Phacoemulsification in Post Vitrectomy Cataracts

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Introduction

Cataract development is one of the most common complications after vitrectomy; it develops in 12.5% to 80% of eyes.\(^{1-7}\) The risk factors for the development and progression of cataract are older age\(^ {7,8}\), degree of preoperative nuclear sclerosis\(^ {9}\), intraoperative lens touch, diabetic retinopathy\(^ {10}\), and silicone oil injection\(^ {11}\). The mechanisms of development of cataract in eyes which have undergone prior vitrectomy are many. These include lens touch with intraocular instruments, intraocular tamponading agents (silicone oil, gas), crystallization process involving anterior hyaloid or posterior capsule resulting in reversible posterior capsular lens feathering and the influence of blood or inflammation leading to free radical release in the posterior segment. The indications for pars plana vitrectomy are fast expanding and the number of patients undergoing this procedure is increasing because of the improved surgical results. Therefore, the number of vitreoretinal surgeries is rising each year and hence a significant increase in the volume of vitrectomized patients, who in their vitrectomized state pose a challenge to the cataract surgeon.

Risks in Vitrectomized Eyes

The vitrectomized eyes are at a higher risk of developing intraoperative and postoperative complications due to following factors:

1. The eyes harbor sequelae of previous surgery and inflammation
2. They have associated comorbid conditions
3. Nuclear brunesence (denser cataracts) is common
4. They lack the support of vitreous gel.

The higher risks stem from the fact that these eyes are anatomically different from eyes that have not undergone prior surgery. The following factors need to be taken care of while dealing with postvitrectomy cataracts:

(a) Conjunctival scarring

 Conjunctival scarring makes conjunctival dissection for fashioning the scleral tunnel difficult. If the patient has undergone prior scleral buckling procedure, scarring around the bridled extraocular muscle makes exposure difficult and insufficient. Increased episcleral scarring and bleeding should be anticipated in the vicinity of previous scleral ports. Therefore, it is preferable to perform phacoemulsification through a clear corneal incision than through a scleral tunnel. A rigid IOL implantation through the clear corneal incision may necessitate enlarging the incision and securing it with sutures at the conclusion of the procedure.

(b) Compromised corneal endothelium

In the postvitrectomized eyes, the corneal endothelium is often compromised especially in those cases where silicone oil is present in the anterior chamber

(c) Poor pupillary dilatation

In most vitrectomized eyes, the pupil does not dilate properly despite the use of mydriatics before phacoemulsification.
(d) Zonular weakness and preexisting posterior capsular rent

The chances of having compromised zonule, loose capsular bag, and pre-existing posterior capsular dehiscence are more in patients who have undergone lengthy vitreoretinal surgery, multiple procedures, and vitrectomy involving vitreous base dissection.

(e) Low scleral rigidity

Low scleral rigidity is seen in vitrectomized eyes especially in patients with high myopia. In these patients additional support using a Fleiringa’s ring or a separate self maintaining infusion may prove useful.

(f) Cystoid macular edema

Vitrectomized eyes are predisposed to a high incidence of cystoid macular edema.

(g) Diabetic retinopathy

Worsening of preexisting diabetic retinopathy necessitates meticulously scheduled postoperative follow-up for early detection of worsening and management.

(h) Increased lens-iris diaphragm retropulsion

An increased lens-iris diaphragm retropulsion or infusion deviation syndrome can occur in vitrectomized eye.

Preoperative Considerations

A thorough preoperative evaluation taking into account the patients’ compromised ocular health, structural changes resulting from trauma of the earlier surgical procedure and the poor visual potential is necessary in formulating a definite surgical plan. A good preoperative surgical planning helps to formulate strategies for the expected or anticipated intraoperative difficulties and goes a long way in giving the patient the best overall visual benefits.

History

A detailed history on the nature of the vitreoretinal pathology and the extent of previous surgery is important as they have a direct bearing on the success or complexity of the phacoemulsification procedure and its overall benefit to the patient. An eye which has undergone a limited vitrectomy and in whom the clear anterior vitreous cortex is left untouched will behave differently from one which has undergone multiple procedures involving anterior vitreous base excision for complex vitreoretinal pathology. Lengthy procedure and vitreous base excision may increase the likelihood of developing zonular dehiscence and occult posterior capsular rupture.

Patients with diabetic retinopathy should be considered for surgery only after their retinopathy is under control, since there is a good chance for worsening of the retinopathy following cataract surgery.

Cystoid macular edema may occur more frequently after cataract surgery in vitrectomised eyes and hence it is prudent to start the patients on preoperative topical nonsteroidal anti-inflammatory drops.

Preoperative work-up

Preoperative examination should make a note of following important findings:

The presence of conjunctival and episcleral scarring, endothelial cell count, deep anterior chamber and presence of emulsified silicone oil bubbles in it, presence of iridophacodonesis indicating compromised zonules, pupillary status, and detailed examination of retinal status especially to assess integrity of macula, and presence of open breaks.

In eyes with advanced cataract, evaluation with an indirect ophthalmoscope may not be feasible and an assessment is made using a B-scan. B-scan in the presence of silicone oil, however, gives very few relevant details and has limited utility.

Intraocular lens power considerations

Intraocular lens (IOL) power considerations differ in eyes without silicone oil tamponade and eyes having silicone oil tamponade.

Eyes without silicone oil tamponade

The IOL power considerations are the same as for a standard phacoemulsification in eyes without silicone oil tamponade.

Eyes having silicone oil tamponade

Silicone oil is used in vitreoretinal surgery as a tool to reduce retinal detachment and in the presence of proliferative vitreoretinopathy among other conditions.
In these eyes IOL power measurements are to be considered under two headings.

(i) **Measurement of the Axial Length**

Measuring the axial length (AL) of an eye filled with silicone oil can be a challenging situation because of various reasons. The low velocity within the silicone oil will cause an erroneous measurement and hence it is also necessary to correct the apparent axial length to true axial length in silicone oil filled eyes.

On B-scan examination the globe appears elongated with an unfocused appearance. On the echogram, the retinal echospike is small and difficult to display due to the sound attenuation within the liquid silicone. The system sensitivity should be increased to better identify the retinal spike.

When the silicone oil fill is incomplete, it may move around, giving rise to shifting retinal echoes, increasing the difficulty in obtaining an axial length measurement. In supine position, the silicone oil will rest on the retina while the liquefied vitreous will layer on top of it. Hence if measurement is made in the supine position (as is usually done in the immersion technique) the ultrasound beam will cross the area of liquefied vitreous first before crossing the area filled with silicone oil. Separate measurements for these two areas will be necessary to accurately measure the vitreous cavity depth. In these circumstances it is advisable to perform biometry while the patient is seated. In this position the residual liquefied vitreous will move towards the superior position of the vitreous cavity, leaving only part of the silicone oil in the optical axis where the measurement is taking place.

In silicone oil filled eye, sound travels slowly (1550 m/s in normal phakic eye vs. 1000 m/s in silicone oil filled eye). This factor makes it difficult to obtain axial length measurement.

The low velocity within the silicone oil causes an erroneous measurement of vitreous cavity depth (VCD). The formula to correct AL in any silicone oil filled vitreous is:

1. \[ VCD_{1532} = AL \times (ACD+LENS) \]
2. \[ VCD_{corrected} = VCD_{1532} \times \left(\frac{1}{1532}\right) \times 980 \text{ m/s (or 1040 m/s depending on viscosity of silicone oil used.)} \]
3. \[ AL_{corrected} = VCD_{corrected} + ACD + LENS \]

(1532 is the average velocity of sound in aqueous and vitreous)

The conversion factor of 0.71 multiplied by the measured axial length has been reported to correct for the apparent increase in axial length induced by silicone oil of viscosity 1000 cSt.

In case of a cataract not so advanced or mature to impair fundus examination, partial coherence interferometry (IOL Master, Zeiss) is preferred over ultrasonography to calculate the axial length of the silicone oil filled eye.

In cases of eyes filled with gas or perfluorocarbons, ultrasound echoes are blocked.

Unsuitable formulas, artifacts or large eyes beyond the machine range may cause significant errors. In certain eyes it is impossible to obtain the axial length. The following options may then be considered:

(a) Measure axial length before vitreoretinal surgery and silicone oil injection
(b) Measure axial length after silicone oil removal
(c) Measure axial length of the fellow eye (provided the patient is not one-eyed)
(d) CT-scan image can be used to measure axial length in eyes with incomplete silicone oil fill.
(e) The final option would be to consider the use of standard power IOL.

(ii) **Calculation of an appropriate IOL power**

Silicone oil tamponade alters the optics of the eye. The index of refraction of silicone oil (1.405) is higher than that of the vitreous gel. The higher refractive index of silicone oil makes it behave like an intraocular minus lens. Therefore, without appropriate power adjustment,
significant hyperopic overcorrection would be expected. As a result, standard theoretical and regression lens power formulas calculate a lens power which is less than needed to achieve emmetropia, resulting in a hyperopic refractive error.

The more curvature or power incorporated in the posterior surface of the lens, the greater is the postoperative error.

If the silicone oil is to be retained in the vitreous cavity at the time of IOL implantation the surgeon should consider adding 3-8 D to the calculated IOL power, depending on lens shape to achieve emmetropia. If silicone oil removal is performed at a later date patient should be forewarned that there will be a myopic shift. This shift is greater in the presence of a biconvex than planoconvex lens with the plane surface facing posteriorly. Eyes with the posterior meniscus IOLs experience the smallest change. Thus when silicone oil is filling the vitreous cavity the rule of thumb to arrive at the necessary IOL power is as follows:

(a) Use convexo-plano IOL to minimize effect of silicone oil (add 3 to the calculated IOL power).

(b) If using a biconvex lens, add 6 D to the calculated power.

(c) When silicone oil removal is performed 2-5 D of induced myopia should be expected.

In some patients the silicone oil tamponade has to be executed for long periods of time. In these cases IOL power adjustments have to be considered as silicone oil alters the refractive power of the posterior surface of the IOL.

Patel (1995) and Meldrum have suggested using the following correcting formula to find the additional IOL power to be added to the calculated IOL power to arrive at the power of IOL to be implanted in a silicone oil filled eye:

\[
\text{Additional IOL power} = \frac{(N_s - N_v)}{(A_L - A_C)} \times 1000
\]

\(N_s\): Refractive index of silicone oil (1.4034)

\(N_v\): Refractive index of vitreous (1.336)

\(A_L\): Axial length in millimeters

\(A_C\): Anterior chamber depth in millimeters

**Choice of Intraocular Lens (IOL)**

Both the hydrophobic and hydrophilic acrylic IOLs have been associated with consistently satisfactory outcome and have been well tolerated by the eye. A rigid PMMA IOL may also be considered. A silicone IOL should be avoided in an eye that has undergone prior vitrectomy. Also one piece plate haptic design lenses and lenses with small and ovoid optics should be avoided. Silicone oil can interact with the posterior surface of the IOL in patients with a posterior capsular rent impairing visual acuity as well as fundus visualization both intra and postoperatively. Postoperatively, these patients complain of defective vision and presence of rainbows or haloes around light. Silicone oil adhesion to IOL surface is maximum with the silicone IOL. However, it can also occur with hydrophobic acrylic, PMMA, and hydrophilic acrylic lenses in a decreasing order. A surface modified heparin coated IOL can reduce the postoperative reaction. A lens with a 360 degree square edge design with a large optic diameter (6-6.5 mm), which gives a greater viewing area for fundus visualization, is preferred. A plano convex configuration of the implanted IOL with the plano surface facing posteriorly ensures minimal refractive surprises. The absence of positioning holes helps reduce posterior synechiae formation postoperatively.

**Preoperative Patient Counseling**

Preoperative patient counseling plays an important role in mentally preparing the patient for the visual outcome after surgery. It is necessary to give the patient a realistic idea of his visual potential as well as to make him aware of the expected and unexpected intraoperative events that can complicate his surgery.

Patients with significant posterior segment comorbid conditions may have only very minimal visual improvement. The benefits of the surgical intervention to the patient may be an improved color perception, better peripheral vision, or only a better view of the fundus for the ophthalmologist. The patient may be bothered by diplopia, metamorphopsia, central scotoma or anisometropia. Paradoxial aniseikonia with smaller images in the silicone oil filled eye may trouble the patient. A series of unexpected adverse intraoperative events may further mar the visual outcome of
phacoemulsification surgery in vitrectomized eyes and includes peripheral corneal injury, stripped Descemets membrane, fluctuations in AC depth, floppy iris, miotic pupil, tears in rhexis margin, marked zonular laxity/dehiscence, posterior capsular plaque, unplanned posterior capsulorhexis, unplanned AC IOL, posterior capsular rent, nucleus drop and suprachoroidal hemorrhage.

Surgical Strategy for Phacoemulsification in Vitrectomized Eyes

Preoperative

Long acting cycloplegic and nonsteroidal anti-inflammatory drops (NSAIDs) should be started at least one week prior to the surgery. This may help to maintain adequate mydriasis throughout the phacoemulsification procedure.

Anesthesia

It is important to decide on the type of anesthesia. Injection anesthesia is preferred by many surgeons although the procedure can be safely performed under topical anesthesia. Injection anesthesia is preferred in patients with hard cataract and associated comorbid conditions like subluxated cataract, small pupil, etc. When performed under topical anesthesia, the patient may experience discomfort during maneuvers that stretch the zonular apparatus, when there is excessive movement of the lens-iris diaphragm. This undesirable sensation may be eliminated by intracameral nonpreserved lidocaine. Enhanced posterior diffusion of the anesthetic drug through zonule may cause transient blindness due to temporary retinal block.

Injection anesthesia, by increasing the orbital volume, may negate the vitreous pressure and reduce deepening of anterior chamber. Digital massage and oculocompressive devices should be avoided as the eye may become hypotonus.

Intraoperative Problems and Surgical Technique

The intraoperative problems to be anticipated during phacoemulsification include: ocular hypotony, deep anterior chamber, disturbed vitreous dynamics, compromised zonule, poor pupillary dilatation, loose capsular bag, pre-existing posterior capsular rent, posterior capsular plaque, dropped nuclear fragments, and infusion deviation syndrome.

Ocular hypotony can be countered by firming the globe with viscoelastics. An infusion cannula may be placed through an inferotemporal sclerotomy port and the flow used to firm the globe. To prevent excessive deepening of the anterior chamber, it is advisable to perform the surgery at a reasonable low infusion bottle height and other phaco parameters are also adjusted appropriately. The microscope magnification (zoom) can also be adjusted at a low level to enhance the depth of focus.

1. Incision

A clear corneal incision is preferred to a scleral tunnel incision. In the presence of compromised zonular apparatus, the incision should be opposite to the area of zonular dialysis. Both the phaco and side port incisions should be carefully fashioned to avoid fluid leakage since fluid dynamics become increasingly important in these eyes.

A scleral tunnel incision is preferred if the patient opts for a rigid IOL or in a very challenging case where surgeon may require to convert to a large incision non-phaco technique. A fornix based conjunctival flap can be dissected which may be difficult, due to the scarring. The conjunctival flap should be anchored at the periphery at the conclusion of surgery.

2. Capsulorhexis

Capsulorhexis may be challenging in view of the increased prevalence of anterior capsular fibrosis in many eyes. The red fundal reflex may also be compromised due to the posterior segment pathology, advanced nature of the cataract at the time of presentation and a lusterless cornea in some patients. Therefore, it is prudent to stain the anterior capsule with trypan blue dye to enhance its visibility.

A sharp cystitome should be used for capsulorhexis. It is prudent to keep a pair of microrhexis forceps and scissors handy. One may need to incise the fibrotic areas with microrhexis scissors. Every effort should be made not to deepen the anterior chamber excessively, during injection of viscoelastic. A large rhexis of about 5 to 5.5 mm should be fashioned. This facilitates nuclear emulsification, reduces the incidence of posterior
capsular opacification and capsular phimosis and promotes adequate fundus visualization during postoperative follow-up.

3. Hydrodissection steps

Hydrodissection must be slow and gentle keeping in mind the possibility of preexisting posterior capsular rent. Slow and gentle hydrodissection followed by frequent decompression should be done to avoid a posterior capsular blow-out. It is necessary to verify that adequate nuclear rotation has been achieved to prevent further stress on the compromised capsulozonular apparatus. In eyes presenting with mature white cataracts after vitrectomy, the possibility of lens touch and occult capsular rupture should be kept in mind. In these cases instead of hydrodissection, a gentle hydrodelineation and/or hydro free dissection may be performed prior to removal of nucleus.

4. Nucleus management

A technique of nuclear emulsification that is least traumatic to the capsulozonular apparatus should be employed. A direct phaco chop technique is believed to be the least traumatic. However, the surgeon may employ any technique which he/she is comfortable with and may include stop and chop or divide and conquer technique. Post pars plana vitrectomy cataracts are denser than the senile cataract and therefore, more time has to be spent in emulsifying the nucleus. Care must be taken not to cause thermal burns to the cornea and not to apply excessive force on the lens while emulsifying it.

Notable fluctuation of anterior chamber depth may occur because of increased movement of the lens-iris diaphragm. If the prior vitrectomy has spared the clear anterior vitreous cortex the fluctuations will be minimal. Excessive fluctuations can be reduced by keeping the bottle height low and maintaining irrigation whenever the phaco probe or irrigation-aspiration probes are in the eye. These patients are prone to infusion deviation syndrome wherein the fluid migrates posteriorly through the weakened zonule. It increases the volume of the vitreous compartment and causes shallowing of the anterior chamber. Raising the infusion bottle has the paradoxical effect of further shallowing the anterior chamber.

5. Cortical clean-up

Cortical clean-up should be thorough and performed using lower I/A parameters and circumferential stripping to reduce stress on zonule. A bimanual irrigation-aspiration system is very efficient for safe and complete cortex removal. Gentle posterior capsular polishing should be performed to reduce the incidence of postoperative posterior capsular opacification.

6. Small pupil strategy

As mentioned earlier, a long acting cycloplegic and NSAIDs should be instilled in the postoperative period. The surgeon should utilize a step-wise approach to small pupil management (Posterior synechiolysis, viscomydriasis, pupillary membrane dissection, stretch pupilloplasty, and iris hooks). The Malyugin ring is also a good option. Intraoperative manipulations and anterior chamber depth fluctuation should be minimized.

7. Dense posterior capsular plaques

Marked posterior capsular fibrosis or plaques are quite common in silicone oil filled eyes. Centrally located plaques may be visually significant and need to be removed. Many plaques may be removed by capsular polishing or dissection with 26 gauge needle. Once an edge is created it can be peeled off with Utrata forceps. Very dense plaques may be managed by including them in the primary posterior capsulorhexis.

8. IOL implantation

IOL should be implanted in such a position so as to ensure long-term fixation and stability as well as to optimize visualization of the posterior segment. Regardless of the IOL design, placement must be gentle, avoiding excessive rotational maneuvers.

If there is zonular dialysis, use of capsular tension ring (CTR) ensures that the capsular bag is evenly distended and the IOL is placed with one haptic oriented in the direction of the dehiscence.

At the conclusion of surgery, hypotony should be avoided by reforming anterior chamber, and ensuring water-tight closure. Altered scleral rigidity and perilimbal scarring may necessitate suture placement to close the phaco and sideport incisions.
Postoperative Management

Rigorous postoperative management is necessary to prevent postoperative inflammation, secondary glaucoma, posterior synechiae and cystoid macular edema (CME). Use of topical steroid drops, nonsteroidal anti-inflammatory drops and cycloplegics are absolutely necessary. Subconjunctival injection of mydriatic agents and steroids should be considered if the intraocular inflammation is not under control. Postoperative fibrin may be managed by successful use of intracameral tPA. Vigilant management is necessary to detect and treat CME and worsening of diabetic retinopathy.

Complications

Early postoperative complications

Early postoperative complications include blepharoptosis, moderate to severe corneal edema, intraocular pressure spike, wound leak, moderate to severe postoperative iritis, peaked pupil with vitreous in the wound, iris prolapse, incorrect IOL power, IOL decentration or dislocation, endophthalmitis, macular phototoxicity, retinal detachment and vitreous hemorrhage. Silicone oil migration to the anterior chamber may occur early as well as late in the postoperative period.

Late postoperative complications

Late postoperative complications which occur more than a week after surgery include blepharoptosis, moderate to severe corneal edema, pseudophakic bullous keratopathy, chronic iritis, irregular pupil, neovascularisation of iris, capsulorhexis contraction (4.5%), IOL decentration (4.5%), and posterior capsular opacification (31.8%). Posterior segment complications include new or persistent macular edema (13.6 %), persistent recurrent choroidal neovascular membrane (CNVM), proliferative diabetic retinopathy, reopened macular hole (2 - 3%), retinal detachment, visually significant epiretinal membrane (15.9 %) and vitreous hemorrhage (4.5 %).

Conclusion

By recognizing the differences in the physiologic state of the vitrectomized eye, and keeping in mind the nature of the patients’ previous vitreoretinal pathology, the modern cataract surgeon may readily adapt a small incisional phaco technique to this challenging patient population. The principles discussed in this chapter will hopefully minimize surgical difficulty and help reduce complications.

References