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Dropped Lens Fragment, Dislocated Intraocular Lens

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Abstract

Management of posteriorly dislocated crystalline lens has traditionally been performed with a standard 20-gauge vitrectomy system. The latest surgical platforms integrate multiple devices into single systems and feature advanced fluidics, vitreous cutting technology, and intraocular pressure control along with continued improvements in small-gauge instrumentation and wide-angle viewing systems. This allows truly robust removal of core vitreous and outstanding control of the surgical field on par with its 20-gauge predecessor, resulting in an expanded spectrum of complex vitreoretinal maneuvers feasible with 23- or 25-gauge systems. Posteriorly dislocated crystalline lens/intraocular lens is one such indication which can be safely and effectively managed by a 23- or 25-gauge vitrectomy system alone or combined with the 20-gauge fragmatome/forceps with lesser complications and early recovery.

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Nucleus drop/retained lens material (RLM) in the vitreous cavity is a potentially serious complication of modern cataract surgery, estimated to occur in 0.3–1.1% of cases [1]. The potential risk factors for RLM include hypermature, dense brunescent, or posterior polar cataracts; zonular compromise; pseudoexfoliation; previous vitrectomy; floppy iris syndrome; miotic pupil, and an inexperienced (trainee) surgeon [2]. Eyes with nucleus drop/RLM or vitreous loss can develop elevated intraocular pressure (IOP), uveitis, corneal edema, vitreous hemorrhage, retinal detachment (RD), and cystoid macular edema (CME), which usually leads to poor visual acuity [3]. When managed properly, however, the risk of further complications can be minimized, and the results can be as good as if it had never happened.

The many publications investigating risk factors associated with posterior capsule rupture and vitreous loss have allowed surgeons to more accurately predict complications prior to surgery, plan more effectively, and counsel patients who are at risk [2]. Early recognition of posterior capsular rupture or zonular dehiscence is key to preventing further problems as surgery progresses; it allows the surgeon to try to avoid certain maneuvers that can upset a precariously perched nucleus. In most cases the nucleus will sit supported by the vitreous if undisturbed; however, vitreous with more syneresis will allow easier passage of

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the nucleus into the posterior segment. High aspiration and a postocclusion surge due to high vacuum settings and turbulence created by phacoemulsification, however, are identified as contributing factors in shifting vitreous support allowing the nucleus to drop [4].

Historically, achieving good visual acuity outcomes after pars plana vitrectomy (PPV)/lensectomy for RLM has been a challenge because complication rates were high. Smiddy et al. [5] reported an RD rate of 8% and final visual acuity of 20/40 or better in 54% of eyes. Scott et al. [6] reported an RD rate of 13% and final visual acuity of 20/40 or better in 56% of eyes. Efforts to optimize the final outcomes of PPV/lensectomy for RLM have focused on surgical techniques to minimize complications, in particular CME, corneal edema, and RD.

Management of /Nucleus Drop/Retained Lens Material

Reducing complications associated with RLM removal by PPV/lensectomy involves not only the surgery, but also management throughout the entire perioperative period, beginning with the cataract surgeon. There is evidence that the clinical course for patients with RLF begins the instant the fragments enter the vitreous and is affected by the cataract surgeon's decisions and actions. The underlying principle of complication management in any surgical setting must be to reduce the risk of further complications [7].

Anterior Segment Management

The primary goal for the surgeon following early posterior capsular rupture or zonular dehiscence is to remove as much of the remaining nucleus as possible, but not without considering the risks that this involves. It is dangerous to continue to phaco (ultrasound plus vacuum/aspiration) in the presence of vitreous in order to remove nuclear fragments at this stage. The phaco tip cannot cut vitreous gel and would instead aspirate, leading to vitreoretinal traction via the vitreous base and creating a high risk of retinal tear. An ophthalmic viscosurgical device, preferably dispersive, can be injected to coat and tamponade the vitreous while also supporting the nucleus, allowing the phaco needle to be withdrawn without letting the vitreous surge forward toward the wound. The surgeon can then remove vitreous by performing bimanual vitrectomy through two paracenteses with a low bottle height, low vacuum (100–150 mm Hg), and highest cut rate possible, using triamcinolone acetonide for visualization. This allows further surgical maneuvers to be performed in a vitreous-free environment, reducing or eliminating vitreous traction. Residual soft lens matter can then be removed using the vitrector in aspiration mode, but blind or aggressive maneuvers should be avoided. In the case of a dense nucleus, an alternative strategy is to enlarge the wound and remove nuclear fragments directly.

Vitreous loss/retained cortical matter during phacoemulsification can also be managed intraoperatively under topical anesthesia via a pars plana approach using 25-gauge vitrectomy instrumentation [8]. In the event of vitreous prolapse, the corneal wound is sutured without further cortical clean up. An additional self-sealing limbal side port is made and an infusion cannula (not opened) is introduced. The clear corneal wound (tunnel) is cleared of vitreous strands with an iris spatula inserted through the other side port. The infusion cannula is subsequently opened. The irrigating fluid increases the IOP making the eye firm, and pushes the vitreous back towards the posterior segment, away from the cornea. A transconjunctival 25-gauge sclerotomy through the pars plana is made [8]. The high-speed 25-guage transconjunctival vitrectomy system under topical anesthesia is introduced and a partial core vitrectomy to debulk the vitreous is

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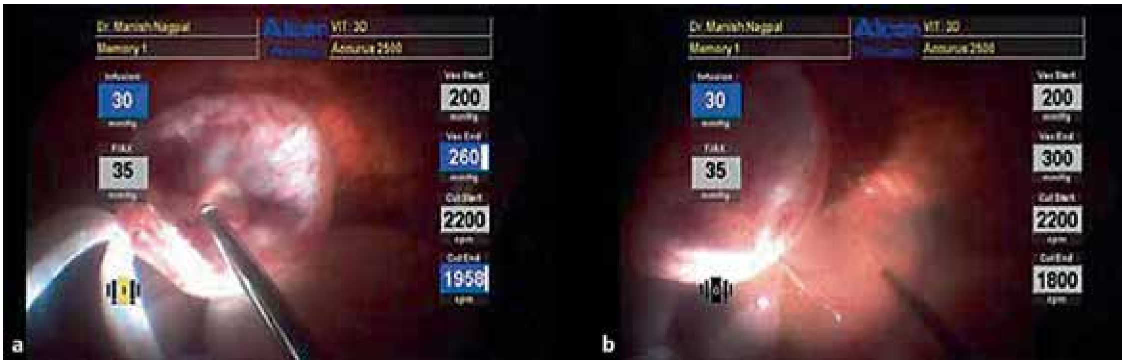

Fig. 1. Lens matter in the posterior segment along with a giant retinal tear. **a** When the nucleus was displaced, the referring surgeon tried to chase it with the phaco tip, and resulting traction probably caused the giant tear. **b** As PFCL is used to flatten the retina, a linear retinal tear extending almost up to the optic disc is also seen, which is along the probable line of the phaco probe approach.

performed. The anterior chamber is also cleared of vitreous and residual cortical matter, and the epinucleus (if present) is removed simultaneously. A foldable intraocular lens is subsequently inserted. This technique is performed in a closed chamber avoiding IOP fluctuations and thus reducing related complications. The high-speed cutter exerts minimal traction on the vitreous. The accessibility to the vitreous improves through the pars plana route, ensuring more complete removal of the vitreous and restoration of normal anatomy. Topical anesthesia avoids the risks of globe perforation, retrobulbar hemorrhage, and prolonged postoperative akinesia of the eye.

In eyes with increased posterior pressure, the pars plana approach is better than an anterior approach as it reduces the amount of vitreous prolapsed into the anterior chamber. Vitreous incarceration, dragging of the retina, entry site retinal dialysis and tears, injury to the ciliary body, fibrovascular downgrowth, suture protrusion, wound dehiscence, difficulty in maintaining stable IOP during closure, and postoperative hypotony (wound leakage) are some of the complications related to a large sclerotomy and are avoided.

If the nucleus has drifted out of reach, an attempt at retrieval via the anterior chamber is ill-advised and should be converted to PPV (fig. 1). In cases managed by an anterior segment surgeon who lacks the experience and equipment, the eye should be closed and the patient referred to a vitreoretinal surgeon. It is especially important to check for vitreous to the wound, which tends to increase the risk of complications, including endophthalmitis.

Considerations of Intraocular Lens Placement at Primary Surgery and Timing of Vitreoretinal Intervention

The question of whether to implant an IOL at the time of nucleus drop if no PPV is undertaken is contentious. Most vitreoretinal surgeons currently agree that placement of a secure IOL at the time of primary surgery is advisable as long as it is stable. With an intact capsulorrhexis, a three-piece IOL can be placed using optic capture with the haptics in the sulcus but the optic behind the capsulorrhexis, resulting in a stable IOL position. A one-piece IOL should not be used in this situation.

Lack of immediate availability of an experienced vitreoretinal surgeon and the necessary

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equipment usually precludes a same-day vitrectomy, which most vitreoretinal surgeons suggest might be the optimal time for RLF removal in the current era [9–11]. Visualization was often a challenge during PPV/lensectomy for RLM as the cornea may not be clear due to edema, and the pupil may be small because of inflammation. The wide-field viewing systems and wide-angle illumination probes available for today's surgical platforms are an asset in situations like this. If required, the pupil can be manually stretched to aid visibility. Several authors have reported better visual acuity and lower rates of complications (RD, corneal edema, elevated IOP, CME, and intraocular inflammation/infection) among immediate/same-day vitrectomy patients [9–11].

Perhaps immediate vitrectomy prevents time-dependent inflammation and the accompanying choroidal congestion that occurs due to RLF and may take advantage of a clear cornea and minimally inflamed eye to enable better removal with fewer complications. Lower rates of elevated IOP and/or CME may be related to less intraocular inflammation/infection [11]. Moreover, a trend toward increasing concurrent RDs (before/during PPV) has been found with increasing intervals between cataract surgery and PPV [12].

Today, patients expect a rapid visual recovery after cataract surgery and most patients of RLM remain very dissatisfied with poor vision postoperatively. Same-day vitrectomy, when feasible, could mitigate patient dissatisfaction, prevent the need for a second procedure, and hasten visual recovery. However, in cases where vitrectomy is delayed, close monitoring is required and if visibility is limited, a B-scan should be done to make sure the retina is not detached. If it is, the intervention should be done immediately. In high-risk situations, such as unstable traumatic cataracts and posterior polar cataracts, where the risk of posterior capsular rupture and nucleus displacement is significant, it may be best for the vitreoretinal surgeon to see the patient preoperatively. This drives home the importance of potential complications and emphasizes that good pathways for professional collaboration are in place to deal with any complications that may occur.

Pars Plana Vitrectomy: Intraoperative Tips and Techniques

The underlying principle of PPV for displaced nuclear fragments is to perform a complete vitrectomy, including removal of the vitreous base as far as possible, employing a standard three-port pars plana approach with the goals of reducing IOP and inflammation, repairing any retinal breaks or RD, and ultimately restoring visual acuity. In cases where only a small amount of cortical material has gone in the vitreous cavity, vitreoretinal surgery may not be necessary, as these fragments often dissolve on their own.

When larger amounts of lens material or nuclear fragments are retained, a three-port PPV/lensectomy is required to remove the fragments, with a conventional 20-gauge system [6, 9, 10, 12] or with a microincision sutureless system (23- or 25-gauge) [13, 14]. A 20-gauge vitrectomy, however, most often requires a conjunctival peritomy, a larger sclerotomy, and suture closure of the wounds, leading to longer operative and healing time, postoperative discomfort, and refractive changes [15]. Decreased healing and operative time, faster visual recovery, and reduced postoperative inflammation illustrate the benefits of smaller-gauge vitrectomy systems. Compared with the conventional 20-gauge vitrectomy, the aspiration and infusion rate through the 23-gauge instruments will inevitably be lower due to smaller port size and narrower inner diameter of the vitrector handpiece. The main difference between the early-generation 25-gauge and 23-gauge systems is the greater stiffness and fluidics of the 23-gauge system that mirror the 20-gauge system, leading to a preference for the 23-gauge system by an increasing number of vitreoretinal surgeons.

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If the RLM to be addressed consists of small fragments and does not include much nuclear material, it is often possible to remove it using only the 23-/25-gauge vitrectomy cutting probe with relatively lower cut rates and higher vacuum settings. When only the vitrector is used to remove the lens material, a bimanual technique can be used in which the light pipe guides the lens material into the vitreous cutter port.

For moderate-sized or denser nucleus material, the vitrector cutter alone may be inadequate for removing, and emulsification with a phacofragmatome is necessary. The superotemporal 23-/25-gauge sclerotomy can be enlarged in such cases for the 20-gauge fragmatome. The advantages of this 'hybrid technique' include having only one incision to suture at the end of a case, being able to perform faster surgery, and speeding up postoperative healing [16]. Phaco in the posterior segment increases the risk for retinal tears and detachments. Also, smaller-gauge vitrectomy systems require high infusion pressures and high flow rates to meet the demand of the aspiration through the wider-bore fragmatome, which might lead to more vitreous traction and intraoperative hypotony. Therefore, ensuring the vitrectomy is complete and the hyaloid is lifted from the retinal surface are key factors to success. Triamcinolone is a useful adjunct for improving visualization of vitreous gel and confirming complete vitrectomy has been achieved. The newer-generation platforms like Constellation have integrated pressurized infusion which constantly monitors infusion pressure with flow-sensing capabilities, resulting in more stable IOP. This IOP compensation feature on the Constellation system automatically adjusts for the pressure drop that occurs due to imbalance between aspiration from the fragmatome and inflow from the 23-/25-gauge infusion line. In other machines, it can be avoided by raising the infusion pressure.

Regardless of the surgical platform and phacofragmentation technology being employed, having a good hold of the lens material at the tip is crucial. When the fragments are not too dense, standard phaco settings do the job adequately. Also, because there is no counterresistance by the capsular bag, it is essential to use a pulse or micropulse setting on the fragmatome, with low-to-moderate vacuum, to avoid bouncing the nuclear fragments around the vitreous cavity due to the repulsion caused by ultrasound energy. However, if emulsification is not progressing in a timely manner and the lens fragments are not holding well to the tip, gradually increase vacuum and phaco power. Under suction, engage the fragments and bring them to the midvitreous, away from ocular structures, to emulsify them.

Perfluorocarbon liquid (PFCL) can be used to cover the macula and float the nucleus away from the retina prior to engaging the fragment with either the vitrector or the fragmatome. This helps to protect the macula during removal of the lens fragments in the midvitreous cavity. After it appears that all RLM is removed, the anterior chamber should be irrigated to remove any fragments that may be trapped in the angle. Prior to closure, it is important to remove all PFCL and to carefully inspect for residual fragments and iatrogenic retinal tears. It is particularly important to inspect the vitreous base with sclera indentation, as tiny retinal breaks close to the ora serrata are easy to miss but can cause subsequent RD. If any are present, they should be treated on the spot with laser.

Another option for lensectomy in RLM cases is to use the INFINITI® Vision System (Alcon) with the OZil® torsional phaco handpiece. It can be used when dealing with dense and hard RLM. Torsional phaco tends to be more efficient than traditional phaco. It creates less turbulence in the eye and draws lens fragments to the phaco tip rather than repulsing them, which helps to protect the retina and decrease the risk of breaks [17]. The OZil® torsional handpiece recently became available with the Constellation® system as well.

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Intraocular Lens Dislocation

Dislocation of an IOL is an infrequent but serious complication of cataract surgery and estimated to occur in 0.2–3% of cases [18]. The most common etiologies include pseudoexfoliation, prior vitreoretinal surgeries, trauma, increased axial length, various surgical complications, white mature cataract, and secondary implantation [19, 20]. This can happen in the early or late postoperative period and the best approach for a dislocated IOL must be determined individually for each patient and is based on factors such as clinical circumstances and coexisting complications. The most common indications for surgery would include decreased visual acuity, persistent CME, increased IOP, inflammation, coexisting RD, monocular diplopia, halo phenomenon, and fluctuating vision caused by a shifting IOL.

During surgical intervention, an important consideration is whether to remove, reposition, fixate with suture, or exchange the dislocated IOL after performing a PPV. In patients who are poor surgical candidates and have good visual function in the fellow eye, observation of a dislocated IOL in the vitreous cavity may be a reasonable option [21]. If there is adequate capsular support, the same IOL may be repositioned to the ciliary sulcus. IOL removal with or without exchange is usually performed for IOL with damaged haptics, small optics, or highly flexible haptics unsuitable for suture support or in eyes with coexisting complex RD [22]. Numerous techniques and IOLs are available if exchange is required in eyes with inadequate capsular support. The posterior iris claw IOL can be anchored to the posterior surface of the iris. Otherwise, the IOL may be anchored to the sclera, using one of several possible techniques, like transscleral suture fixation, externalization of one or both haptics, and glue fixation.

The majority of patients with posterior IOL dislocations are treated surgically by either a limbal or a pars plana approach. If the IOL is still supported to some degree by the capsular remnants, a limbal approach may be considered. However, when the patient is supine on the operating table, the IOL frequently falls further posteriorly, making a limbal approach more difficult. PPV techniques offer several advantages to a limbal approach, including more complete and controlled removal of formed vitreous, better access to the posterior vitreous cavity, and better ability to address potential intraoperative complications, such as retinal tear, suprachoroidal hemorrhage, and progressive IOL dislocation into the posterior vitreous.

A complete three-port PPV is essential. The vitreous has to be removed from the anterior chamber, from around the capsule and from the vitreous base. If it is not, the manipulation of instruments inside the vitreous may cause traction on the vitreous and the retina and its attendant complications. A complete vitrectomy around the capsular remnants also ensures that the vitreous does not tend to push the IOL and reduces the chances of redislocation. Also, the IOL has to be freed from all of the vitreous gel enveloping it (fig. 2a).

The IOL is retrieved from the retinal surface and brought anteriorly with the help of end-gripping forceps grasping the haptic optic junction (where the shadow of one of the haptics cast on the retinal surface by the light from the endoillumination probe, thus showing that it was above the level of the retina). The IOL is then either repositioned in the sulcus or removed through the limbal incision (fig. 3a, b). Although removal and exchange of a dislocated PC IOL using the limbal approach may be easier than repositioning the lens, the former approach often induces intraoperative fluctuation in IOP, iris prolapse, postoperative astigmatism, and corneal endothelial damage [22]. However, managing a posteriorly dislocated IOL completely in the posterior segment reduces the risk of several intraoperative complications, is more efficient, and offers patients a more comfortable recovery period.

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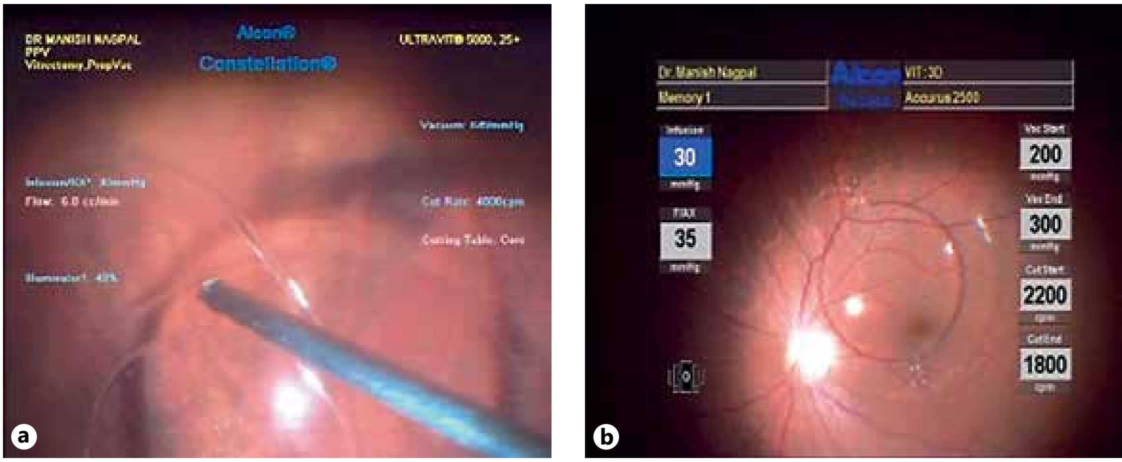

Fig. 2. a After a thorough vitrectomy the IOL is free from all its vitreous adhesions and lying flat on the retinal surface. **b** Heavy liquid PFCL buffers the IOL from touching the macular surface.

Fig. 3. a, **b** IOL being grasped with end-gripping forceps in order to bring it up for either reposition or extraction from the limbal area.

A newer technique for managing a dislocated IOL completely in the posterior segment involves a standard three-port 20-gauge vitrectomy with a chandelier light and BIOM® wide-angle viewing system. It important to accomplish a complete vitrectomy so the IOL is free of vitreous, especially near the sclerotomies. The 10-o'clock sclerotomy (right-hand side) is enlarged to accommodate a pair of Packer/Chang IOL Cutters (MST, Redmond, Wash., USA). These microscissors are designed for cataract surgeons to use through the paracentesis and have exceptional cutting ability. The IOL is safely grasped with forceps and elevated into the midvitreous cavity. With forceps in the left hand and the scissors in the right hand, the IOL is cut into several thin strips. When it is in sections, the same enlarged sclerotomy is used to remove the pieces one at a time with forceps. One

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caveat worth mentioning: this procedure will not work with a polymethyl methacrylate lens – only silicone and acrylic lenses are flexible enough to be cut with scissors. Rigid polymethyl methacrylate lenses must be removed as a single unit, and this is most easily done through a limbal incision. While the new technique could also be performed with the Accurus® Surgical System or other state-of-the-art vitrectomy systems with chandelier lighting (to free up both hands for grasping and cutting), the chandelier lighting system available for the Constellation® system is brighter and has a broad illumination angle of 106°, providing excellent visualization for the necessary IOL manipulations described.

When the IOL is on the retinal surface, flexible, silicone plate haptic IOLs may be difficult to grasp. The use of active suction with a vitrector to engage the IOL, or PFCL to 'float' the IOL anteriorly, may be helpful (fig. 2b). At the end of case, inspection of peripheral retina with sclera depression is necessary to avoid subsequent RD.

Following PPV/lensectomy for RLM or a dislocated IOL, it is important to closely monitor patients for inflammation, elevated IOP, and signs of peripheral retinal tears or detachments. Topical steroids and topical nonsteroidal anti-inflammatory drops, which are tapered slowly over 6–8 weeks, or longer if necessary, are prescribed. If visual acuity does not improve as expected by the 4-week visit, OCT scans should be obtained to check for CME. If CME is detected, it should be treated aggressively with a sub-Tenon's or intravitreal injection of triamcinolone, as necessary.

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