

MASTER CLASS IN CATARACT SURGERY

The Challenge of Weak Zonules

David F. Chang, MD

David F. Chang, MD, is clinical professor at the University of California, San Francisco. His consulting fees from AMO and Alcon are donated to the Himalayan Cataract Project and Project Vision. He has no financial interest in any product or device discussed in this presentation.

Detailed Curriculum

Pseudoexfoliation

For cataract surgeons, pseudoexfoliation frequently poses the intraoperative challenge of weak zonules and a small pupil. This complicates virtually every step of cataract surgery. Besides the need to avoid posterior capsular or zonular rupture, there is the additional problem of providing adequate long-term IOL fixation in light of the progressive zonulopathy that continues to occur over time.

CAPSULAR IOL FIXATION STRATEGIES WITH PSEUDOEXFOLIATION

If the capsular bag is preserved, the surgeon must decide whether to use a capsular tension ring, which is often but not always indicated. These videos cover the spectrum of zonular instability when the IOL is implanted into the capsular bag.

- 1. Choosing an IOL When No CTR Is Needed (2 minutes)**
In this case, there was no zonular instability noted during phaco. A 3-piece acrylic IOL is implanted and a secondary enlargement of the capsulorhexis is performed to avoid too small of a capsulotomy diameter.
- 2. Secondary Enlargement of Capsulorhexis (1.5 minutes)**
One sign of zonular weakness is floppiness of the anterior capsular rim. A CTR is implanted prior to insertion of a 3-piece acrylic IOL. Secondary enlargement of the capsulorhexis is then performed.
- 3. CTR Insertion, Pre-IOL (1 minute)**
Another sign of zonular weakness is laxity of the anterior capsule. This may cause the cystotome to dimple the anterior capsule prior to perforating it. A CTR is implanted prior to inserting a 3-piece acrylic IOL. Secondary enlargement of the capsulorhexis is performed.
- 4. CTR Insertion, Post-IOL (1 minute)**
The distending force of the 3-piece IOL haptics will ovalize a round capsulorhexis if the zonules 90 degrees away from the axis of the haptics do not provide sufficient centrifugal tension. In this case, a CTR is implanted after the IOL, nicely demonstrating the mechanism of action. As the CTR redistributes the forces more evenly to the entire zonular circumference, the oval capsulorhexis becomes round once more.

SULCUS IOL FIXATION WITH WEAK ZONULES — WHY AND HOW?

In cases of severe diffuse zonular weakness, preservation of the capsular bag does not assure long-term IOL fixation if the zonules progressively weaken with pseudoexfoliation. One option is sulcus fixation of a 3-piece IOL, as demonstrated in this video series.

1. **Sulcus Fixation with Severe Zonular Weakness (9 minutes)**

In cases of severe diffuse zonular weakness, preservation of the capsular bag does not assure long-term IOL fixation if the zonules progressively weaken with pseudoexfoliation. Despite CTR use, capsular bag IOL implantation may result in delayed bag-IOL dislocation. In this situation, an underutilized option is sulcus fixation of a 3-piece IOL, as demonstrated by this series of 3 cases of diffuse zonulopathy. The option of capturing the optic with the capsulorhexis is also demonstrated.

CORTICAL CLEANUP: PEARLS

With insufficient centrifugal zonular tension, the posterior capsule is abnormally lax. The pliant posterior capsule will tend to be aspirated by the IA tip, increasing the risk of capsular rupture during cortical cleanup.

1. **Dispersive OVD and Morcher Preloaded CTR (3.5 minutes)**

Repeatedly distending the bag with dispersive OVD can restrain the posterior capsule from trampolining toward the IA tip. The Morcher preloaded CTR with disposable injector system is demonstrated in this case.

2. **Dispersive OVD and Bimanual IA (2.5 minutes)**

In addition to keeping the bag inflated with dispersive OVD, the benefits of bimanual IA instrumentation are demonstrated in this video.

ZONULAR DIALYSIS: CTR TIMING

These videos address the intraoperative management of a zonular dialysis. Whether and when to place a capsular tension ring is a difficult decision, and these videos demonstrate some of the options. Capsule retractors provide more support to the capsular bag and do not impede cortical cleanup.

1. **CTR with Smaller Dialysis (5.5 minutes)**

A CTR can compensate for 3 to 4 clock hours of zonular dialysis by redistributing instrumentation forces to the remaining stronger zonules. This reduces the risk of aspirating the dehisced portion of the capsular bag. The advantage of bimanual IA instrumentation is the ability to dissociate the aspiration and irrigation ports. The latter can be deliberately distanced from the region of the zonular dialysis to avoid posteriorly directed infusion of fluid.

2. **CTR with Larger Dialysis (2.25 minutes)**

With 6 to 8 clock hours of zonular dialysis, a CTR implanted prior to cortical cleanup can be a liability, as demonstrated in this case. There are not enough sufficiently strong zonules to redistribute forces, and the CTR may pin the cortex to the equatorial region of the bag. The lack of zonular counter-fixation makes it particularly difficult to strip cortex pinned by the CTR.

3. **Henderson CTR (3.5 minutes)**

The scalloped contour of the Henderson modification CTR (Morcher) facilitates cortical stripping following implantation and is a very useful option. The Henderson CTR works well with a smaller

zonular dialysis, but may still constrain cortical cleanup when there is diffuse circumferential zonular instability.

4. **Capsule Retractors (Iris Hooks) with Delayed CTR Use (3.5 minutes)**

This video demonstrates the advantages of capsular retractors over a CTR to stabilize the dehisced portion of the capsular bag during cortical removal. Having been previously placed to expand the pupil, 4-0 Prolene iris retractors are used to support the capsulorhexis rim in the region of the zonular dialysis. CTR insertion can be delayed until after the cortex has been removed.

5. **Mackool Nylon Capsule Retractors with Delayed CTR Use (2.5 minutes)**

The Mackool Capsular Support System has evolved from metal, to polypropylene, to nylon capsular retractors. This latest single use iteration (FCI, Impex) is made of nylon with a rounded bulb on the tip to avoid puncturing the equator of the capsular bag.

6. **MST 5-0 Nylon Capsule Retractors with Delayed CTR Use (5 minutes)**

MST has developed double-barreled capsule retractors with a looped tip to reduce the chance of capsular puncture. This video demonstrates diffuse zonular laxity associated with pseudoexfoliation. Three single-use capsule retractors are spaced 120 degrees apart for circumferential support..

BRUNESCENT LENS WITH WEAK ZONULES

The 4+ nucleus makes zonular dehiscence or capsular rupture much more likely with pseudoexfoliation. The challenges associated with rock hard nuclei are compounded by zonular weakness. In particular, the greater nuclear size and rigidity more directly transmit the forces of every surgical maneuver to the zonular complex. Although the zonules may be intact in many eyes with pseudoexfoliation, the presence of a brunescient nucleus is typically associated with advanced zonulopathy. These videos demonstrate a number of pearls for tackling such cases.

1. **Vertical and Horizontal Chop (6 minutes)**

The improved access and visualization afforded by iris retractors are evident in this case. Phaco chop substitutes mechanical forces for much of the sculpting required with divide and conquer techniques. This in turn reduces the forces transmitted to the zonules. With a brunescient nucleus, sculpting half of a trench followed by 180 degrees of nuclear rotation permits the phaco tip to impale the nucleus at a deep enough level to execute an efficient vertical chop. After fragmenting the nucleus with sequential vertical chops, the elevated fragments are further subdivided with horizontal chopping. The IOL is implanted in the capsular bag following CTR placement.

2. **Capsule Retractors and Sulcus Fixation: Case 1 (5 minutes)**

This case demonstrates greater zonular weakness than in the prior video, and 4-0 Prolene iris hooks are therefore used as capsular retractors. The same principles of chopping are demonstrated. In particular, the use of dispersive OVD to block the pliant posterior capsule from trampolining to the phaco tip is demonstrated. A 3-piece acrylic IOL is implanted into the sulcus.

3. **Capsule Retractors and Sulcus Fixation: Case 2 (5.5 minutes)**

As in the preceding case, the zonules are diffusely weak in this eye. The video demonstrates the technique of repositioning iris hooks from retracting the pupil to retracting the capsulorhexis edge, and later back to retracting the pupil. Due to the larger size of this anterior segment, a STAAR AQ2010 foldable IOL is selected for sulcus implantation because of the overall 13.5-mm length of this 3-piece silicone lens.

CONVERTING TO ECCE

The presence of a brunescient nucleus in eyes with pseudoexfoliation is associated with a much higher risk of zonular dehiscence, capsular rupture, and vitreous loss. Whenever performing phaco in these eyes, the surgeon should mentally rehearse and be prepared to convert to a manual ECCE technique if necessary. If severe zonular dehiscence is diagnosed early enough, manual extraction of the nucleus with a lens loop can prevent a dropped nucleus.

1. **Manual ECCE: Case 1 (1 minute)**

Excessive phacodonesis is seen as the entire capsular bag and nucleus begin to tilt. Manual ECCE rescues the nucleus. Following an anterior vitrectomy, an AC IOL is implanted.

2. **Manual ECCE: Case 2 (3 minutes)**

The severe extent of zonular dialysis is not apparent until the nucleus is rotated. The decision to convert to a manual ECCE is made early enough to avoid posterior capsular rupture. A large 3-piece PMMA IOL (6.5 mm optic; 14.0 mm overall length) is implanted into the sulcus.

LATE IN-THE-BAG IOL DISLOCATION: IOL EXCHANGE TECHNIQUE

Eyes with markedly abnormal zonules carry the risk of delayed in-the-bag IOL dislocation, often occurring many years later. Pseudoexfoliation is the most common associated cause of progressive zonulopathy. If the capsular bag is completely dislocated, it can be challenging to remove. It may look deceptively accessible at the slit lamp, but with the patient supine in the operating room, the IOL complex often drops farther posteriorly.

1. **In-the-Bag IOL Dislocation: Multifocal Lens (3 minutes)**

This video demonstrates Viscoat posterior assisted levitation (PAL) to explant 2 in-the-bag IOL complexes that dislocated many years after original surgery. In each case, an anterior vitrectomy is performed through a pars plana sclerotomy, followed by implantation of an AC IOL.

2. **In-the-Bag IOL Dislocation: 3-Piece Silicone Lens (3 minutes)**

Haptic deformation can be associated with a contracted capsular bag. This is a potential problem with trying to suture the IOL complex to the sclera by lassoing the haptics with 9-0 Prolene sutures.

3. **In-the-Bag IOL Dislocation: Plate-Haptic Lens — 2 Cases (4.5 minutes)**

Two cases demonstrate the difficulty of explanting plate-haptic IOLs. The Viscoat PAL technique is used in the first case. In the second, MST microforceps are used from a limbal approach to grasp the descending IOL edge.

4. **In-the-Bag IOL Dislocation: 1-Piece Acrylic Lens (1.5 minutes)**

This video demonstrates a unique approach for an IOL that is posterior and peripheral. The patient's head is turned acutely sideways to allow the dislocated IOL to settle into view, where it can be elevated into the anterior chamber using the Viscoat PAL technique.

Zonulopathy: Other Causes

A number of conditions besides pseudoexfoliation and trauma can be associated with weak or deficient zonules. These include retinopathy of prematurity, retinitis pigmentosa, scleritis, and prior surgery, such as trabeculectomy or vitrectomy. The principles of surgical management and IOL fixation previously discussed apply to these situations as well. Two examples are presented.

1. **Congenital Glaucoma (3.5 minutes)**

This eye with congenital glaucoma has an extremely large anterior segment. The opposite eye has NLP. One particular challenge in this one-eyed patient is the surgeon is without a good backup plan should the capsular bag become torn. There is no anterior chamber or sulcus IOL sufficiently large for fixation outside the capsular bag. Because of high astigmatism, a toric IOL is planned.

2. **Bilateral Microspherophakia (7.5 minutes)**

Surgery is scheduled urgently for this 18-year-old female with bilateral microspherophakia because of angle-closure glaucoma. The anterior chamber has been effectively flattened and the angle closed by forward displacement of the crystalline lens. A Cionni modified CTR is implanted to keep the intact capsular bag from becoming anteriorly displaced again. Both eye surgeries are shown.

Trauma

A second major cause of zonulopathy is trauma. In addition to the zonular problems, these eyes often suffer from anterior segment co-morbidity such as secondary glaucoma, traumatic mydriasis, iris trauma, and anterior capsular tears from penetrating injury. Iridodialysis is typically accompanied by zonular dialysis, and in some cases, vitreous prolapse into the anterior chamber. These videos present a representative sample of approaches to the myriad of problems associated with traumatic cataracts.

TRAUMATIC CATARACT AND MYDRIASIS: PUPIL CERCLAGE TECHNIQUE

Traumatic mydriasis may be as functionally bothersome as the cataract itself. In addition to the cosmetic issues, the functional problems include photophobia, glare, and loss of contrast sensitivity. There is currently no artificial iris technology that is FDA approved.

1. **Traumatic Cataract with Pupil Cerclage (6 minutes)**

This video demonstrates the principles of phaco with abnormal zonules followed by pupil cerclage utilizing two interrupted 10-0 Prolene sutures. These are passed with a McCannel suturing technique and tied with a Siepser slipknot.

2. **Pupil Cerclage Technique (4.25 minutes)**

This video demonstrates the same 10-0 Prolene pupil cerclage, but using the MST microforceps and microscissors that can be introduced through corneal stab incisions.

TRAUMATIC ZONULAR DIALYSIS

In contrast to pseudoexfoliation, traumatic zonular dialysis is often localized but associated with an iridodialysis. The same principles of using capsule retractors to stabilize and support the capsular bag apply. Long-term support of the IOL must also be considered. Options include bag implantation with or without a CTR, ciliary sulcus implantation, or use of implantable capsular devices sutured to the sclera.

- 1. Zonular Dialysis with Capsule Retractors (4.5 minutes)**

This video demonstrates the principle of using capsule retractors (Prolene Mackool Capsular Support System) to support the quadrant of the zonular dialysis. CTR implantation can be delayed until after the cortical cleanup. Because the remaining quadrants of zonules are strong enough, the single piece acrylic IOL is implanted into the capsular bag.
- 2. Zonular Dialysis, Iridodialysis, and Vitreous Prolapse (4 minutes)**

Triamcinolone suspension is used to stain the vitreous that has prolapsed through a traumatic zonular dialysis and the pupil. Compartmentalizing the vitreous prolapse with a dispersive OVD prevents vitreous aspiration until the cortical aspiration stage. The vitrectomy is performed via a pars plana sclerotomy to prevent drawing more vitreous anteriorly through the zonular defect. Following CTR placement, the IOL is implanted within the capsular bag.
- 3. Zonular Dialysis, Iridodialysis, and Vitreous Prolapse: Cionni CTR (6.5 minutes)**

Triamcinolone suspension is used to stain the vitreous that has prolapsed through a traumatic zonular dialysis and a dilated pupil. Because of the sizable degree of prolapsed vitreous, a pars plana anterior vitrectomy is performed prior to the capsulorhexis. Two Prolene Mackool capsular retractors are used to prevent posterior tilting of the partially dehisced capsular bag during phaco. Due to the severity of the zonular dialysis and the tendency of the lens to tilt posteriorly in this region, a Cionni CTR is implanted and sutured to the sclera to provide long-term capsular-bag support. The pupil cerclage technique is used to repair the traumatic mydriasis.
- 4. Zonular Dialysis with Ahmed Capsule Tension Segment (8 minutes)**

This video features the MST capsule retractors, which have a unique design intended to reduce the chance of tearing the capsulorhexis or puncturing the equatorial region of the capsular bag. Dr. Chang illustrates the need to adjust the tension of the retractors to avoid overly stretching or tearing the capsulorhexis as the entire bag is posteriorly displaced by the hydrostatic force of the phaco tip infusion. Because the entire capsular bag tends to tilt posteriorly in the quadrant of zonular disruption, an Ahmed Capsular Tension Segment (CTS; FCI/Morcher) is implanted and scleral fixated with a 9-0 Prolene suture. The traumatic mydriasis is repaired with the 2-interrupted-sutures cerclage technique.

TRAUMATIC ANTERIOR CAPSULAR TEAR

In addition to extensive iris trauma, penetrating injuries may be associated with tears in the anterior capsule that might not be appreciated initially. These two cases illustrate the unique surgical challenges posed by these eyes, and the principles for repairing the iris defects

- 1. Traumatic Anterior Capsular Tear: Case 1 (7 minutes)**

This teenager had a blunt paintball injury 5 months prior to surgery. The lens capsule and iris were lacerated, causing extensive adhesions. This video demonstrates the utility of MST micro-instrumentation, capsular staining, anterior vitrectomy performed via the pars plana, STAAR AQ2010 3-piece IOL placement in the ciliary sulcus, and pupil cerclage with McCannel 10-0 Prolene suturing tied with a Siepser slipknot.
- 2. Traumatic Anterior Capsular Tear: Case 2 (8 minutes)**

This 48-year-old man had a penetrating injury with a mature white cataract and extensive zonular dialysis and iridodialysis. He had RK and LASIK procedures many years prior to the injury. The video demonstrates the use of trypan blue dye to diagnose the anterior capsular rupture and the management of a traumatic cataract in this situation. Suture repair of the iridodialysis and traumatic mydriasis is shown.