidence of Posterior Capsular Rent

The overall incidence of PCR reported in the literature varies from 0.2% to 14%.[1-6] The rate of VL is found to be between 1% and 5%.[5-16] In the recent years, advanced techniques, instrumentation, and technology have reduced PCR rate to 0.45%–5.2%.[1,17] The incidence of PCR in surgeries performed by experienced surgeons is placed at 0.45%–3.6%.[1] For surgeons converting from extra capsular cataract extraction (ECCE) to phacoemulsification, the PCR incidence is around 4.8%–11%.[1,15,16]

Common Predisposing Factors for Posterior Capsular Rent

Certain risk factors predispose to PCR.[15,17] These risk factors should be looked for in every patient planned for cataract surgery. Identification of high-risk factors can potentially improve on the informed consent process for patients and for surgeons to institute appropriate prophylactic measures to postpone or reduce the occurrence of this much dreaded complication.

The predisposing factors may be broadly classified as patient-related, surgeon-related, intraoperative factors, and those related to devices/machines [Table 1].

General Factors

It has been the experience of the author and others that elderly, anxious, demented, and disoriented patients are at higher risk for PCR. This could be due to inadvertent head movements during surgery or associated comorbidities. Narendran *et al*. confirmed a steady rise in complication rate with increasing patient age.[15] Berler noted a variation in complication rate with age, with an increase in rates of PCR, VL, and retained nuclear fragments over the age of 88 years.[18]

Chief, Cataract and Glaucoma Services, Chakrabarti Eye Care Centre, Kochulloor, Trivandrum, Kerala, [1]Assistant Professor, Ophthalmology ESI-PGIMSR, ESIC Medical College and ESIC Hospital, The West Bengal University of Health Sciences, Kolkata, West Bengal, India

Correspondence to: Dr. Arup Chakrabarti, Chakrabarti Eye Care Centre, No 102, Kochulloor, Trivandrum - 695 011, Kerala, India. E-mail: arupeye@gmail.com

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Extraocular Factors

Extraocular risk factors are usually associated with difficult access to surgical field due to physical limitations and/or limited visibility of operative field. This includes deep set eyes with prominent brow, exaggerated Bell's phenomenon and corneal opacities (pterygium, extensive arcus senilis, scar, and band keratopathy). Dense asteroid hyalosis may render the posterior capsule PC less visible during phacoemulsification. The surgeon is advised to stay away from PC during phacoemulsification in these eyes.

Reduced Work Space

Small Pupil: Intraoperative miosis is an important risk factor.[15,19,20] Attempt should be made to dilate the pupil pharmacologically. A pupil dilating device may be employed. Intraoperative floppy iris syndrome (IFIS) is an important cause of small pupil and may be associated with a high incidence of intraoperative complications including PCR with or without VL.[21,22]

Shallow Anterior Chamber

In high hypermetropia, the anterior chamber (AC) is crowded and shallow. The PC is closer to phaco needle and thus at increased risk of PCR. Iris prolapse is also more common since infusion from the phaco tip may flow behind the iris root ballooning it and forcing it out of the incision. Hence, early use of pulsed phaco fluidics is of paramount importance. A slightly more anterior incision with careful attention to incision size and minimal use of second instrument in AC during phacoemulsification is desirable.[23]

Excessive Anterior Chamber Depth

In high myopia and previously vitrectomized eyes, AC is deeper with more trampolining of PC. Excessive AC deepening occurs due to a pressure gradient resulting in reverse pupillary block (lens-iris-diaphragm retropulsion syndrome [LIDRS]). Vitreous is more likely to be liquefied and degenerated. There is thus an increased risk for loss of nucleus fragments into deep vitreous in case of PCR. Several strategies can help deal with LIDRS-lowering the infusion bottle and machine vacuum and flow settings. Another method is to neutralize the pressure gradient between anterior and posterior chambers by using the second instrument to manually elevate iris from anterior lens surface. A single iris hook also may serve the desired function.[24]

Cataract Type

Certain types of cataract are at a higher risk for developing PCR. They are: (1) Posterior polar cataract PPC[25,26] and cataract associated with posterior lenticonus or lentiglobus.[27,28] (2) Postvitrectomy cataract [Fig. 1] (3) White cataract (4) Brunescent/black cataract,[15,29] and (5) Traumatic cataract. Preoperative counselling in such patients should include thorough discussion on potential for PCR and its sequelae.

Pseudoexfoliation

Pseudoexfoliation (PXF) syndrome is known to be associated with weak zonules, poor pupillary dilation, and hard cataract predisposing the eye to an increased incidence of PCR or zonular dehiscence. In their study, Drolsum *et al*. found that eyes with PXF syndrome undergoing cataract surgery had a 2.6-fold increase in capsular/zonular complications compared to eyes without PXF.[30]

Surgeon-related Factors

Surgeon inexperience is considered high-risk factor for PCR. PCR rate for phacoemulsification performed by experienced surgeons is 0.45%–3.6%[1] while for surgeons converting from ECCE to phacoemulsification, it is around 4.8%–11%.[1,15,31] The current incidence of PCR in surgeries performed by residents is around 0.8%–8.9%.[31-34] The incidence of PCR is lower in high-volume surgeons.

Intraoperative Factors

Frequent preoperative instillation of topical anesthetic agents and povidone-iodine (an important component of infection prophylaxis) on cornea may result in corneal epithelial haze. This may be aggravated by surface exposure due to infrequent blinking. Suboptimal visibility may increase the risk of PCR. Hence, it is prudent to be judicious in the use of topical

Table 1: Common predisposing factors for posterior capsular rent

A. Patient-related		
(i) General	**(ii) Extraocular**	**(iii) Intraocular**
Demented disoriented anxious elderly patients with possibility of subsequent inadvertent head movements	Deep set eye Prominent brow Exaggerated Bell's Phenomenon Poor visibility Corneal opacity Pterygium Thick arcus senilis Band keratopathy	Reduced work space Smll pupil Intraoperative miosis Shallow anterior chamber Excessive AC depth High myopia Post-pars plana vitrectomy Cataract type (posterior polar cataract) Pseudoexfoliation Dense asteroid hyalosis
B. Surgeon-related	**C. Intraoperative**	**D. Machine/devices**
Inexperienced surgeon Learning curve High-volume camp surgery	Small rhexis with rhexis block Rhexis-radial tear Fluidics-fluid imbalance	Unfamiliar machine Machine malfunction Microscope issues Exhausted irrigation fluid

anesthetic agents in the preoperative period. Instructing the patient to keep the eye closed during the immediate preoperative waiting period and frequent intraoperative lubrication may minimize this problem.

A small diameter continuous curvilinear capsulorhexis (CCC) may predispose the eye to develop capsulorhexis block during cortical cleaving hydrodissection. Continued hydrodissection without capsular bag decompression raises hydrostatic pressure thus causing a blowout of PC. There is also a constant risk of trauma to the small capsulorhexis margin with the oscillating phaco needle or chopping instrument. Enlarging the small capsulorhexis before hydrodissection is a good strategy to prevent hydrodissection-related complications including PCR.

An incomplete or escaped CCC is another important risk factor. In the presence of an incomplete capsulorhexis or a sharp angular notch in the capsulorhexis margin, the rapid buildup of intracapsular pressure or vigorous endocapsular manipulations may result in a peripheral extension of the capsulorhexis margin leading to a capsular tear. Hence, cortical cleaving hydrodissection, if performed, should be done very gently. Furthermore, aggressive in-the-bag nuclear maneuvers (rotation, cracking, or chopping) should be avoided. Some surgeons prefer using a nonrotational phaco technique employing gentle chopping maneuvers in the capsular bag or even in a more anterior plane while protecting cornea with the dispersive ophthalmic viscosurgical device (OVD).

The most severe tears occur during attempted emulsification of nucleus. An intact capsulorrhexis and use of low vacuum, low aspiration phacoemulsification reduce the incidence of PCR by minimizing surge. Low power phacoemulsification adds to the safety by reducing the chance of piercing through the nucleus and rupturing the PC. However, with the available current new-generation phacomachines, phacoemulsification can be performed safely with high vacuum parameters. During phacoemulsification, the second instrument of an appropriate design may be placed behind the remaining nucleus to hold the PC back and physically prevent it from contacting the phaco needle. Recently, a silicone irrigation aspiration (I/A) tip has become available, which may provide superior capsular protection.

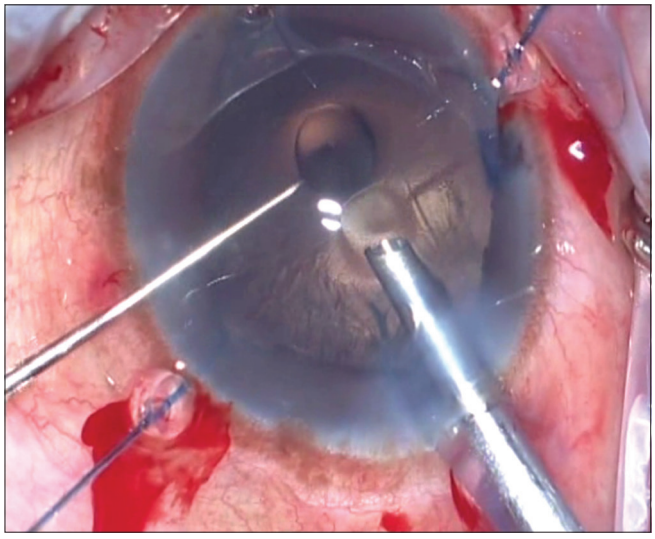

Figure 1: Posterior capsular rent in a postvitrectomy silicone-oil filled eye. Note the appearance of silicone oil globule

A thorough knowledge of phacoemulsification machine parameters is mandatory to prevent the occurrence of surge, maintenance of AC depth, as well as incidence of PCR. Sudden intraoperative equipment malfunction, suboptimal illumination or alignment of the microscope, the inadequacy of the infusion flow ("bottle-over" situation!) as well as kinked infusion or aspiration tubings may predispose to PCR. A thorough assessment before starting surgery will prevent these mishaps.

Prevention of Posterior Capsular Rent

An ounce of prevention is better than a pound of cure. An all-out effort should be made to avoid PCR during phacoemulsification.

Having an intact capsulorhexis margin is of paramount importance to prevent PCR. Cortical cleaving hydrodissection should be avoided in cataracts with a compromised PC. Posterior capsular blow out and "pupillary snap" is a common sequelae when cortical cleaving hydrodissection is attempted in these circumstances. Pupillary snap may also complicate a brisk hydrodissection in small capsulorhexis situations especially in elderly females with hard cataracts.

The pupillary snap sign was first described by Ronald Yeoh who reported sudden jerky pupillary constriction during hydrodissection and backward tilting of nucleus when phacoemulsification was continued.[35] He explained the phenomenon occurring when collected fluid behind the nucleus burst through the PC with posterior displacement of lens-iris diaphragm.

Knowledge of the stage of phacoemulsification when PC breach is more likely to occur is important. PCR is most common toward the end of phacoemulsification (a) at the time of emulsification of last nuclear piece (b) during IA and (c) during PC polishing; followed by early/mid phaco when the phaco needle may be inadvertently passed through the nucleus resulting in tear of PC or capsular equator.

Figure 2: Large irregular posterior capsular rent

Early Recognition of Zonular Rupture or Posterior Capsular Rent

If a PCR is not recognized in time, continued intraocular maneuvres required for phacoemulsification (viz., nuclear rotation, sculpting, cracking, and chopping) and fluctuations in AC depth will quickly enlarge the tear. Early recognition of PCR [Fig. 2] and prompt prophylactic measures will prevent expansion of the tear size, nucleus drop, and vitreous prolapse.

Signs of early PCR or zonular dehiscence are:

- Sudden deepening of AC with momentary pupil dilation
- Sudden transitory appearance of a clear red reflex peripherally
- Apparent inability to rotate a previously mobile nucleus
- Reduced efficiency of nucleus sculpting and a tendency for the nucleus to display a vibratory/tremulous movement
- Sudden difficulty in burying the phaco needle into nucleus
- Excessive tipping of one pole of the nucleus
- The partial descent of the nucleus into anterior vitreous space.

Some of these signs are transient. However, if the surgeon is alert, an early diagnosis of PCR may be suspected even though the PCR may not be visualized due to the overlying nucleus. If posterior capsule or zonular rupture is suspected the surgeon should decide whether to continue with phacoemulsification or convert to a safer nonphaco technique. This decision is based on the amount of nucleus remaining, the density of nucleus, other accompanying risk factors (e.g., small pupil, loose zonules, suboptimal endothelial status, etc.) and the individual surgeon's level of confidence and experience.

Most PC tears are small, to begin with. The surgeon should try to keep them from enlarging or extending peripherally preserving as much of PC as possible.

Posterior Capsule Rent-Avoiding (or Delaying) Extension of the Rent and Vitreous Loss

As soon as a problem is sensed, a knee-jerk reflex to suddenly withdraw the phaco or I/A tip from the eye should be avoided because this causes sudden AC collapse, rapid enlargement of PCR and vitreous prolapse. Rather the surgeon should stay put with irrigation running. AC should be filled with OVD through the side port incision to block vitreous prolapse and stabilize any remaining lens material before the removal of the phaco or I/A handpiece [Fig. 3]. The surgeon should stay in foot pedal position 1 with the irrigation running, and as the OVD is injected, he should change to foot position 0. The handpiece can then be safely removed. A low viscosity, less cohesive, and highly dispersive OVD is ideal as this helps to plug the PCR and tamponade the anterior hyaloid face better. However, if not available at hand, any other OVD can be used. Capsular pathoanatomy should be carefully assessed based on which the subsequent surgical strategy should be planned.

Figure 3: Posterior capsular rent; injection of ophthalmic viscosurgical device substance into anterior chamber with Irrigation in-place

Posterior Capsular Rent and Retained Nuclear Material without Vitreous Prolapse

In such situation, the surgeon should decide whether to continue with phacoemulsification or convert to a safe nonphaco technique (manual small incision cataract surgery, i.e. M-SICS or standard ECCE). If the nucleus is soft, and particularly if only a small residual amount remains, continuing with phacoemulsification may be a reasonable option. A Visco Shield strategy is employed in which the area of PCR is plugged with a generous dollop of dispersive OVD (Viscoat, Alcon). The remaining nucleus is moved away from the tear with the second instrument such as Sinskey hook to complete the emulsification. The nucleus should not be rotated using the phaco tip. The nuclear emulsification should be slowed down by reducing the aspiration flow rate, decreasing the vacuum (thereby reducing post occlusion surge) and by lowering the infusion bottle (to prevent pressurizing the anterior segment and driving the nucleus into the vitreous cavity). Short bursts of low energy ultrasound with low aspiration, effective vacuum, and reduced irrigation will decrease the risk of nuclear loss, chamber shallowing, and vitreous prolapse.

Intraocular lens (IOL) Scaffold [Fig. 4] is another technique which has been described wherein a multipiece hydrophobic

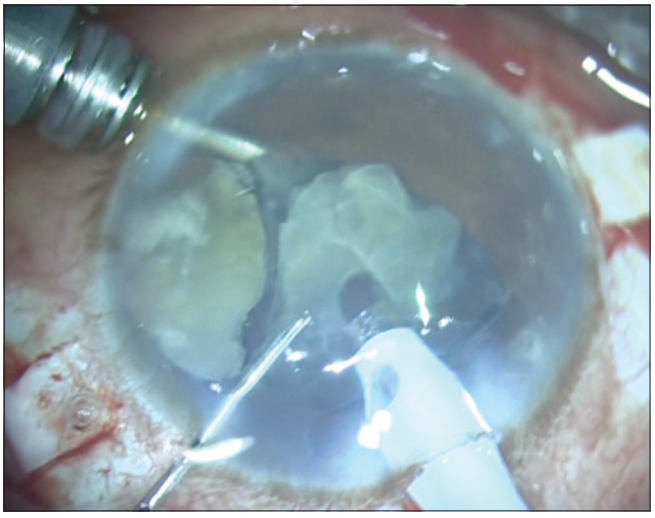

Figure 4: Intraocular lens scaffold technique (Picture courtesy Dr. Priya Narang). In this technique, a multi-piece hydrophobic acrylic intraocular lens is placed at a plane anterior to the posterior capsular rent and the nucleus is emulsified in anterior chamber in front of the intraocular lens

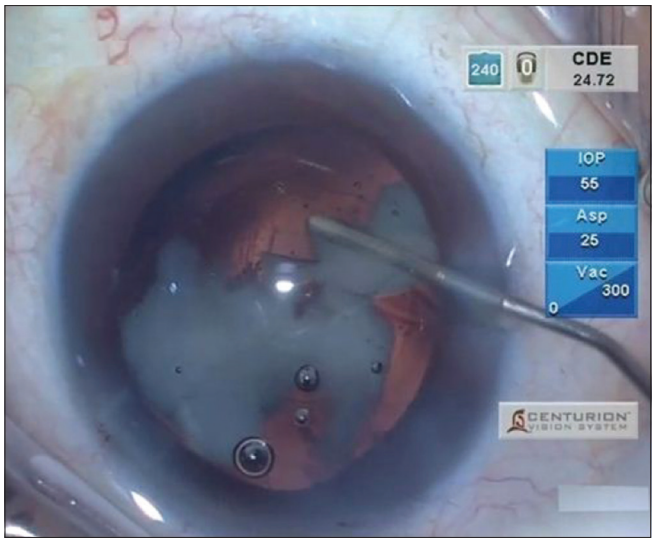

Figure 5: Triamcinolone acetate injection in anterior chamber to stain the vitreous prior to anterior vitrectomy in case of posterior capsular rent

acrylic IOL is placed at a plane anterior to the PCR and the nucleus is emulsified in AC in front of the IOL.

Removal of residual cortex and epinucleus can be safely accomplished without extending PCR by following several surgical principles. The bimanual technique offers safer and better access to the sub-incisional area and allows the aspirating port to be positioned peripherally aimed away from the rent or dehiscence. Lowering I/A flow and vacuum settings will reduce speed and postocclusion surge, respectively. The cortex remote from the tear should be removed initially and should be stripped toward the rent. Any force generated away from it will cause its extension. Heroic efforts to remove all cortex should be avoided since such attempts might extend the tear and further compromise capsular bag integrity. An alternative method of cortical removal is manual aspiration using both a bent cannula and a J-shaped cannula under the protection of an OVD. This manual technique of "dry" aspiration of cortex decreases the risk of tear extension and VL.

Conversion to a Safer NonPhaco Technique (Manual Small Incision Cataract Surgery/Extra Capsular Cataract Extraction)

If a PCR is suspected or discovered at an early stage and if there is a significant amount of residual nucleus (especially brunescent), or if other coexisting risk factors are present, it is advisable to convert to either M-SICS or ECCE. The first step is to prevent the loss of nuclear fragment(s) into vitreous. After stabilizing the nucleus by injecting a dispersive OVD underneath it, a Sinskey hook passed through a fresh paracentesis opposite the incision may be used to loosen and manipulate nuclear material into the AC. It may be necessary to apply a relaxing incision to the capsulorhexis margin for nuclear manipulation. A bimanual technique using the second hook from an additional paracentesis site may help in some situations.

If a temporal clear corneal incision was constructed, it may be sutured, and a fresh superior or temporal sclerocorneal tunnel incision should be constructed. If a sclerocorneal incision had been utilized to start with it, it can be extended. Incision size depends on the size of the residual nuclear fragment. Next, an irrigating vectis and/or secondary lens manipulator is used to extract nucleus under cover of OVD. While expelling the nucleus the vectis should apply gentle pressure against the posterior lip of the wound. Lifting and dragging of nucleus against the cornea and bimanual pressure-counter pressure technique should not be employed. Once the lens nucleus has been removed, anterior segment surgery should proceed as per the guidelines suggested in the succeeding sections. The wound is sutured with interrupted or running 10-0 nylon suture.

A sheet's guide-assisted nucleus fragment removal is another option but is not used commonly nowadays.

Posterior Capsular Rent with Residual Nucleus and Vitreous Prolapse

The goal in this situation is to remove the remaining lens matter (nucleus, epinucleus, and as much cortex as possible) without causing vitreoretinal traction and without extending the PCR while at the same time minimizing vitreous loss (VL). The following strategies help the surgeon in arriving at this goal: (1) rescuing or managing a partially descended nucleus, (2) an appropriate anterior vitrectomy technique and (3) removal of the residual lens matter.

Rescuing a Partially Descended Nucleus

Early recognition of PCR is crucial to avoid a dropped nucleus. If the surgeon fails to detect a PCR early enough, he may continue with standard phaco maneuvers and the forces will expand the small defect into a bigger hiatus thus causing nucleus drop. Sinking of the nuclear fragment into posterior segment depends on factors such as brunescence of the nucleus, the status of the vitreous, and size of the PCR. A brunescent nucleus may quickly sink into the posterior segment through a liquefied vitreous even without antecedent vitreous loss. However, in the presence of formed vitreous, the nucleus may descend only partially allowing for rescue maneuvers.

In the face of a descending or partially descended nucleus below PC, no attempt should be made to chase the nucleus with the phaco tip. An ideal strategy is to lift the nucleus into a more anterior plane in the bag, pupillary plane or AC for subsequent management either by extraction via a nonphaco technique or by careful phacoemulsification. This can be accomplished through pars plana or through anterior segment.

The nucleus may be successfully maneuvered by injecting dispersive OVD behind the nucleus (viscolevitation) and/or guiding it with a hook via limbal approach. This strategy may fail in presence of a small and intact capsulorhexis, small pupil, vitreous prolapse around the nucleus and lateral or posterior location of the descended nucleus.

Posterior-assisted Levitation Technique

Charles Kelman described this technique in 1996 and coined the term posterior assisted levitation (PAL).[36,37] However, in 1991, Richard Packard described a similar technique.[38] He later modified his technique by using a dispersive viscoelastic through the pars plana to elevate nuclear pieces, which was presented at the American Society of Cataract and Refractive Surgeons Meeting in 1999.

In the classic PAL technique,[38,39] a pars plana sclerotomy is performed at the 11 o' clock meridian, 3.5 mm behind the limbus using a 20 G microvitreoretinal (MVR) blade. A spatula passed through the sclerotomy is placed behind the nucleus which is then elevated forwards into the AC and subsequently managed by phacoemulsification or manual removal. Residual vitreous is removed by performing bimanual anterior vitrectomy through pars plana sclerotomy and the limbal paracentesis.

The PAL technique has been discouraged by vitreoretinal surgeons as a complication-prone procedure with the potential of inducing unwarranted vitreous base traction leading to retinal holes and subsequent retinal detachment.

Managing Residual Nucleus with Vitreous Loss

If the rescued nucleus has been levitated largely intact into the AC, it may be desirable to convert to manual SICS or ECCE (as described previously). Smaller fragments may be removed by phacoemulsification employing "Visco Shield" strategy. "Lens Scaffold" technique may be utilized.[40,41] Surgical removal of vitreous in AC and endothelial protection with generous amounts of a dispersive OVD are 2 prerequisites before attempting phacoemulsification through this strategy.

If there is minimal vitreous in AC and if it can be accomplished safely, an attempt may be made to remove cortex and epinucleus by employing bimanual I/A or "dry technique" before vitrectomy. This maneuver may decrease the chance of lens matter loss into the vitreous, as the supporting vitreous is surgically removed. However, once vitreous gets ensnared in the phaco tip or aspiration port, it should be suitably addressed (described in the subsequent section).

Vitrectomy for Anterior Segment Surgeons

Every anterior segment microsurgeon should have vitrectomy techniques and equipment at his or her fingertips and should be aware of

1. Vitrectomy instrumentation
2. Infusion options
3. Basic principles and technique of anterior vitrectomy.

Vitrectomy Instrumentation

Microsurgical advanced vitrectomy cutter with high performance proportional linear suction control is a necessity for anterior segment surgery. Although 20-gauge (20G) vitrectomy cutter can be used, nowadays 23G and 25G cutters have become more popular. Phacoemulsification handpiece should never be used to remove the vitreous as the phaco probe liquefies hyaluronic acid alone but does not cut the collagen fibers.

Settings for Anterior Vitrectomy

Use of the maximum possible cutting rate, lowest vacuum and flow rates reduces traction on the retina. The vitrectomy cutter should be advanced or held stationary during anterior vitrectomy and never pulled away while cutting.

Testing for Vitreous in Anterior Chamber

Detection of vitreous in AC at an early stage is crucial to prevent further vitreous disturbance and contain collateral damage.

Vitreous gel is invisible under the microscope. Hence, triamcinolone acetonide (TA) has been used by retinal surgeons to optimize visibility of vitreous body [Fig. 5] during pars plana vitrectomy.[42,43] Burk *et al*. and Yamakiri *et al*. have reported the intracameral use of TA to enhance the visibility of vitreous in the AC after PCR during cataract surgery.[44,45] TA particles get entrapped and impregnated in the vitreous rendering it visible under microscope.

Preservative-free triamcinolone (Aurocort, 4%, Aurolab, India) is preferred. Vitreous in AC should ideally be confirmed by triamcinolone injection as soon as a PCR is suspected. It is also used after IOL implantation. If vitreous strands are detected, a final vitrectomy is done.

Infusion Options

1) Coaxial Infusion Cannula for vitrectomy by slipping the infusion sleeve over the vitrectomy tip is no longer used since there are several disadvantages and dangers of using a coaxial system such as: (a) Enlargement of the PCR (b) Hydration of the vitreous and (c) Flushing more vitreous into AC.

Bimanual Technique with Separate Infusion Line

This is the preferred technique and can be achieved through either bimanual limbal or pars plana anterior vitrectomy.

Bimanual limbal anterior vitrectomy

The infusion line is connected to an AC maintainer or the irrigation handpiece of the bimanual I/A system. The infusion cannula should be kept parallel to the iris farthest from the location of PCR and hence the infusion is directed toward AC and the vitrectomy cutter can remove the fluid before it escapes into the body of the vitreous [Fig. 6]. The vitrector tip is passed through a paracentesis wound of matching size. A fresh paracentesis may be fashioned if not already present. This facilitates vitrectomy in a closed chamber away from the main phaco wound. The vitrectomy tip is inserted through the opening in the PCR and placed 1–2 mm behind the posterior capsule. The aspiration port is directed upward toward cornea.

The strategy is to pull the vitreous in AC down to the vitrectomy tip until AC is clear of vitreous. Vitreous should be removed to the level of and just below the PC leaving the remaining vitreous intact. Vitreous removal is facilitated by staining with triamcinolone. An effective strategy is to initiate dry vitrectomy and then gently initiate balanced saline solution

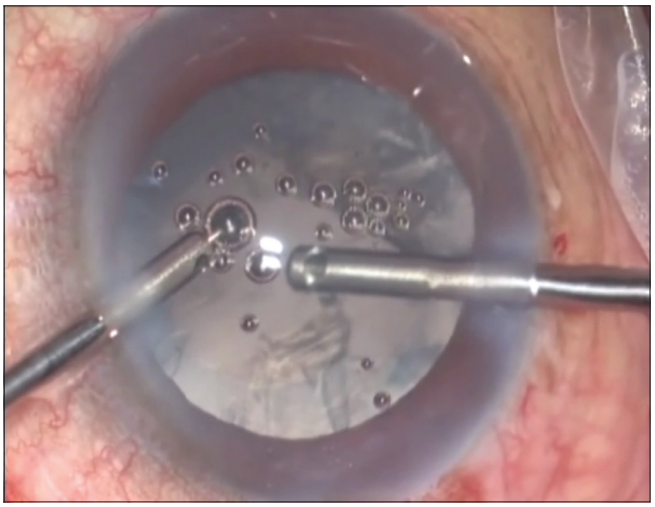

Figure 6: Bimanual limbal anterior vitrectomy

infusion when the chamber tends to collapse. A closed chamber environment with a deep AC is mandatory to optimize the outcomes.

The pars plana approach for anterior vitrectomy

Vitreoretinal traction can be reduced significantly by performing the vitrectomy through a pars plana incision. This allows the surgeon to "pull down" or "bring home" the prolapsed vitreous from the AC, thus markedly reducing the amount of vitreous that is removed from the eye. When working from the limbus and bringing vitreous *upward*, it is more difficult to find an endpoint, hence unintentionally a considerable portion of the vitreous body is removed and the eye becomes hypotonic.[46]

Another advantage is the enhanced access to residual lens matter. The surgeon can remove even dense nuclear material with the vitrector by gradually increasing vacuum and reducing the cutting rate. For performing an anterior vitrectomy, the recommended parameters are highest cutting rate with lowest possible vacuum that will permit vitreous aspiration.[47] In this way, a more complete anterior vitrectomy can be achieved thereby reducing secondary complications: increased intraocular pressure (IOP), inflammation, and cystoid macular edema. To assess completeness of vitrectomy and for better visualization, staining of the vitreous with preservative-free TA is advised.[48]

Infusion may be placed through a limbal paracentesis incision or a second pars plana incision. The surgeon should select the clock hour of vitrectomy incision to best access remaining lenticular material. The 3, 6, 9, and 12 o'clock scleral incisions should be avoided to avoid injury to ciliary vessels and nerves. A caliper should be used to measure 3.5 mm posterior to the limbus in the quadrant most convenient to the dominant hand, avoiding perforating vessels.[49]

Depending on surgeon's preference, a 23 or 25-gauge vitrectomy can be performed.[50] These allow sutureless surgery. A dedicated disposable valved trocar cannula should be used to create an appropriately sized watertight biplanar incision. The trocar system is a hollow tubed cannula that encases a sharp MVR blade. Once the incision is completed the blade is withdrawn leaving the tube as a conduit for the vitrectomy cutter. A trocar cannula system offers another advantage: it protrudes into the vitreous cavity, and hence, the vitrectomy probe never gets close to the retinal surface, as it does when inserted through a bare sclerotomy. This design provides a margin of safety for entry and exit and decreases the risk of retinal tears.

A soft eye can develop choroidal detachment or hemorrhage due to incomplete penetration with this procedure.

It is important to preserve as much of the capsule as possible, especially the anterior capsular rim, to facilitate IOL implantation. The infusion should be minimal—just enough to maintain an adequate IOP. Generous use of appropriate OVD will aid in maintaining volume, further decreasing the need for infusion. A dispersive OVD works best to tamponade the hyaloid face, while a more cohesive OVD maintains space.

Vitrectomy without Irrigation (Dry Vitrectomy)

This is a useful technique in performing a small vitrectomy. This technique has the added advantage of pushing vitreous backwards thus reducing the amount of vitrectomy required.

Intraocular Lens Management in the Presence of a Posterior Capsular Rent

The primary requirement for a well-centered in the bag IOL after phacoemulsification surgery is a stable capsule-zonular support. In a PCR situation, the capsule-bag complex is compromised. In this situation, the surgeon is confronted with the issue of when and how to correct the aphakic status for optimal visual rehabilitation.[51] The residual capsule-zonular support and the exact anatomy of the PCR should be clearly understood before making a decision.

Gentle retraction of the iris under OVD protection at multiple locations may provide an idea as to the most desirable location and orientation of posterior chamber IOL (PCIOL), its design and optimal implantation technique. The various methods of IOL fixation in the absence of an adequate capsule-zonular support are summarized in Table 2.

If PCR is small with well-defined borders and is central in the location the irregular rent can be converted into a posterior continuous curvilinear capsulorhexis (PCCC). This renders the tear strong and resistant to a peripheral extension even if the capsular bag happens to be stretched during IOL implantation. The surgeon may then employ any in the bag PCIOL of his choice. IOL implantation using a dialing technique is likely to exert more force than a trailing haptic compression maneuver or a slowly unfolding IOL in the capsular bag.

However, if there is a significant loss of the posterior capsule a standard endocapsular PCIOL is ruled out. A 3-piece hydrophobic acrylic PCIOL (with a minimum optic diameter of 6 mm and haptic diameter of 13 mm) placed in the ciliary sulcus is a good option. If the capsulorhexis is intact and smaller than the optic, the PCIOL optic should be posteriorly captured/buttonholed [Figs. 7, 8]. This strategy locks the IOL in place guarding against future decentration. IOL power adjustment is not required since the IOL optic is located within the capsular bag. If successful optic capture has not been achieved the PCIOL is fixed in the ciliary sulcus. Since the IOL position is more anterior the power is adjusted in accordance with an online nomogram available at http://doctor-hill.com/iol-main/bag-sulcus.htm.[52] This roughly corresponds to a 5% reduction from the predicted capsular bag IOL power. A single-piece hydrophobic acrylic IOL

Table 2: The various methods of fixation of an intraocular lens in the presence of an inadequate capsule-zonular support

Anterior chamber IOL
Iris fixated IOL
Anterior iris claw IOL
Posterior iris claw IOL
Iris sutured IOL
Sulcus fixated IOL
Scleral fixated IOL
Sutured IOL
Sutureless Intrascleral haptic fixated IOL
In-the-bag IOL
Temporary aphakia followed by secondary IOL implantation

IOL: Intraocular lens

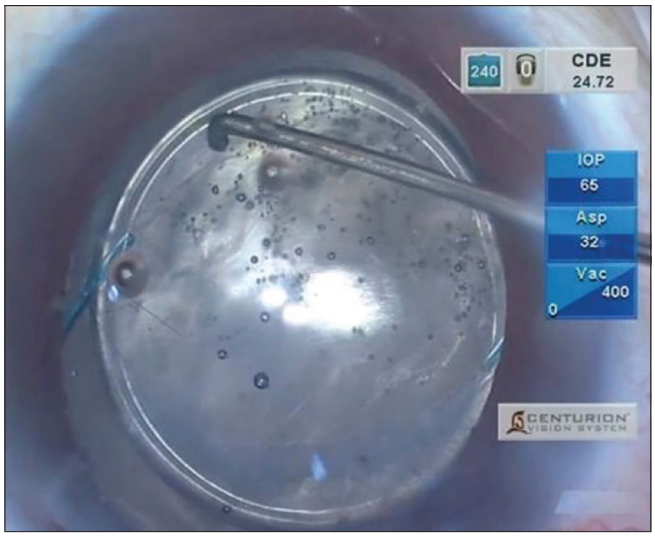

Figure 7: Posterior chamber intraocular lens posterior chamber intraocular lens implantation in case of posterior capsular rent; optic of the intraocular lens being captured through the posterior capsular rent

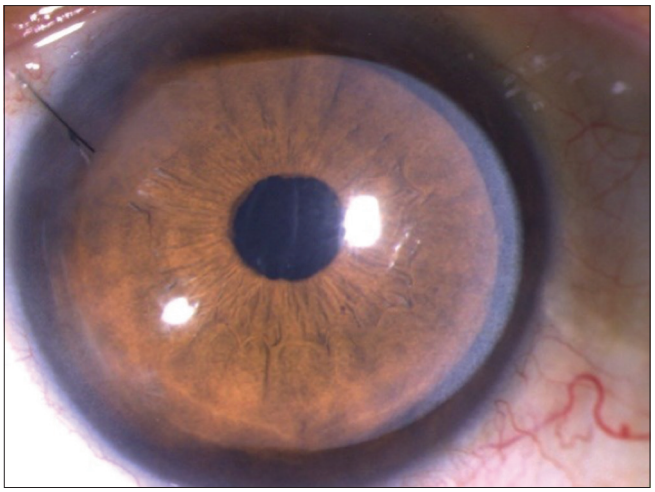

Figure 8: Round pupil and well-centered posterior chamber intraocular lens (placed in the capsular bag with optic capture) in a case of posterior capsular rent

should never be implanted in the ciliary sulcus. If the overall capsular support is found inadequate for PCIOL implantation, a power-adjusted ACIOL or iris-fixated IOL is an option. Some surgeons prefer to leave the patient aphakic and consider a secondary IOL implantation with the hope that progressive capsular fibrosis may offer stability for a sulcus-fixated PCIOL. Scleral fixated (sutured/unsutured) IOL is another option. With recent advances in VR surgical techniques, some surgeons prefer implanting an IOL in the primary sitting with the dropped lens matter removal by pars plana vitrectomy by a VR surgeon planned as a secondary procedure.

Postoperative Management in Posterior Capsular Rent

Endophthalmitis prophylaxis with intracameral moxifloxacin available as Vigamox (off-label) and postoperative use of one oral dose of moxifloxacin (400 mg P. O.) should be considered since it crosses the blood–retinal barrier to achieve an appropriate minimum inhibitory concentration (MIC) in the vitreous.[53]

Patients with a ruptured hyaloid face need an aggressive anti-inflammatory regimen which should start in the immediate postoperative period.[54]

It is necessary to warn all patients who have undergone anterior vitrectomy to expect floaters postoperatively and to report if they experience pain or decreasing vision at any time. Postoperative IOP spikes should be treated aggressively and followed up closely, especially over the first 48 h. Retinal examination with scleral indentation to visualize the retinal periphery is done in all patients 1–2 weeks after surgery. The patients should be closely monitored for cystoid macular edema CME with an Amsler grid at home looking for decreased contrast and metamorphopsia. Optical coherence tomography is indicated during follow-up. A longer taper of topical steroids and continuing topical nonsteroidal anti-inflammatory drugs for a longer period than routine cases (off-label) to prevent CME is indicated. Ocular hypertension prophylaxis is wise for eyes with residual OVD or lens fragments. In case of retained lens material, a timely referral to a retinal specialist for definitive treatment is needed. It is critical to inform these patients of their increased risk of developing a retinal tear or detachment in future, in addition to the increased risk of glaucoma and CME.[54,55]

Complications Associated with Posterior Capsular Rent

PCR carries the risk of precipitating additional problems which may require vitrectomy, loss of lens material into the vitreous cavity (0.05%–1.2%), a higher incidence of postoperative complications such as chronic intraocular inflammation, CME (41%), IOL dislocation, retinal detachment (0.2%–8.3%), and endophthalmitis.[1-3]

Complications associated with PCR can be classified into those involving the anterior segment and posterior segment of the eye.

Anterior segment complications of PCR can be divided into:[4,5]

- Early postoperative anterior segment complications: Striate keratopathy, corneal edema, glaucoma, uveitis, and fibrinous reaction
- Late postoperative anterior segment complications: Pseudophakic bullous keratopathy, glaucoma, and epithelial downgrowth into AC.

Early Postoperative Anterior Segment Complications

Striate keratopathy and corneal edema[5,6] may be caused by (a) corneal endothelial damage and inadequate endothelial pump function due to surgical trauma, (b) excessive intraocular manipulation during vitrectomy and removal of the nuclear fragments from AC (c) increased IOP after surgery (d) uveitis due to excessive intraoperative iris damage and (e) presence of vitreous in the AC, if not cleared adequately, will cause persistent vitreo-corneal touch and endothelial damage in the long run.

Glaucoma: Both open-angle and closed-angle mechanisms may contribute to elevated IOP in the early as well as late postoperative

period. Open-angle glaucoma may result from blockage of outflow channels by retained OVD, vitreous, retained nuclear/cortical fragments, inflammatory cells, pigment dispersion from excessive intraocular manipulation, and exacerbation of preexisting glaucoma or steroid-induced glaucoma. Use of TA may also cause an IOP spike in the postoperative period if a thorough anterior vitrectomy is not performed.

OVD molecules block the trabecular meshwork and cause open-angle glaucoma within the first 4–8 h postoperatively, and resolves within 24–72 h.[6-8] Close monitoring of IOP is required in the early postoperative period. IOP spikes can be managed with topical and systemic anti-glaucoma drugs.

Presence of vitreous in AC may cause aqueous outflow obstruction in the early and late postoperative period. It may or may not be associated with significant inflammation.

Dislocation of lens fragments into vitreous cavity is associated with elevated IOP in up to 50% of the cases.[9] Vitrectomy within the first 2 weeks postoperatively is recommended to reduce the incidence of glaucoma. IOP should be medically controlled till corneal edema resolves before planning vitrectomy. Residual cortical matter in the anterior segment is common after a PC tear and may cause lens-particle glaucoma necessitating topical steroids and anti-glaucoma drugs.

Inflammatory glaucoma may be due to trabeculitis, endotheliitis or cellular debris blocking the trabecular meshwork. Topical beta-blockers, topical and systemic carbonic anhydrase inhibitors and hyperosmotic agents (mannitol 20%) are the preferred agents. Miotics and prostaglandin analogs are avoided because they may induce more inflammation.

Uveitis and fibrinous reaction:[5,10,11] Iritis and uveitis occur postoperatively due to excessive intraoperative handling of uveal tissue, retained cortical material or OVD, and residual vitreous in the AC. Intraoperative factors such as prolonged surgical time and vitrectomy may contribute to increased inflammation.

Late postoperative anterior segment complications

Pseudophakic bullous keratopathy[5,10,11] presents as long-standing corneal edema, unresponsive to medical management. It is due to corneal decompensation as a result of the inadequate endothelial function. In patients with an intraoperative VL the risk of corneal decompensation is increased.

Epithelial downgrowth into AC-vitreous incarceration in surgical wound prevents proper wound closure and may allow surface epithelium to enter AC. This may result in a sheet of epithelial downgrowth over the iris or corneal endothelium and may further contribute to bullous keratopathy and intractable glaucoma.

Posterior segment complications of posterior capsular rent

Dislocated lens fragment

The reported incidence of nuclear fragments in vitreous cavity following a PCR is 0.3% (2-3operations/1000/year)[12,13] to 1.1%[14] and is reported to be inversely proportional to the surgeons' experience and surgical volume. PCRs in phacoemulsification are more central than in ECCE and are hence more conducive to the posterior migration of the nuclear fragment.

The complications of a dropped nucleus include elevated IOP, uveitis, corneal edema, CME, and retinal detachment. Hence, proper management of VL and retained lens fragments is the most crucial factor influencing the chances of an excellent visual outcome.

Dislocated posterior chamber intraocular lens

Early postoperative dislocation is caused by placing part or all of the IOL through the PCR into the anterior vitreous. When dislocation occurs more than a few days or weeks after surgery, it is attributed to spontaneous IOL haptic rotation away from the meridian of posterior capsular remnants. A dislocated IOL can produce complications such as corneal edema, recurrent intraocular inflammation, retinal detachment, CME, and glaucoma all of which form relative indications for vitreous surgery.

Pseudophakic cystoid macular edema

The incidence of pseudophakic cystoid macular edema (PCME) in eyes with PCR and VL has been reported as 21%–46%.[15] Presence of PCR, iris trauma, VL, retained lens fragments, and prolonged operating time are all predispositions which result in multiple insults to the vascular permeability and retinal homeostatic mechanisms, resulting in an increased risk of developing PCME.[15] Selection of IOL also plays a role in PCME development. Iris-fixated IOLs have the highest reported rate of PCME, and AC IOLs (ACIOLs) have a higher rate than PC IOLs.[15]

Retinal detachment after cataract surgery with posterior capsular rent

Pseudophakic retinal detachment (RD) constitutes 40%.[16-18] of patients referred to vitreoretinal surgeons for retinal reattachment surgery. The incidence of RD after cataract surgery ranges from 0.6% to 1.7% during the first postoperative year. The estimated risk for developing RD was 5.5 times higher in patients who had undergone cataract surgery than in those who did not. The average 1% incidence of RD after uncomplicated cataract surgery increases to 8.6% after the occurrence of intraoperative PCR and VL, and 14.5% when lens fragments are retained.

Postoperative endophthalmitis

The incidence of endophthalmitis following cataract surgery in estimates from eight large studies range from 0.05% to 0.30%.[19-24]

Taban *et al*. in a meta-analysis of the literature identified 215 studies reporting rates of postoperative endophthalmitis after cataract surgery, collectively among 3,140,650 patients. The endophthalmitis rate was 0.128%.[23] One of the most important risk factors associated with endophthalmitis following cataract surgery is the occurrence of intraoperative PCR and need for anterior vitrectomy.

The risk of developing this complication is increased in the presence of intraoperative (such as PCR, VL, etc.) and postoperative complications such as vitreous incarceration at the section, vitreous wick, wound dehiscence, suture abscess, or wound site infection.

Conclusion

The incidence of PCR can be decreased significantly by identifying the presence of predisposing factors and appropriate modification of the surgical plan. Early recognition of posterior capsular tear along with prompt management of capsular tear and vitreous prolapse is key to the good postoperative outcome.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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