Perils in the Operating Room: How in the World Did I Get Here?

Faculty: Steven Dewey, MD; Randall Olson, MD; Sam Garg, MD; Jeff Pettey, MD; Audrey Talley-Rostov, MD

ASCRS, May 9, 2016

As we review cases that somehow went differently than we had planned, sometimes commonalities pop out. What we think has happened and what actually happened may be two different things entirely. The video is the best form of identifying the proceedings of a specific case. (While it may seem really boring, watching your own work is the quickest way to identify your own flaws. There is a difference between the way you believe the surgery proceeds and the way it actually happened.)

Simple steps to avoid a lot of problems:

1) A clear shield to the non-operative eye. Marking the positive site is not fool-proof, the pupils don’t dilate as they used to, and it can be switched to the operative site right after the case.

2) Have your surgical plan and any “extras” outlined on a wall sheet that follows the patient through the process. Fuch’s, PXE, post-PPV, need to be in a convenient place to visualize.

3) Discontinue the superior surgical approach, unless anatomically necessary. Don’t let the eyebrow/forehead become a fulcrum against your instruments.

4) Restrain the patient across the chest above the arms, and tape the head. The patients actually appreciate this.

5) Consider Tessalon Perles to suppress coughing. No it’s not the propofol, it’s the topical anesthetic.

6) Save your neck - have a consistent surgical positioning. chair, bed height; microscope position.

7) Use appropriate intracameral pupil dilation/anesthesia. Drops in the pre-op area don’t always get the job done.

8) Cheap viscoelastics are cheap for a reason. Once you’ve used a poor one, recapturing the situation may be much more difficult as a result.

9) Minimize your incision size to avoid leakage during surgery. Maximize the working space to avoid oarlocking and avoid wound tears during IOL insertion.

10) Low-flow, Slo-mo phaco is a myth. Turn up the vacuum, and turn down the needle gauge.

11) Consider the Dewey Radius Tip from MST. (If the ultimate problem is contact with the capsule, or the iris, and we’re concentrating this hard on avoiding that, when ultimately it does happen, don’t we want to avoid the damage from a sharp tip?)

12) Have alternative cortical removal techniques at the ready. Biaxial/bimanual comes to mind.

13) Absolutely, positively be certain of the incision’s integrity at the end of the case. After all, this is the easiest time to fix a leak.

And, most importantly, have an emergency kit readily available for the unexpected situations. This should include, but not be limited to, trypan blue, iris retractors, iris dilation rings, capsule retractors, capsule tension rings, bimanual instrumentation for I&A, extra different viscoelastics, vitrectomy packs, special sutures (10-0 prolene on a CIF-4, etc.), kenalog, and, well, you get the picture. Jerry Roper calls his emergency packs “success kits,” which is absolutely brilliant given the patient is awake and listening to the proceedings of the case. (“Disaster kits” was my idea, but I have surrendered to Jerry’s wisdom.)
The majority of the result is a successful deployment of the surgical plan. Without successful execution of the plan, the rest just doesn’t work. The intangibles include pre-existing comorbidities, dry eye. Oh, and the 15% of patients with a refractive target just off perfect. But, in the presence of an intact surgical platform, most problems with the result can be dealt with.
Hypermature Cataract

Randall J. Olson, MD

Hypermature cataract (hypermature, white cataract or Morgagnian cataract) represents an end-stage in the process of aged cataract formation, in which the cortical lens fibers become liquefied to produce a milky fluid, which due to hypertonicity imbibes fluid and leaves a very tense capsule with a nucleus often suspended in gelatinous and fluid cortex\textsuperscript{1,2}. Besides severe visual impairment, serious sequelae such as phacolytic glaucoma may occur in these patients and cause irreversible visual damage. Therefore, hypermature cataracts should be operated as soon as possible\textsuperscript{1,3}.

There are potential pitfalls when performing cataract surgery on hypermature cataracts, which include: (1) Lack of red reflex which causes difficult visualization of the anterior capsule against the white background; (2) The release of milky cortex obscures the surgeon’s view as the capsulorrhexis is initiated; (3) The liquefied, swollen cataractous material places pressure on the capsule and thus extension of the capsulorrhexis to the lens equator or beyond can occur by just opening the capsular bag (Argentine flag sign); (4) A freely mobile nucleus that is hard to hold in place and hard to perform typical removal maneuvers such as divide and conquer; and (5) A hard nucleus with no protective cortex or epinucleus which can result in a high rate of posterior capsule rupture during phacoemulsification.
Capsulorrhexis

Anterior continuous curvilinear capsulorrhexis (CCC) can be difficult to perform in eyes with hypermature cataract because of pitfalls 1, 2, and 3, as listed above. General recommendation for creating a CCC in these eyes include dimming the OR room lights, increasing the operating microscope’s magnification (x25 or more) with oblique coaxial illumination, and routinely using OVD in the anterior chamber. Highly viscous OVDs like Healon 5 (Abbott Medical Optics, Santa Ana, CA) are advantageous in such cases to counteract the high intracapsular pressure. Dye-enhanced cataract surgery with the use of trypan blue for capsular staining is the preferred method in such cases. After the anterior chamber is filled with an OVD like Healon 5 to create enough intraocular pressure to start to flatten the anterior capsule, 0.1 mL trypan blue solution (0.1%) is injected into a layer of BSS under the OVD just above the capsule before the CCC is created. Then the CCC is created carefully, preferably through a side-port incision with microcapsulorrhexis forceps because the anterior chamber will be maintained and no OVD will flow out of the eye. If performing a capsulorrhexis with a microforceps through the side-port incision seems a daunting task, then the surgeon should be prepared as soon as the capsule is open to aspirate some of the milky cortex to release capsular pressure and minimize the spread of the milky cortex that obscures visualization. Because capsulorrhexis extension can result no matter how fast you move to aspirate cortex, and you often have to repeat the aspiration as more cortex flows out of the bag and obscures visualization, it is a good idea to learn how to do a capsulorrhexis through a side-port incision so the skill set is available for such tough cases.
Extension of the capsulorhexis tear due to capsular tension could be a major problem, which can turn a routine case into a disaster as the nucleus and remaining lenticular material drop into the vitreous cavity. Understanding the cause is the key to avoid the problem. An opening in a tense capsule in an intraocular chamber of zero pressure will cause viscous cortex to surge out of the capsular tear and extend it. Of the many ways for managing this situation, again, the easiest solution is performing the capsulorrhexis with a 25 gauge forceps (MST, Seattle, WA, among other excellent microcapsulorrhexis forceps) through the side-port incision before making the primary incision.

Work through a sub 1-mm incision and use highly viscous Healon 5 to inflate the anterior chamber and increase pressure so that the anterior chamber pressure at least equals the internal capsular pressure. This is actually very easy to visualize because as the anterior chamber is inflated you will see when you reach this point that you start to flatten out the capsule. Intraocular pressure can be increased to a high level if you inject more so just place enough to start to flatten the capsule. Once the pressure in the anterior chamber equals the pressure inside of the capsule, capsulorrhexis extension simply cannot occur. The advantage of this side-port incision approach is avoiding OVD escaping, which is common with a regular incision, in which the viscoelastic escapes through the regular incision during capsulorrhexis formation resulting in tear extension and/or milky cortex obscuring the view. Remember, the very act of capsulorrhexis creation will lower the OVD viscosity causing it to flow due to the principle of pseudoplasticity. A small incision largely filled with a forceps solves this problem.

This technique requires the surgeon to have experience in using a microcapsulorrhexis forceps through a small stab incision. While it actually is not difficult to use, the main thing to remember
is that the wound must serve as a fulcrum in all the actions otherwise the eye will move and corneal folds will result.

Management of a Mobile Nucleus

With no solid or semi-solid cortex or epinucleus to stabilize the nucleus, creating a groove is almost impossible on a mobile nucleus. The latest phacoemulsification (phaco) instruments where high flow and vacuum are possible with a stable chamber, make aspiration and impaling the nucleus with the phaco tip a straight-forward proposition. The zero degree tip is very helpful because the nucleus, once aspirated, does not angle off from the tip and you can impale the nucleus with your tip pointing toward the opposite pole of the nucleus. An actual advantage of a freely floating nucleus is that it does not much matter where you impale the nucleus as long as the tip is pointing to the opposite pole. The use of micro-pulsed longitudinal ultrasound under these circumstances to minimize chatter and use enough energy to finally impale the nucleus up to the sleeve is advantageous. For such cases I rotate the sleeve back so that 2-mm of the tip is exposed. With vacuum set at 300 to 400 mm Hg or higher and the nucleus impaled (hold on the nucleus with maximum vacuum), horizontal chop is performed using an instrument that reaches across to the opposite pole to split the nucleus into two fragments. These hypernature nucleii tend to be more brittle than rock hard and usually do not have any woody connections so a chopping maneuver is usually quite simple.

Then either of the two heminuclei is aspirated with the assistancance of the second instrument to manipulate the fragment, which can be impaled on the recently cut edge, and, a small fragment is cut off the heminucleus (Figure 2). Transverse ultrasound works well for
emulsification and removal of the fragment, but not for the impaling maneuver. However, micropulsed ultrasound with the chopping instrument pushing the fragment into the phaco tip and actually crushing it a bit between the two instruments is also very efficient and is the best power modulation for impaling the remaining nuclear material. Little ultrasound is needed and the piece is rapidly subsumed. Just repeat the process keeping the fragments small (the harder the nucleus, the greater the number of fragments) until the nucleus is gone. With a little bit of patience not much ultrasound is necessary, and these cataracts can usually be removed with a nice clear cornea the next day. Furthermore, because the little cortex or epinucleus present is usually rapidly aspirated, it is nice to always work mid-chamber and away from the posterior capsule. As a safety measure, I always put my chopper between the nuclear fragment and the posterior capsule when the last few fragments are being removed. Another precaution is floating all of the nuclear fragments on dispersive viscoelastics to protect the capsule and replace the same viscoelastic in the corneal vault as often as is needed to protect the cornea.

Because hypermature cataracts tend to be brittle with little or no woody connections between lens fragments, although they can be quite hard, they chop up very nicely and tend to cleave cleanly. The Visco-shell technique with Healon5 (Healon5 sandwich technique) may facilitate phacoemulsification in eyes with hypermature cataract for those not accustomed to phaco chop. In this technique, an ample amount of Healon5 is injected above and beneath the nucleus to stabilize the nucleus after the CCC is created. With this procedure, the nucleus is wrapped by a visco-shell and stabilized, thus emulsification can be performed somewhat more easily, however, horizontal chop is clearly a superior approach in these eyes.
Summary

Using capsular stain, Healon 5, microcapsulorrhexis forceps through a small side-port incision, good phaco machine fluidics, a zero degree tip and horizontal chop, hypermature cataract surgery can be quite straightforward.

References

WOUND BURN

INTRODUCTION

With the introduction of ultrasonic phacoemulsification a new complication was born and that is incisional burn. This happens due to the friction of the motion of the phacoemulsification tip which in longitudinal phaco can reach a peak velocity of fifty miles per hour. At such a speed frictional energy can increase temperature quite rapidly. Once any area of the incision reaches 60°C then in a matter of a few seconds there is a permanent contracture of the collagen in the region of the wound that will result in gaping of the incision with difficulty closing the wound and induction of large amounts of astigmatism\(^3\). \(^4\).

Ultrasound generated thermal damage to the corneoscleral wound site may also result in damage to the adjacent corneal stroma and endothelium, and fistula formation\(^4,5\). Wound burns can vary from being mild with some elements of contraction lines pointing to the wound with increased astigmatism all the way to a marked contraction with transplanted tissue needed to close the wound and induction of such large amounts of astigmatism as to be visually very difficult for the patient. What will be covered is what we understand about how wound burns are created and their prevention, and then what should be done when a wound burn is encountered.
1. **Major Risk Factors for Creation of a Wound Burn:**

Wound burn is a frictional issue. It is important to understand that fluid flow around the phacoemulsification needle is a major source of eliminating any of the heat generated by motion of the phacoemulsification tip. Therefore, the single biggest risk factor for wound burn would be little or no fluid flow\(^4, 6, 7\). This most typically would occur whenever the tip is occluded and a tight wound such that there is zero fluid flow. Under these circumstances, the temperature can increase quite rapidly. Combine blockage then with high ultrasound power, and it does not take many seconds for a wound burn to occur. Unfortunately, for the surgeon there is no indication of the elevation in temperature until a wound burn suddenly appears\(^8\). The surgeon generally focuses on the phaco tip, and it is not until contracture of the wound, which rapidly accelerates, starts affecting central visualization before it is often noticed at which point a very severe wound burn is the result.

Another time when there is no or little fluid flow is a blockage by an anterior chamber full of viscoelastic (OVD). Under such circumstances, specially if the ultrasound is used on a hard nucleus and, again, we have a situation where a wound burn has been documented after only seconds of ultrasound use. This, therefore, certainly is another risk factor easily avoided by making sure that there is some irrigation and aspiration of a little viscoelastic overlying the nucleus thereby allowing free fluid flow. Immediately recognizing a wound burn and identifying the causes during the surgery are crucial. The signs of a wound burn vary and may be manifested as whitening of the wound and contraction of tissue, gaping of the incision lips, and...
wound leakage, which is evident as both entry and exit of fluid to and from the anterior chamber\textsuperscript{9-11}.

One of the major misconceptions by ophthalmologists is the difference between maximum vacuum and full occlusion with peristaltic pump systems. Maximum vacuum is the point after an occlusion where the vacuum has built to its maximum level at which point most machines are set up to give some indication that you have a maximum vacuum. Occlusion occurs as soon as a fragment of the lens is in the phacoemulsification tip, at which point vacuum starts to build. As soon as the tip is occluded in particular with a very tight wound, then with little to no fluid flow, temperature rise can be very swift.

2. Ultrasound Modulation and Wound Burn:

How we control ultrasound does vary between machine and we now have multiple different means of energy modulation. The most common control of ultrasound is a foot pedal that works like a gas pedal in your car: the further you push down on the pedal the more energy is delivered to the ultrasound tip. So if you are driving in hilly country (removing soft or hard lens material) if you have a fixed amount of gas (or ultrasound) being delivered, you would accelerate while going downhill and decelerate going uphill. Therefore, by adjusting foot pedal position you can get the desired effect on the tip. Another approach, however, is more like a cruise control in your car. If you set the speed at 50mph then the gas surges going uphill to maintain the speed and you coast going downhill. This would be the same for a stroke length protected foot pedal. Even though you do not change the foot pedal pressure, the energy would ramp up the harder the nuclear material is you are trying to remove. The Legacy (Alcon, Ft.
Worth, TX) machine has a stroke length protected foot pedal while virtually all other machines, including the Infiniti (Alcon) machine, function more like a gas pedal where the amount of ultrasound energy is controlled by foot pressure. Couple that with the different ability to pulse energy in very short cycles, as well as the new transversal modalities where the phaco needle moves from side to side or in an elliptical motion, and it is clear that ultrasound energy can be delivered in a multitude of ways and how that relates to wound burn is an important subject.

3. Ultrasound Modulation and Differences in Heat Production.

In early work looking at the creation of wound burn, we found that very short pulses of energy in the range of 5 to 6msec on and 6 to 12msec off seemed to be quite forgiving in regard to wound burn. Just why this might be was certainly not clear, so this led to a series of experiments to understand just how heat was generated between the different machines. One of the first things we discovered is there is no agreement between the machines in regard to what percent power means. This variation is further amplified when you look at work load in which those machines that act like a gas pedal will not show much difference in heat production if fluid or hard nuclear material is being aspirated, whereas the Legacy machine, will dramatically increase its power when under a load.

Pulsing ultrasound also can have a big effect on heat production. Duty cycle was very simple in that the amount of heat production directly related to the duty cycle. In other words, if you are on one-third of the time, the machine will produce one-third of the heat at any power setting, and if you are on one-half time you will have half the heat production. None of this suggested
any reason why extremely short pulses (5-6ms on) should necessarily be protective of wound burn nor do we have evidence that this is necessarily so in the clinical setting.

4. A Survey of Wound Burn in the United States and Canada:

It was decided, with no evidence of what wound burn incidence might be or how it correlated with different machines or features, that a survey would be undertaken in the United States and Canada\textsuperscript{14}. From this we were able to gain information on almost a million surgeries in which we had about 500 wound burns with an incidence of about 1 per 2,000. The strongest correlation (P<0.0001) was with surgical volume; the higher the surgeon’s volume the lower the incidence of wound burn. This says that an efficient surgeon without wasted ultrasound is less likely to create a burn. The second strongest correlate with burn (P = 0.0001), which fits nicely with the surgeon’s volume, is surgical approach. Divide and Conquer and Carousel were much more likely to create a burn than any of the chop techniques with Stop and Chop right in the middle, which makes sense as it is halfway between the two. The third correlate (P = 0.0025) was with the type of viscoelastic used. More on that later in section 6. Nothing else correlated with wound burn risk.

5. How OVDs Relate to Wound Burn:

While it is true that OVDs can block the inflow and outflow of fluid resulting in a more rapid buildup of heat during ultrasound, the rapidity with which wound burns can occur in an anterior chamber full of viscoelastic, is hard to explain simply based on the lack of outflow and inflow. It was decided, therefore, to look to see what would happen with ultrasound in an artificial chamber full of viscoelastic, and what was found in every case is that there is an exothermic
reaction with greater heat generation than with a chamber full of balanced salt solution in which, again, there is no inflow or outflow. Furthermore, there was a marked difference between viscoelastics in regard to how much exothermic energy was released. While the most forgiving had 50% greater heat buildup over balanced salt solution alone, those that were the most exothermic actually increased heat production by as much as 500%. Interestingly, the least forgiving represented one of the least viscous (Viscoat) and the most viscous, Healon 5. It would appear that an anterior chamber full of either is the riskiest and anecdotally these are the two that seem the most commonly associated with wound burn. Again, an important principle at the beginning of the case is to always spend a few seconds with irrigation and aspiration to remove an area of viscoelastic over the nucleus to avoid this problem.

WHAT TO DO IF A WOUND BURN OCCURS?:

While we have talked about why wound burn occurs and prevention, it is important to understand what to do when a wound burn actually occurs. Strive to recognize this early because a mild burn can be very forgiving. Our natural focus on the needle tip means that folds radiating centrally from the wound and decreased visualization are our first signs of a problem, and by then the burn is a bad one. Wound burns can vary from very mild with increased astigmatism that dissipates over time to very severe burns. In severe burns primary closure is essentially impossible, and patients have been referred to me with as many as eleven sutures and then glue over this as the only means of creating a water tight incision. Because of stromal contracture this creates the same problem as loss of tissue and, therefore, either a patch graft or sliding scleral graft in the contracted area best resolve the underlying problem, lead to better wound closure and a faster visual recovery. Because immediate access to donor tissue is often
problematic, resect the conjunctiva from the limbus and make a partial (about 50% depth) thickness incision in the sclera. Dissect this scleral flap anteriorly and use this as excess tissue to fill the defect. Suture with 10-0 nylon to fill the defect, and both closure of the wound and astigmatism recovery will be greatly enhanced. Leaving a partial thickness area of sclera under conjunctiva has not been a problem. Other than in mild cases, wound burns are best closed when they occur and a new incision used to finish the case. A single suture is often enough to create a water-tight incision closure if there is enough relaxation of the contracted tissue to result in easy closure.

Increased astigmatism is always an issue. As soon as the incision has healed and all sutures removed, a relaxing incision in the cornea just in front of the wound burn can be very helpful in eliminating large amounts of astigmatism. A $90^\circ$ arc 600 micron deep relaxing incision just ahead of the wound burn has eliminated in one severe case of wound burn referred to me over 8 diopters of cylinder; therefore, this can be a very effective approach. Wait for at least three months after the burn occurred, however, because astigmatism will relax over time and the correction should deal with the final picture rather than a moving target.

References


Perils in the Operating Room: How in the World Did I Get Here?

Steven Dewey, MD

1) Zonular Laxity: CTRs and Capsule Support Devices

There are two types of zonular laxity—those we spot in the office prior to surgery, and those we find out about somewhere in the midst of the case.

Regarding the cases we spot in the office, there is absolutely nothing wrong with referring a case of obvious zonular laxity to another surgeon or equipped for the situation, and there is no evidence to show that a sutured/glued IOL is superior to an ACIOL in these situations. This section is much more about the localized dialysis encountered in the OR.

One to two clock hours of zonular laxity.

The real question is how this area of capsule became detached. A quick glance at a well-prepared wall sheet reflecting the surgical plan will notify the surgeon of a previous pars-plana vitrectomy. Perhaps an old trauma. I personally hate seeing pseudoexfoliation in the OR and not in the office, but I have nuclear dilation systems in the OR, and we don’t do that in the office.

The obvious overlooked cause of a localized dialysis is a corticocapsular adhesion. This was described by Abhay Vasavada in the early 2000s. These are highly localized adhesions of cortex to the capsule that can resist hydrodissection. Unfortunately, they are most often in the inferior, nasal, or most commonly, inferonasal area. I say unfortunate as this is exactly opposite the incision, even with a superior approach.

The question becomes how stable the dialysis will remain. If trauma, or perhaps unknown, (or iatrogenic), the likelihood of the dialysis extending during surgery, or presenting a risk of IOL dislocation after surgery is low. A post-PPV case, particularly in a high myope is likely to stay put during surgery, but has a poorer long-term prognosis. PXE is highly variable.

Remembering how the capsulorhexis proceeded will help. Peripheral striae forming as the tear proceeds, or if the lens seems to torque during the rhesis, the zonules are likely weak. This usually results in a smaller-than-desired rhesis. If the dialysis is likely small and stable, you probably didn’t notice anything during performance of the rhesis.

(I personally prefer a dispersive viscoelastic for the capsulorhexis, and a bent needle. Using a cohesive tends to make my rhesis smaller, and using forceps tends to make the rhesis smaller as well. These are personal preferences due to my own observations, and may or may not be applicable to your technique.)

The next question is the surgical technique being employed to remove the cataract. If the surgeon is using a chop technique, and even a flip with a larger rhesis, the stresses on the remaining zonules will be lessened. Divide and conquer, or alternative techniques that use a lot of trenching will place an inordinate stress on the zonules as the case proceeds.
The goals with a small dialysis are to 1) AVOID VITREOUS PROLAPSE and 2) MAINTAIN AN INTACT RHEXIS. The first step is to tamonade the viscoelastic with a dispersive or supercohesive viscoelastic. There is absolutely nothing wrong with placing a capsule tension ring at this point, or at any point from here along the way. Vitreous in the AC will only make the dialysis worse, and if the rhexis is not intact, the ring can’t be deployed.

Oh, and if the ring is in place and a radial tear forms, you don’t need to remove the ring. The tension of the ring will be distributed across the equator of the capsule evenly. Placing a ring with a radial tear is an entirely different situation. If that is the case, the point force of the CTR during insertion will likely shred the capsule.

The advantage of using the extra-heavy-duty viscoelastic (compared to a vanilla cohesive) is that the case can proceed with a relatively higher flow and higher vacuum. This allows for good hold on the nuclear fragments, withdrawing them into the anterior chamber for emulsification. In cases with a smaller gauge needle, the restricted lumen will dampen the fluctuations of the chamber that are inherent to fragment removal. If you started with a larger gauge needle, reducing vacuum and flow are the only alternative.

**Three to four clock hours of dialysis**

The real difference in this situation is that the capsule tension ring is indicated the moment this extent of capsule disinsertion is identified.

(UNLESS, it is apparent that the rest of the capsule is ready to go as well. In these situations, I place the capsule retractors to stabilize the capsule position and will remove the nucleus with the idea in mind that the capsule will not be salvaged at the end of the case.)

Moving forward as if the capsule is stable, but has 90 to 120 degrees of lost support, I place the viscoelastic as described, and assess where I am in the case. If there is a lot of remaining cortex, I will sometimes perform subincisional hydrodissection with a j-cannula prior to placing the CTR. Fluid into and out of the anterior chamber won’t destabilize the capsule, and loosening the cortex will make its later removal easier.

The choice of CTR, as well as the suturing of segments, is a bit beyond the intended scope of this course. The space for the CTR should be established by a dispersive or supercohesive viscoelastic. The tip of the CTR is placed just proximal to the dialysis, and it is advanced into the region of laxity. Every attempt is made to avoid significant tilting of the plane of the CTR, as this can worsen a stable dialysis. In some cases, I use a bimanual technique, using a Lester hook to hold the distal tip of the CTR through the fixation hole to stabilize the advancement. Ken Rosenthal has told me he uses a 10-nylon suture through the distal fixation hole to achieve the same effect.

Once the CTR is in place, the next step is to decide how much material is in the way of the IOL placement. It doesn’t take much encouragement for me to place the IOL once the central capsule is free of cortex, even if there are several nuclear fragments remaining. The CTR effectively re-establishes the two chamber eye, and will keep the vitreous at bay.

The IOL choice depends on the presumed cause of the dialysis. In cases of general laxity, a three piece IOL with the haptics in the sulcus and optic capture in the rhexis may provide a good level of stability.
cases of presumed stability, either a single-piece or three piece in the capsule will work. Removal of the nuclear fragments will be best in the presence of copious viscoelastic. Removal of the cortex will be a combination of a direct irrigation (bimanual, j-cannula) and a direct aspiration.

Viscoelastic removal will be a bit more challenging.

**Five or more hours of dialysis**

The primary consideration here is the survival of the capsule in general. Ahmed CTR segments or Cionni CTRs will allow for suture support of the IOL/capsule complex. Ideally, the suturing will take place at the time of the primary surgery, but, this can take place in a staged fashion. (Obviously, if the staging is to be “easy,” a Cionni CTR should be properly placed with the fixation curl at the center of the dialysis.)

Beyond six hours of dialysis will depend on the need for a capsule-supported IOL in this particular patient’s situation, and the conditions surrounding the necessary support to maintain the capsule.

**Summary**

Dealing with a dialysis/zonular laxity will be easier if

1) No vitreous prolapse
2) Intact capsulorhexis
3) Larger capsulorhexis
4) Stable anterior chamber
5) CTR “as late as possible, but as early as needed”
6) Capsule retractors (iris retractors will do in a pinch, but are not designed for the capsule)
   AND...
7) There is no evidence that a CTR will prevent later IOL dislocation in a PXE case.

**2) Dropped Nuclei/Retained Fragments**

This situation arises a lot more frequently than we realize. The “Bermuda Triangle” formed by the flow of fluid escaping through the primary and secondary incisions will allow small bits of material to escape the aspiration flow through the phaco needle. After all, while the irrigation is active, and the lumen of the needle is occluded, the lowest pressures will be found at the incisions, and fluid will flow toward the incisions and carry anything and everything in those directions.

For the small observed fragment, either nuclear or epinuclear, up to a millimeter or so, it is, of course, best to remove these at the end of the case. If these are retained, for whatever reason, a simple YAG fragment dissection can be performed at a later date. The classic tell-tale sign of a retained fragment is persistent edema in the lower ¼ of the cornea.

Larger fragments have a difficult time avoiding detection. The subincisional space, with the normal stromal hydration occurring during the case, can hide slightly larger fragments.
Fragments of nucleus, or sections of cortex in the anterior chamber or vitreous can be observed for a period of time, but recognize that the longer the delay in recovery from surgery, the less likely the recovery will be optimum.

From personal experience, the most likely setup for retained fragments are small pupils and low-flow phaco. For a period of time, I tried low-flow phaco to reduce the risks associated with IFIS. The result was a greater collection of retained fragment in the anterior chamber than I had previously encountered. I had traded one problem (IFIS-associated iris damage) for another (retained fragments.) Fortunately, the treatment plan for IFIS became more organized, and now iris damage is a much lower risk, even in high-flow phaco.

**Big Fragments in the Vitreous**

In the case of a dropped nucleus, or a larger dropped nuclear fragment, the best initial reaction is to take a deep breath. We are taught that this is one of the worst problems associated with cataract surgery. Perhaps, in the days of comparing phaco to extracapsular surgery, a dropped nucleus could be considered a tremendous strike against phaco in general.

To the contrary, while it does involve an additional surgery, in the hands of a good vitreoretinal surgeon, a dropped nucleus is not likely to change the grander scheme of the desired outcome.

**Steps for a good outcome in a dropped nucleus case:**

First, with a bit of good fortune, the capsulorhexis is intact, centered, and less than 5.5 mm in diameter. The most important step is to preserve this structure. But, the posterior capsule is expendable at this point. Vitreous is likely streaming into the anterior chamber, and the remaining cortex is a mess.

The vitreous is the first point of business. Take .1 cc of kenalog and instill it into the anterior chamber to stain the vitreous for easy visualization. This can be repeated, and too much will simply descend into the posterior segment. An anterior vitrectomy will likely clear the capsule, and allow a bimanual/coaxial I&A to take place. Yes, switching the settings on the machine will allow the cutter to become an aspirating device, but the size of the port on the vitrector is much larger than optimum for removal of cortex.

Regarding anterior versus posterior, a posterior approach is much cleaner in retracting the vitreous from the anterior chamber. From the perspective of effect, both can achieve the same goal, but timing makes the difference. If the cataract has barely been removed, and vitreous is coming forward, the posterior approach will preserve more capsule, and should allow the rest of the surgery to progress less impeded. If the capsule opens due to a chamber shallowing with the last quadrant, the better option may be an IOL implantation with the fragment trapped in viscoelastic. The posterior approach may offer no benefit in this situation.

The thorough removal of cortex is the next step. Remember, if the nucleus is coming out in another surgery, a little cortex in the vitreous won’t be a problem.

Placement of a stable IOL in the face of a compromised capsule is critical. This will be discussed in the next section.
Lastly, suture the incision. Regardless of how stable it is on the table, the mechanical stresses of a pars plana vitrectomy exceed the stability of your sutureless incision.

Summary

1) A dropped nucleus should not threaten the outcome for the patient . . .
2) . . . provided the surgeon is not attempting to be a hero.
3) Preserve the anterior capsule, and capsulorhexis if possible
4) Avoid vitreous strands impeding IOL placement
5) Thorough cortical removal (or displacement into vitreous)
6) Suture the incision.
7) This is far from the worst thing that can happen.

3) IOL Placement in the Compromised Capsule

This section is devoted to how to place an IOL in the presence of a somewhat intact capsule. Yes, the role of sutures is exceptional in expanding the ability of a bit of available capsule in supporting an IOL.

Advantages of the capsulorhexis

A perfectly circular, perfectly centered intact opening in the anterior capsule provides any number of advantages in small-incision cataract surgery. This perfect opening can provide support for a three piece IOL with optic capture, or potentially reverse optic capture. Lately examples of toric IOL support have been reported as an option for support without a posterior capsule (David Chang), or simply stopping the rotation of a misbehaving toric in the presence of an intact posterior capsule (the author).

Reverse optic capture is performed with a three-piece IOL, initially placing the IOL in the sulcus. The usual challenge is the presence of vitreous, and the potential loss of red reflex from excessive kenalog used to stain the vitreous. (Remember, only .1 cc of kenalog is necessary, and can be repeated.) The sulcus is distended with any viscoelastic, and in this case, a cohesive is easier to remove.

With the lead haptic properly oriented—remember, “S” stands for stupid—the IOL is allowed to unfold to a planar configuration. The IOL can be inserted, with the optic allowed to unfold in the AC, but this will throw off the orientation of the haptics. The trailing haptic is ejected from the cartridge, many times outside the incision. Once the IOL is unfolded, any hook can be used to rotate the IOL into the sulcus. Simply place the hook at the optic-haptic junction, and push forward, causing the IOL to rotate clockwise.

Occasionally, the trailing haptic will need to be guided into the sulcus, and this can be accomplished by a second hook, or by microforceps.

With the IOL in the sulcus, the appropriateness of the optic capture can be assessed. In general, a capsule opening at least 4.5 mm, but less than 5.5 mm will capture the optic well. Too large an opening, and simple sulcus placement will have to suffice. Too small an opening, and leaving it in the sulcus is still the perfect option. With capsule fibrosis and contraction over time, the platform will become more stable, and the opening can be enlarged with the use of microforceps and microscissors.
As this IOL is in very nearly the same position (ELP) it would be were it in the bag, there is no need to adjust the power of the IOL. If the placement is in the sulcus, subtracting one-half diopter from the power of the IOL will be consistent with the original planned refractive result.

**Single-piece optic capture** can be performed with the haptics in the posterior segment, and the optic in the anterior segment. This is a bit trickier, as it requires proper sizing of the capsulorhexis prior to IOL insertion. Frankly, the only real opportunity for this to be an advantage over a three-piece IOL is in the case of a toric IOL.

Single piece IOLs, however, should not be placed in the sulcus. The chafing of either the sharp anterior optic edge, or from the thick haptics, against the posterior surface of the iris can result in a form of pigmentary glaucoma.

**Anterior and Posterior Capsule Tears.**

This is probably the most complex situation for placement of an IOL, and yet, a single-piece IOL is sometimes the perfect solution for this problem. For this situation to work, and to be optimal, at least three clock-hours of intact capsule are necessary 180 degrees apart. Now, this usually isn’t an issue of a perfect radial split in the posterior capsule, but the issue of a peripheral capsule tear extending far enough into the central capsule.

Microforceps will be very helpful for this step, but two hooks will suffice.

The capsule should be free of vitreous, and with no residual kenalog to disturb visualization. The single-piece IOL is loaded with the lead haptic extended. This haptic is either placed directly into the viscoelastic-distended capsule, or directly anterior to the capsule. The trailing haptic is loaded onto the optic, and a small amount of resistance to unfolding is desired. While the optic is still unfolding, and the trailing haptic is unfurling, the lead haptic is placed into its final desired position. The optic is displaced toward the lead haptic, placing the optic posterior to the anterior capsule.

Placement of the trailing haptic exactly opposite the lead haptic is now the critical step. One option is to stabilize the optic with microforceps as the trailing haptic unfolds. If the trailing haptic ends up anterior to the anterior capsule, it can be swept centrally, and “dropped” into its final position. With the haptics fully extended, the IOL should be stable.

Removing the viscoelastic should be as gently performed as possible.

**Summary**

1) Preserving the largest amount of intact capsule will leave intact the most IOL options
2) Final placement of the IOL does not need to take place at the time of the primary surgery
3) When placing a sutured IOL, the residual capsule provides stability from tilt
4) The IOL can be sutured to the remaining capsule after fibrosis takes place
4) Iris Damage: Location, location, extent.

I find it a bit ironic I’ve never seen an iris damage grading scale. This, of course, pertains to a profession that lopped off half of the iris during “routine” cataract surgery just a couple of decades ago.

Visually significant damage differs from incidental damage by one of two processes: Either the iris no longer functions as a light-blocking diaphragm, or the pupil sphincter no longer serves its appropriate cosmetic/functional role. Regarding blocking light, this can be significant sphincter damage to the point we would classify it as traumatic mydriasis, or the stroma is damaged to the point it appears moth-eaten. It is surprising how well a mild to even moderate degree of pigment loss off of the posterior surface of the iris is tolerated, but even a small through-and-through iatrogenic subincisional iridotomy can yield significant subjective displeasure.

Mechanisms of iris damage include, but of course are not limited to: 1) Iris prolapse from either the primary or secondary incisions 2) Iris interaction with the phaco needle 3) Iris interaction with the IOL or IOL injector.

Observing with Iris Prolapse

To paraphrase Roger Steinert, for the iris to be coming out of the eye, something typically has to be behind it pushing it out. For the most part, the iris is going to behave more appropriately with good dilation, a deep chamber, a properly placed incision, the proper amount of viscoelastic, the proper phaco settings, and a cooperative patient. All of this in the absence of aqueous misdirection.

With those characteristics in place, I’ve had virtually every situation possible result in iris prolapse, even a very deep anterior chamber, beautifully dilated, with what I considered to be a perfect incision with ideal viscoelastic use. Cough, cough, and the game changed before my eyes.

Dealing with a Shallow Anterior Chamber

How shallow is shallow? I would contend that a shallow anterior chamber itself is a concern, but add a denser nucleus, or a smaller pupil, and the complexity changes considerably. The fundamental problem is that the shallow chamber will remain shallow until it becomes deeper, which is somewhere during/after the nucleus is removed. Preoperatively, IV mannitol and a Honan balloon may be useful to decompress the globe. In these cases, I try to avoid performing hydrodissection, and instead, perform an in-situ horizontal chop. The first cleaving crack creates space. Do not rotate. Then, by angling the chopper and phaco needle about 30 to 45 degrees toward your dominant hand, section another fragment of nucleus. This will end up being about 1/6 of the nucleus.

Now, space is created, a channel in the viscoelastic has been created, and hydrodissection can be carried out with less risk. Alternatively, in some, if not most cases, the very act of the chop has disrupted the corticonuclear interface, and a bit of fluid has made its way into this plane of dissection. Nudging either remaining nuclear fragment may further dislodge it, without introducing additional fluid. One can complete a chop without hydrodissection, but there will be a whole bunch of cortex left. I don’t recommend this for the divide-and-conquer surgeon.
One may be tempted to perform a pars plana tap to decompress the vitreous and deepen the anterior chamber. The only observation to make is that in exceptionally short eyes, there may not be a pars plana through which to decompress—the retina may insert adjacent to the ciliary body.

**Dealing with a Shallowing Anterior Chamber**

There is a functional difference between an anterior chamber that starts out shallow and becomes deeper as the case progresses, and a case that starts out deeper and becomes shallow along the way. The obvious question is why, and the most emergent problem would be the dreaded expulsive hemorrhage. In my experience, coughing was the problem in the majority of cases where the chamber shallowed during surgery. Hence, I was particularly delighted when an anesthesiologist colleague of mine recommended Tessalon Perles in the pre-op area. In a not-so-randomized trial, the likelihood of coughing dropped precipitously. Even to the point where I have had several patients ask for a prescription to reduce their spontaneous coughing upon reclining for sleep.

As the chamber shallows, obviously, the first plan of action is to use the indirect ophthalmoscope and look for choroidals. If choroidals are present, pressurize and close the eye. Perform a posterior sclerotomy as appropriate for the situation. In the absence of choroidals, check for other issues, such as an improperly positioned lid speculum, or significant patient discomfort. Unfortunately, there isn’t much we can do for the individual with a large torso and short, thick neck except to be aware of their increased risk for labored breathing.

We are now left with excess fluid in the posterior segment, and the best approach is a pars-plana tap. The most creative suggestion came from Lawrence Brierley. He utilizes an anterior chamber maintainer on a routine basis, but simple viscoelastic pressure in the anterior chamber will suffice. He uses a TB syringe, removes the plunger, attaches it to a 23-gauge needle, and directs the needle under visualization at 3.5 mm posterior to the limbus and into the mid vitreous. The liquid vitreous flows into the syringe, and after .2 cc is removed, the chamber is usually deep enough to resume work.

In cases where liquid vitreous is not easily found, a posterior vitrectomy becomes the better choice. Ken Rosenthal reminds us to direct the cutting port posteriorly, as watching this marvel of modern science at work can result in a thorough chewing of the posterior capsule. This can create a new problem, which has fortunately already been covered.

**Dealing with the Prolapsing Iris**

The situation is now one in which our efforts to work around the shallow chamber have not succeeded, or our efforts at shallowing the chamber are too late, and the iris has found the incision. Again, this is typically because something is pushing the iris out of the eye, and this simply a pressure gradient, involving BSS or viscoelastic, or rarely a nuclear or cortical fragment.

The goal is to minimize the extent of the damage. Do not—repeat—do not push the iris back in the eye. If it is possible to use the long blunt side of an instrument already in place, that may work, but this requires a bit of situational finesse. Instead, leave whatever instrument you have in place exactly where it is, and decompress the anterior chamber through a second incision.

Once the anterior chamber has been decompressed, stroke the cornea starting distally and moving centrally over the position of the iris within the incision. If the prolapse is mild, and the iris is not
ballooned out of the incision, the stroking maneuver is highly effective. Daniel Chang has an award-winning video on the subject.

Unfortunately, sometimes when the iris prolapses, it does so with a bit of vigor, and has ballooned due to viscoelastic or BSS. Stroking the cornea in these situations doesn’t make much difference. Once the anterior chamber is decompressed, sweeping the iris back into the eye from the second incision will minimize the induced damage.

Now, the iris is back in the eye, and the question arises as to how to deal with the rest of the case with essentially one clock-hour of iris stroma and sphincter damage. The first step is to break out the Healon 5 to hold the iris into a perfect position.

The conventional answer is to move the incision to a different location to reduce further damage to the damaged area. This answer makes a great deal of sense, provided the anterior chamber has been deepened, and the new iris under the area of the new incision isn’t likely to prolapse as well.

One alternative is to place iris retractors adjacent to the incision, to restrain the iris. This has some potential to help, but will depend on how shredded the stroma has become. Too shredded, and the stromal fibers will simply flow to the incision. Disappointingly, the iris can prolapse even in the presence of a Malugyn ring.

A less conventional option is to forego this area of iris, minimizing the damage in area, but not necessarily in severity. In this scenario, the plan at the end of the case is to repair the iris via coreoplasty. But, only about a clock hour of damage can be overcome with this technique. Extending the damage to a second site, or failing to limit the damage at the primary incision will render this solution useless.

It is important to recognize that regardless of the steps taken to prevent damage, if significant damage occurs, the patient will benefit from a coreoplasty. Referring a patient for this procedure is entirely appropriate, and is certainly better than the resulting photosensitivity. The coreoplasty will not only gather the damaged stroma, it will re-attach the free ends of the pupil sphincter. At the end of the surgery, the pupil will seem distorted toward the surgical wound. In a relatively short time (days), the pupil will be normal in size and centration.

Iris Damage from Instrument Interaction (Without Iris Prolapse)

Sphincter/Stroma damage resulting from instrument contact comes in two forms—active and passive. Even a phaco needle with simple irrigation running will have a relative vacuum within the lumen if the tip passes too close to the iris. My suggestion is too simple for many—use a needle that doesn’t have a sharp tip. The damage from a sharp edged needle contacting the iris is immediate and severe. The effect achieved with power delivery is like a knife oscillating at 38,000 Hz. The iris doesn’t survive that interaction very long.

With a rounded needle edge, the iris will still lose posterior pigment, but the stroma will stay largely intact. More significantly, the iris sphincter will not change in shape or function. The iris won’t stay intact under these circumstances for long, but typically long enough to disengage your foot pedal.
Significant damage to the iris sphincter will be cosmetically and functionally significant. Fortunately, in a dilated eye, the lumen of the needle is typically only a clock hour or so in interactive size. Closing this defect with a simple suture is certainly a good solution to an unintended problem.

Preventing the iris damage seems to be fairly simple—avoid interacting with the iris. For the most part, this does work. I have on video cases where the iris jumped 2 mm into the lumen of the needle. I’m expecting that I created a channel in viscoelastic, and somehow a tunnel of directed flow/vacuum was achieved. I’m only guessing, as we all know viscoelastic is transparent. I have another where the tip of the needle broke through the nuclear fragment, and another 2mm iris jump took place.

Aside from these rare events, two generalizations can be observed. One, is that the lower the flow, the more “fishing” has to take place to acquire a nuclear fragment. Using a higher flow, or by moving to Venturi vacuum, the fragments tend to move toward the tip without taking the tip out of the center of the eye. Much less likely to engage the iris from this position.

The second generalization has to do with the depth of field provided by the microscope. We have acquired a microscope with a slight offset to the optics, giving a greater depth of field than I had previously experienced. I can now see that I’m just above or below the capsule with a much greater ease than before. This isn’t necessarily an option that is easily achieved, but is certainly an endorsement for improved technology providing improved results.

Lastly, avoiding the formerly-prolapsing iris during IOL insertion can be a significant trick. One must attempt a bolus of viscoelastic over the iris and below the incision (Healon 5), but this is not perfect. The step I’m recommending takes a bit of faith that the IOL has been properly loaded: Don’t advance the IOL in the cartridge until the tip is in the incision. The bolus of viscoelastic within the tip of the cartridge will push the iris back, typically enough to allow the lead haptic and the lead optic edge to slide by and into the capsule.

Summary:

1) Reducing the risk of iris prolapse
   a. Comfortable patient position
   b. Reduce coughing risk (Tessalon Perles)
   c. Intracameral dilatation
   d. Awareness of a shallow anterior chamber
   e. Properly placed/sized incisions
   f. Appropriate viscoelastic

2) Reduce the extent of iris damage
   a. Properly decompress the eye
   b. Reposition the iris by stroking the incision, or by sweeping from a second incision
   c. Use Healon 5 to stabilize the situation

3) Reduce the risk of iris/instrument interaction
   a. Higher flow reduces “fishing” for fragments trapped over the iris
   b. Use a rounded-edge needle to avoid instant damage from a sharp edge

4) Repair the iris when appropriate
   a. Refer when necessary
5) Hyperdense and White Cataracts

It’s obvious that there is a difference between that rock-hard piece of granite masquerading as a former lens, and that pearly-white “mystery” lurking just on the other side of the pupil. There are, however, a lot of similarities, and so, the two will be generalized together as much as possible.

Visualization

This can refer to either your mental outlook moving forward, or how you are going to actually see to do the case. In both situations, the red reflex is typically inadequate for visualizing the anterior capsule. Staining thus becomes a necessity. Trypan Blue is the obvious answer—it’s commercially available, pre-approved for the task, non-toxic, and can be repeated if necessary. Other agents can stain the capsule, but their role is either peripheral, or relegated to a historical footnote.

When using Trypan Blue, I instill it just after the interacameral dilation/anesthesia. I try to avoid placing the viscoelastic prior to using the capsule dye. Invariably, there is a bubble in the dye, but this bubble does nothing to help the staining process. I leave the stain in place for a full minute. Certainly, the effect is useful in a shorter period of time, but I want the capsule to remain stained throughout the case, not just for the capsulotomy.

A persistent rumor about Trypan Blue is that it should be used under an air bubble. Not so. Minos Coroneo, the holder of the patent, personally assured me that the bubble is not useful. His observation of the capsule staining was while doing work in an eye bank. The technician would stain the cornea with trypan blue, with the stain only taken up by non-viable cells. It did not harm viable endothelium, and brilliantly stained the anterior capsule.

One can either wash out the trypan blue with BSS, or displace it with a good dispersive viscoelastic fill. Either way, little bits of trypan blue will sneak out from under the iris during the surgery.

Visualization, part 2.

Now, the capsule is stained, and you’re ready to go. How large is the pupil?

In a case where I’m dealing with a small pupil and a relatively mild density of cataract, I may choose to wait until I need some form of iris retraction. Not in either of these situations. I will consider that either the hyperdense cataract will require a lot of additional energy and fluid, and the white cataract may present the exact same problem (or it may be just a squishy little burp). I place iris hooks, or an iris ring at this point. My most familiar, convenient device is the Malugyin Ring.

I do this prior to the start of the capsulorhexis as it might be just a touch problematic to engage the torn edge of rhe rhexis with the iris retraction system. The iris retraction system can certainly be placed later in the case, but the time and effort during a complex situation is best spent anticipating a potential problem rather than reacting to the existing problem.

Capsulotomy

Ideally, a perfect capsulorhexis is created as the alternative means of IOL support, given the uncertain nature of the situation. Ideally.
The concern in a white cataract is the dreaded Argentinian Flag Sign that occurs when the anterior capsule of a stained white cataract is punctured by a sharp implement. The pressure within the lens causes the anterior tear to extend radially in both directions as the pressure equalizes between the lens and the anterior chamber.

There are any number of suggestions as to how to deal with a white cataract. One of the difficulties with all of these suggestions is the sporadic nature of white cataracts both in terms of frequency and consistency. They are all quite different, ranging from lens milk to lens chalk. Many advocate a small needle puncture, which in my experience can initiate the tear, or phaco with full-on bevel down power against the anterior capsule, or even a YAG iridotomy to equalize the pressure prior to initiating the capsulotomy.

My preferred route is the lens massage. At one of David Chang’s Spotlight sessions at the AAO, Brock Bakewell presented the idea of lens massage in a white cataract. A blunt (very blunt) instrument is introduced into the anterior chamber, and the anterior capsule is gently massaged. This includes some stroking, and some downward pressure.

The theory in this situation is that the pressure gradient is not just between the intumescent lens and the anterior chamber, but a “corking” effect within the lens is preventing the egress of fluid from behind the nucleus. In the non-massaged lens, the liquid egress from the anterior space allows the pressure from behind the nucleus to push the nucleus forward, creating the radial tears. In the massaged nucleus, the corking effect has been somewhat neutralized, and the entire lens decompresses without the additional force of the nucleus pushing forward.

Fortunately, even if the Argentinian Flag should appear, the forces creating the radial tears diminish quickly, and is infrequent that the split extends beyond the equator.

The capsulotomy should be as close to 5.5 mm in diameter as possible. This preserves the alternative support for the IOL, and allows the maximal working area for phaco. Larger is much preferred over smaller.

Hydrodissection is absolutely not necessary in a white cataract—that plane of dissection has been created for you. On the other hand, in a hyperdense cataract, mobilizing the nucleus is of considerable value.

**Settings and Secrets for Dense Lenses**

The first consideration is the phaco needle, and the method of nuclear fragmentation. The divide-and-conquer surgeon will place significant stresses on the zonules working against the dense nucleus. An impaling chop, however, will allow the use of higher levels of vacuum.

My preferred needle is a 30-degree straight 20 gauge. The irrigation sleeve is slightly retracted, leaving a good 1.5 mm or so exposed needle. Don’t worry about passing the needle too deeply—the irrigating sleeve provides a firm stop to the excursion of the needle in an intact fragment. The vacuum in a significantly dense cataract should be set at a higher level—300 or so for Venturi, and 300 to 400 for peristaltic. This firm hold allows the direct transfer of power from the needle tip to the fragment. In addition, provides the pulling of a fragment onto the vibrating tip, providing some relief to the stresses on the zonules.
I place the lumen of the needle flat against the nucleus and press down on the footpedal into position three, holding the needle steady with a gentle downward pressure. Given the density of the nucleus, the embedded location should be at the junction of the proximal 1/3 and the distal 2/3, or about 1/3 of the distance across the nucleus. In an ideal situation, the needle embeds in the nucleus with the application of maximum vacuum and increasing power. Maintain position two to hold the nucleus securely.

The distal tip of the horizontal chopper is now placed around the equator of the nucleus, directly opposite the point of nuclear impalement. The two instruments are drawn together, and a gentle side movement will create an initial crack.

In the leathery, woody, dense nucleus, not much may happen with the first attempt. Simply rotate the nucleus, and try another point to impale the lens. While this may not be too effective in initiating the chop, repeated attempts at impaling can certainly weaken the nucleus significantly. This process is repeated until the nucleus is fully segmented. It may now resemble a flower with several distinct petals.

A leathery posterior plate may provide a significant barrier to fulling separating the segments. One choice is to continue to work the chopper deeper within the cracked nucleus, pushing the segments further apart to achieve the split.

An alternative is to flip the nucleus at this stage, placing the dense posterior plate on the anterior surface. To do this, one of the petals of the segmented cataract opposite the incision is impaled/grasped with the needle tip using the higher vacuum. Raising this segment, and drawing it centrally, the horizontal chopper is placed closer to the incision, pressing slightly down and forward. This torqueing action will frequently invert the nucleus in the bag, directly exposing the leathery plate.

Because of the density of the nuclear material, there is little opportunity for a complete occlusion. This has the good fortune of maintaining chamber stability without a lot of surge. Be exceptionally careful as the last segment is emulsified—there are no remaining fragments to hold the capsule back, and the power delivery is usually much higher than average to achieve emulsification. As there is likely very little cortex, the IOL can be placed with one or two remaining pieces of nuclear material. This does require working closer to the cornea, but it provides good protection for the posterior capsule.

As you finish the case, any number of variables will affect the red reflex—vitreous hemorrhage, PSC plaques—take a moment to look at the faint residual staining of the capsule. It will definitely help visualize the placement of the IOL as appropriate for the situation.

Summary:

1) Improve visualization in settings of poor red reflex
   a. Trypan blue to stain the anterior capsule
   b. Pupil expansion devices to improve the working space

2) Manipulations to decrease radial capsule risk during capsulotomy
   a. Massage the lens
   b. Maintain good AC depth and pressure with dispersive or supercohesive viscoelastic
   c. Then, consider a lens puncture with a 23-gauge needle

3) Protect the adjacent tissues from collateral damage
   a. Copious dispersive viscoelastic, BSS+ to protect the endothelium
b. Iris retraction to avoid incidental contact 
c. Chop technique to minimize zonular stresses
4) Proper exposure of the needle shaft
5) Proper bevel/bend/gauge to achieve and maintain good occlusion
6) Use higher vacuum settings 
   a. More firmly grasps material for movement 
   b. More effectively transfers power to impale or emulsify
7) Be wary of higher vacuum and power use 
   a. Work at the iris plane as best possible 
   b. Consider protecting the posterior capsule with the IOL for the last fragments