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Perioperative Management of Dropped Lenses: Anterior and posterior segment considerations and treatment options

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Abstract

Posterior migration of lens fragments into the vitreous cavity is a rare complication of cataract surgery. Sight-threatening sequelae, including persistent intraocular inflammation, secondary glaucoma, corneal edema, cystoid macular edema and retinal detachment, can occur as a result of this complication. As such, judicious intra-operative and post-operative management must be employed to reduce the risk of complications in the setting of retained lens fragments. This often requires the collaboration of anterior and posterior segment surgeons.

I. Introduction

Over 3 million cataract surgeries are performed annually in the United States.[1] Despite meticulous surgery, posterior capsular rupture (PCR) can occur at rates between 0.45% to 14.7%, with higher rates seen with surgeons in training.[2] However, dislocation of the lens nucleus into the vitreous cavity in the setting of a PCR is a rare but potentially severe complication of cataract surgery, with an incidence of 0.3% to 1.1% also depending on surgeon experience.[3–5]

Sequelae of retained lens material in the vitreous cavity, particularly nuclear material, can increase the risk for persistent intraocular inflammation, secondary glaucoma, corneal edema, cystoid macular edema, retinal tears or detachments or endophthalmitis, all of which can cause permanent vision loss.[6,7] Risk factors for posterior lens dislocation can include advanced age, corneal opacity, poor pupillary dilation, floppy iris syndrome, increased axial length, presence of a posterior polar cataract, pseudoexfoliation syndrome, previous ocular trauma, prior vitrectomy surgery and surgeon inexperience,.[7–9]

As such, judicious intra-operative and post-operative management must be employed to reduce risk of such complications and can often require the collaboration of both anterior and posterior segment surgeons.[6]

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II. Considerations for the anterior segment surgeon

Early recognition of a PCR and/or zonulopathy is critical for the cataract surgeon. This can prevent further extension of the capsular tear, vitreous prolapse, and descent of lens fragments into the posterior pole.

Signs of a PCR can include momentary pupillary dilation or constriction, immediate deepening of the anterior chamber, altered fluidics in the anterior chamber that may lead to difficulty retaining lenticular fragments with the phacoemulsification needle, and descent of the nuclear fragments away from the phacoemulsification needle.[2,7,10]

Once a PCR is noted, the anterior segment surgeon should not reflexively withdraw the phacoemulsification probe from the main corneal incision. Instead, the irrigation or bottle height should be lowered to avoid sudden pressure and volume changes that can induce vitreous prolapse. The second instrument should be withdrawn from the paracentesis wound and a viscoelastic agent, preferably a dispersive viscoelastic, should be injected to coat and tamponade the vitreous in the area of the PCR. Without a viscoelastic tamponade, removal of the phacoemulsification probe can provoke further anterior migration of vitreous and/or even vitreous incarceration into the wound, increasing the risk of vitreoretinal traction. Once adequate tamponade of the vitreous is achieved, the phacoemulsification probe can be withdrawn and the situation can be more thoroughly assessed.[10,11]

In a case of a PCR without posterior dislocation of lens fragments and without prolapse of vitreous into the anterior chamber, remaining nuclear fragments can be cautiously removed with phacoemulsification, using the proper settings that will be described later in this paper, or by enlarging the main wound and manually removing lens fragments. The surgeon must be cautious as to not apply traction on the vitreous.

If vitreous is observed in the anterior chamber, an anterior vitrectomy should be performed prior to removal of residual lens material. It is sometimes helpful to stain the vitreous with vital dyes such as triamcinolone acetonide to aide with visualization. A downward directed infusion can propel fragments further in the vitreous cavity. Continuing phacoemulsification without adequate tamponade or removal of the anteriorly migrated vitreous can be hazardous as aspiration of the vitreous with the phacoemulsification tip can cause vitreous dragging and/or traction at the vitreous base, increasing risk for a retinal tear or detachment.[12]

Once large nuclear fragments are removed, the main wound should be closed sutured to stabilize the anterior chamber. Dispersive viscoelastic can then be injected to move smaller nuclear and epinuclear fragments towards the anterior chamber angle to prevent posterior migration of additional fragments. Bimanual anterior vitrectomy can be performed either through two separate limbal incisions or with an anterior infusion and a port through the pars plana through which the vitrector can be introduced. Introduction of the vitrector through the pars plana (3.5 to 4.5 mm posterior to the limbus) has been thought to help debulk the vitreous and maintain the anterior-to-posterior pressure relationship that can limit further anterior migration of vitreous, especially in eyes with increased posterior pressure. It has also been though to allow improved access to the vitreous and ensure more complete removal. Low bottle height, low vacuum rate and high cut rates should be used when

performing an anterior vitrectomy in attempts to remove all residual vitreous and eliminate any vitreous traction. Preservative-free triamcinolone acetonide can be used to stain the vitreous and ensure the anterior segment and wounds are free of any vitreous.[2]

Once the anterior chamber is free of prolapsed vitreous, any remaining nuclear or epinuclear fragments anterior to the posterior capsule can be removed. Fragments can be brought to the iris plane with injection of dispersive viscoelastic behind the fragments. Soft lens material and remaining cortical material can be removed with the vitrector in aspiration mode. Larger nuclear fragments can be removed with phacoemulsification, using low aspiration and irrigation rates, low bottle heights, low vacuum, and short bursts of ultrasound power to safely remove remaining pieces and avoid anterior chamber volume and pressure fluctuations.[10] Extracapsular cataract extraction via extension of the pre-existing corneal wound may be preferable for larger nuclear fragments if they are too large or dense for phacoemulsification.

Once all lens fragments are above or at the iris plane, a Sheet's glide can be inserted to prevent further posterior migration of lens fragments and anterior migration of vitreous. The IOL scaffold technique, as described by Kumar et al, can also be used to prevent posterior migration of lens fragments after a PCR, with the IOL serving as a barrier between the nuclear pieces and the vitreous cavity.[13] In this technique, a three-piece foldable IOL is injected and maneuvered beneath nuclear pieces. The trailing haptic is positioned on the iris and the trailing haptic is placed in the incision site; the optic is positioned to block the pupillary zone. Once removal of the lens material is complete, the IOL is positioned in the ciliary sulcus.[13] Once the IOL is positioned in the sulcus, a miotic agent should be used to constrict the pupil and to verify that there are no vitreous strands extending to the paracentesis or main wound.

In cases where nuclear fragments have partially descended into the anterior vitreous, the posterior-assisted levitation (PAL) technique can be performed. The PAL technique, as initially described, involves insertion of a cyclodialysis spatula through a pars plana sclerotomy in attempts to levitate nuclear fragments into the anterior chamber. This technique was subsequently modified where dispersive viscoelastic is injected through a pars plana sclerotomy to levitate lens fragments above the posterior capsule into the anterior chamber. Additional manipulation with the cannula can be used to further elevate lens fragments into the anterior chamber. Lens material is then emulsified with the phacoemulsification probe or manually extracted via an enlarged corneal wound. Often a Sheet's glide can be inserted over the pupillary region to serve as mechanical barrier to prevent posterior migration of the levitated lens fragments.[12] Other proposed techniques for nucleus retrieval have included removal of the lens nucleus using a Vectis loop,[2] the bimanual chopstick technique of using two sinskey hooks, one from the corneal incision, and the other from the pars plana, to remove the dislocated nucleus through the corneal incision,[14] or irrigation of the posteriorly dislocated nucleus to move it anteriorly.[15] However, all of these anterior segment approaches have been associated with severe complications, including vitreoretinal traction leading to peripheral small retinal tears, giant retinal tears or retinal detachments, suprachoroidal hemorrhage as well as iris or corneal damage.[2,12]

III. Considerations for the posterior segment surgeon

Vitreoretinal surgery is often required when lens material has descended into the posterior vitreous or onto the retina, nuclear and/or cortical material cannot be safely retrieved by the anterior segment surgeon.[16] It is important to evaluate the type and amount of retained lens material. Nuclear material is poorly tolerated in the eye; however, epinucleus followed by cortical material, are better tolerated.[17] Lens fragments less than 2 mm in size can often resolved with medical management, including topical, sub-tenon's or oral corticosteroids combined with intraocular pressure lowering drops. However, close monitoring of the patient is required to detect secondary phacoantigenic uveitis, glaucoma or corneal decompensation, which should prompt expedient surgical intervention.[18,19] When fragments are larger than 2 mm in size or when the entire lens/capsule complex has descended posteriorly, vitreoretinal intervention is usually required.[20]

Timing of vitreoretinal surgery is up for debate. Studies have shown that vitreoretinal intervention can be pursued early (within 1 week) or late (later than 1 week after cataract surgery).[21] Performing a pars plana vitrectomy (PPV) at the time of complicated cataract surgery is often optimal as it can allow for decreased post-operative inflammation, preclude the need for a second operation, and mitigate patient dissatisfaction. However, immediate access to a vitreoretinal surgeon is required and may be difficult logistically.[6,7] Several studies have reported improved visual acuity and lower rates of complications, such as secondary glaucoma or retinal detachment, in the same-day vitrectomy patient.[21–24] Other studies have suggested no difference in final visual acuity between early and late vitrectomy.[19,25,26] If PPV is delayed, the patient should be monitored closely, either clinically and/or with ultrasonography, for development of a retinal detachment.

A standard 3 port PPV is employed for retrieval of dropped nuclear fragments by the vitreoretinal surgeon. A 20-, 23-, 25-, or 27- gauge system can be used. Smaller gauge systems, while allowing for faster visual recovery and less post-operative inflammation, may preclude removal of moderate-sized or denser lens fragments.[27,28] The smaller gauge vitreous cutters can be used for removal of smaller nuclear, epinuclear and cortical pieces using low cut rate and high vacuum settings. However, for larger lens fragments, a phacoemulsification probe or 20-gauge fragmatome may be required.[29] In such cases, the superotemporal sclerotomy of a 23- or 25- gauge PPV set-up can be enlarged to introduce the fragmatome, or a separate fourth sclerotomy can be created.

A core vitrectomy with induction of a posterior vitreous detachment is performed to release any vitreous adhesions or strands around the descended lens material and the retinal surface. Preservative-free triamcinolone can be used to facilitate visualization of residual vitreous strands in the retinal periphery. Once the core and peripheral vitreous has been removed, attention can be directed to removal of lens material. Perfluorocarbon liquid can be used to float the nuclear material away from the retinal surface prior to engaging fragments with either the vitrector or fragmatome, protecting the macular region, and facilitating removal of fragments in the mid-vitreous cavity. Meticulous removal of perfluorocarbon liquid must be ensured at the completion of the case to prevent ocular toxicity. If perfluorocarbon is not used, the globe should be rotated so that there is minimal contact with the macular region

with phacoemulsification. In addition, prior to closure, careful inspection for retinal breaks must be performed and treated with laser.

In some circumstances, extremely dense lens fragments may require manual extraction. Lens fragments are brought to the mid-vitreous using suction and then secured to the fragmatome tip with a short burst of ultrasound, after which they can be removed by extracapsular extraction via an enlarged corneal incision. Watanabe et al proposed implementation of a transcorneal vitrectomy with bimanual phacoemulsification as a safe and less invasive technique for a dropped dense nucleus as compared to a conventional PPV. In this technique, a vitrectomy is performed through the corneal incisions used for the initial cataract surgery, after which the dropped lens nucleus is floated on perfluorocarbon liquid into the anterior chamber, and removed in the anterior chamber using bimanual phacoemulsification.[30] Nakasato et al reported a method to retrieve dislocated nuclear fragments smaller than one-fourth the size of the lens through the sclerocorneal incision used for cataract surgery as opposed to using a pars plana incision. An anterior vitreous cutter with a 27-gauge chandelier endoilluminator is used for the core vitrectomy and a fragmatome with another 27-gaugte chandelier endoilluminator is used to grab and move the larger dislocated nuclear fragments into the anterior chamber where they are removed.[31]

Adjunctive devices have also been manufactured to assist vitreoretinal surgeons in stabilizing lens fragments during removal. The “Frag Bag” is one such device that is a retractable basket made from nitinol that allows retrieval and stabilization of the lens material in the mid-vitreous cavity as well as softening of the nuclear material. The material can then be safely and efficiently removed with the vitreous cutter, away from the vitreous surface.[32,33]

IV. Secondary IOL options

After all lens fragments are removed, the surgeon has several options for IOL implantation.[34] If the PCR is small with well-defined borders, the capsular bag can be inflated with viscoelastic and a posterior chamber IOL (PCIOL) can be implanted in the bag. If the posterior capsule is largely comprised but there is adequate anterior capsule and ciliary sulcus support, a 3-piece IOL can be placed in the sulcus after inflation of the sulcus with viscoelastic. The optic can be further secured capturing the optic with the anterior capsule and can help avoid IOL subluxation within the ciliary sulcus. Haptics should be oriented 90 degrees away from the axis of the PCR or area of zonular weakness.

Single-piece acrylic hydrophobic IOLs are not recommended for sulcus fixation. These lenses have a roughened, hydrophobic acrylic optic surfaces along with sharp, square optic edges and large, bulky haptics in a planar configuration that render them susceptible to iris chafing and chronic complications such as iris transillumination defects, pigment dispersion syndrome, elevation of intraocular pressure, or uveitis-glaucoma-hyphema syndrome. Their horizontal diameter of 13.0 mm also renders them too short for stable sulcus placement, increasing the risk of post-operative IOL decentration.[35]

3-piece IOLs with thin, posteriorly angulated optics are recommended for sulcus placement. Studies however have shown that 3-piece lenses with a smooth anterior optic surface with rounded edges are preferred for sulcus placement to minimize the possibility of chronic post-operative complications.[36–38] Polymethylmethacrylate posterior-chamber IOLs can be also be considered for sulcus placement, however, they require larger incisions for implantation. In cases with a PCR where a premium IOL was initially planned, 3-piece multifocal IOL designs can be placed in the sulcus with optic-capture if available or a monofocal lens can be chosen instead.[35]

Once the IOL of choice is well-secured, the pupil can be constricted with a miotic agent to assess for further vitreous prolapse and promote stabilization of the lens. Peaking of the pupil can indicate vitreous prolapse or vitreous incarceration in the paracentesis or main wound. The residual vitreous can subsequently be cut with the vitrector or swept away with a cannula or spatula. Rounding of the pupil can indicate complete vitreous removal; additional staining with triamcinolone acetonide can also be used to verify that no further vitreous is present in the anterior chamber.[10]

When there is inadequate sulcus support, options for IOL implantation include open-loop anterior chamber IOLs (ACIOL), iris-sutured IOLs, scleral-sutured IOLs, and sutureless scleral-fixated IOLs.[39] Each of these lens fixation options have certain advantages and drawbacks, and can be used effectively in the appropriate clinical scenarios.

ACIOLs are easier and quicker to insert when compared with iris-sutured or scleral-sutured IOLs techniques. Designs of modern open-loop ACIOLs render them less susceptible to post-operative corneal decompensation, secondary glaucoma and cystoid macular edema. During insertion, the correct size of the ACIOL has to be determined based upon the corneal white-to-white diameter and the IOL needs to be positioned correctly in the anterior chamber without incarceration of the haptics into the angle. A peripheral iridotomy is also recommended to prevent pupillary block. Meta-analyses of studies comparing ACIOLs with scleral or iris-sutured PCIOLs show similar visual outcomes among all techniques.[40] However, while scleral-sutured and newer sutureless scleral-fixated IOLs techniques are more technically challenging, they can provide a more natural position for the posterior-chamber IOL and are less dependent on anterior-segment anatomy.[40,41]

IOL insertion can either be done at the time of the initial cataract surgery or in a staged fashion. Typically, if the dislocated nuclear fragment is large and dense, IOL implantation should be deferred until after vitreoretinal intervention to permit easier removal and/or manual extraction. If the nuclear fragments are softer, and IOL can be inserted by the anterior segment surgeon prior to vitreoretinal surgery. Depending on the degree of ocular inflammation, corneal edema, operative time, and need for further vitreoretinal intervention, IOL implantation may also be delayed.[42]

V. Follow-up and patient outcomes

Most cases with retained lens fragments fare well in the post-operative period. Studies have shown final visual acuities of 20/40 or better in 56–68% of patients. Improved visual outcomes can be attributed to improved perioperative care.[25,43]

VI. Conclusion

In conclusion, prompt recognition of a PCR or zonulopathy is critical to preventing migration of lens material into the posterior segment. However, in the setting of the dropped lens nucleus, thoughtful perioperative management must be employed to reduce the risk of vision-threatening complications. This often requires a multidisciplinary approach with collaboration between the anterior and posterior segment surgeon.

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