Pearls for Cataract Removal

Surgeons offer their advice for soft, medium, and hard cataracts.

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INTRODUCTION

No two cataract surgeries are alike. Although some cases are uncomplicated and progress smoothly from start to finish, others are plagued with complications that require the surgeon to make difficult decisions.

The lesson all cataract surgeons have learned at some point is that there is no standard technique that can be used for all procedures. It is best to adjust your technique depending on the case and the cataract type. In this article, key opinion leaders in cataract surgery offer their pearls for cataract removal in soft, medium, and hard cataract cases. As most imply, you must be able to change your strategy at any time to achieve the optimal outcome in any given case.

DAVID ALLEN, FRCS, FRCOPHTH

Soft cataract. These can be challenging for the beginning surgeon. The danger is being left with a posterior plate of epinucleus and cortex, which is difficult to remove. To avoid this, perform careful cortical cleaving hydrodissection followed by multiple attempts at hydrodelineation (Figure 1) in different layers. It is often possible to sculpt through to reach a small nucleus (Figure 2) that is easily consumed. Then, different layers of softer material can be repeatedly removed using the flip technique, made popular by I. Howard Fine, MD, of Eugene, Oregon.

Medium cataract. My preferred technique is horizontal chopping; however, the following pearl is also applicable to the divide-and-conquer technique. Rotation of the fragments within the capsular bag is easier if all nuclear pieces are in place. Therefore, completely break the nucleus up into as many pieces as you like before removing any. This may not be possible if fragments spontaneously dislocate forward, but it is usually achievable. For chop techniques, I prefer to break the nucleus into at least six or eight pieces—more if the nucleus is very hard.

Hard cataract. Hard cataracts usually have a tough, sometimes leathery, posterior nuclear plate. The key to successfully breaking the nucleus into small pieces, by whatever method, is to create some space in the center of the nucleus. I learned from Abhay R. Vasavada, MS, FRCS, of Ahmedabad, India, to sculpt a small but deep crater in the center of the lens, allowing the remaining ring of nucleus to be chopped or cracked. This maneuver is easier when one is using a Kelman angled tip because you can reach deep into the nucleus without distorting the cornea and losing your clear view.

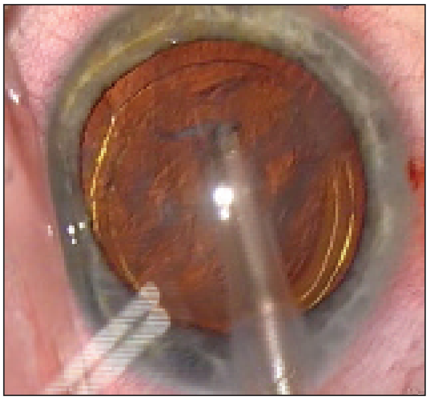

Figure 1. Multiple golden rings after hydrodelineation.

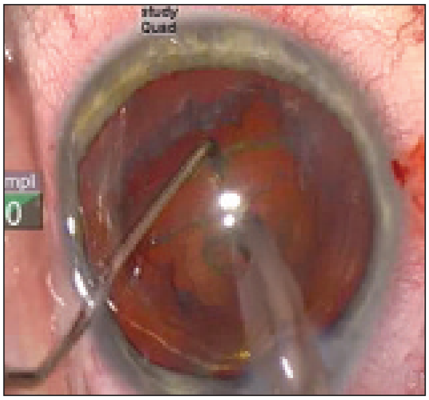

Figure 2. The small, central nucleus is easily displaced and then consumed.

JOHAN BLANCKAERT, MD

Soft cataract. In most soft cataract cases, the patient is young and would like to continue leading an active lifestyle. A premium IOL solution or a multifocal IOL is the best option for these active patients. Its obvious that in any cataract case you always need to do whatever you can to avoid posterior capsule rupture and zonulolysis. These two complications can compromise IOL centration, an essential component when implanting premium IOLs. For this reason, in those softer cataracts I frequently opt to do either a phaco roll or nucleus rotation technique, which has been so well described by Jose L. Guell, MD, of Spain. This technique reduces zonular stress and is safe for the posterior capsule. The most important pearl is achieving a good hydrodissection.

Medium cataract. Patients with medium cataracts are typically standard cataract patients. My first pearl would be: Do not fall into a routine. Secondly, a good anterior capsulorrhexis must be centered on the first Purkinje reflex of the cornea. A 5.5-mm capsulorrhexis is the best choice in these patients because it is large enough to avoid anterior capsule contraction and small enough to provide an overlap of the IOL optic. If posterior capsule rupture forces you to use a sulcus-fixated IOL, then optic capture can still be done with excellent IOL centration.

Hard cataract. Avoiding corneal burn is the most important point in patients with hard cataracts. I would choose either torsional phaco with the Infiniti platform (Alcon Laboratories, Inc., Fort Worth, Texas) or the Whitestar Signature Ice platform (Abbott Medical Optics, Inc., Santa Ana, California). Both systems are notorious for the cool phaco needle temperature needed in those hard, long cataract emulsifications.

RAJA DATTA, MS

Soft cataract. Cracking the nucleus and completely separating the quadrants is difficult in very soft cataracts. The procedure is not made easier by soft lens material and cortical matter that continuously enter the anterior chamber and decrease visibility. To combat these difficulties, the central two-thirds of the soft nucleus should be hydrodelineated after initial hydrodissection. Following separation of the central nucleus from the thick surrounding epinucleus (Figure 3A), it is slowly brought out into the anterior chamber (Figures 3B and C). Depending on its hardness, either this soft central nucleus can be aspirated with the phaco tip (footswitch in position 2), keeping the vacuum at no more than 150 mm Hg and aspiration flow rate (AFR) no more than 30 cc/minute, or a little phaco energy may be used (Figure 3D).

The thick epinucleus can be aspirated with the phaco tip using a maximum vacuum of 100 mm Hg and AFR of 25

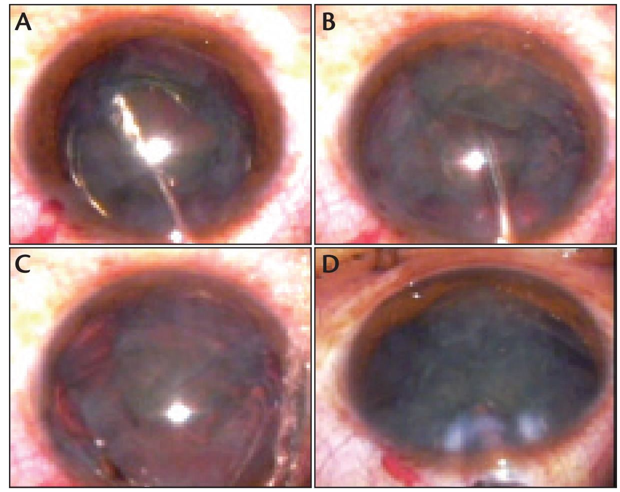

Figure 3. (A) Hydrodelineation of the central nucleus. (B) The nucleus core is brought into the anterior chamber. (C) The nucleus core in the anterior chamber. (D) The nucleus is phacoemulsified in the anterior chamber.

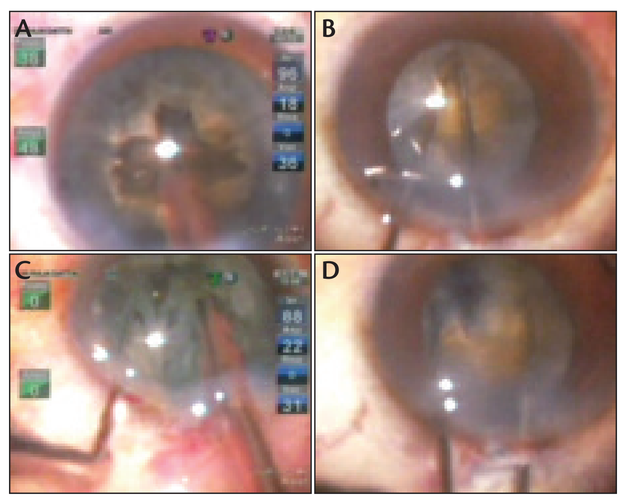

Figure 4. (A) Deep Sculpting of a hard cataract. (B) The two instruments used for cracking are kept together in the deepest part of the groove. (C) Achieving complete division of the nucleur fragments. (D) Separating the intranuclear fibers.

cc/minute. Alternatively, you may use a coaxial I/A tip. This method is easier and takes little time, especially in young patients (up to 50 years of age) or those with posterior subcapsular, central, or very early nuclear cataracts.

Medium cataract. These cataracts are the easiest to tackle. During sculpting of these nuclei, it is not necessary to go as deep as you do with very hard ones. Sculpting up to two-thirds of the total depth of the nucleus will crack it completely. Going deeper may often lead to passage into the vitreous cavity because the resistance of the central nucleus is much less than in harder cataracts.

While one is removing the last piece of nucleus, the vacuum should be between 100 and 150 mm Hg and AFR between 25 and 30 cc/minute. The reason for these settings is not because of the jumping fragments that may hit and rupture the posterior capsule, but in case of accidental occlusion of the phaco tip with posterior cortical matter and the posterior capsule, which can cause a rent. With these parameters set low in the event of accidental occlusion, you can immediately switch to footswitch position 1, which should release the posterior capsule without causing damage.

Hard cataract. Cracking the nucleus in the two extremes of nuclear hardness (ie, very soft and very hard) is a difficult task. Hard to very hard cataracts, especially those that are amber or black in color, are the most difficult to crack. In these cases, it is advisable to adopt the four-quadrant or stop-and-chop method.

Sculpting should be done deeply, until the posterior nuclear plate is reached (Figure 4A). The two instruments used to crack the nucleus are placed so that the tips touch each other as well as the floor of the groove (Figure 4B). The tips are then slowly separated to create a crack in the nucleus that should start from the periphery, under full visibility, and gradually move toward the center. Care must be taken to ensure complete separation of the nuclear fragments, including the posterior nuclear plate (Figure 4C).

Difficulty arises in these cases due to the resilient intranuclear fibers, which are tenacious and difficult to separate. It is always advisable to break these fibers by separating the fragments at their site of origin (Figure 4D).

Utmost care must be taken while separating the nuclear fragments to achieve a complete crack, which should extend throughout the depth of the nucleus. Since these nuclei are not only hard and leathery but also extra large in size, they occupy almost the whole of the capsular bag, which is distended, with little or no cortical matter separating them.

Care must also be taken while creating the crack. Pulling the pieces away from each other to crack the nucleus transmits pressure directly to the capsular bag. The more distance between pieces, especially at the periphery, the more the stretch force on the already distended capsular bag, which may lead to a capsular tear. Therefore, it is imperative to start cracking at the periphery and go slowly down to the center of the nucleus.

I. HOWARD FINE, MD

Soft cataract. For soft nuclei, I hydroexpress the lens into the capsulorrhexis plane and carousel it with the bevel of the phaco tip pointed toward the lens equator. I place the second instrument above the nucleus, protecting the cornea.

Medium cataract. For these cataracts, I prefer horizontal chopping. Prior to embedding the tip, I go over the equator with the horizontal chopper, pulling up and toward the incision to stabilize the nucleus as I bury the phaco tip. This ensures that I am not transmitting any force to the capsule or zonules.

Hard cataract. For hard cataracts, I use vertical chopping and perform all chopping in the traditional, longitudinal phaco mode prior to mobilizing the segments. Therefore, the tip is not widened as it is buried. Then I change parameters for segment mobilization to include torsional or elliptical phaco.

ALESSANDRO FRANCHINI, MD

Soft cataract. Removing very soft nuclei and cracking the lens into small fragments can be harder than it would seem during either divide-and-conquer or chop techniques. Especially for surgeons in training, it can be difficult to separate the two epinuclei or the four nuclear quadrants after sculpting. The nuclear fragment substance can be gummy, and manipulators or choppers can easily penetrate the substance without applying the necessary strength to separate it. In these cases, it may be useful to deepen the groove as much as possible; however, this maneuver risks a posterior capsule break, especially in the hands of a young surgeon. If the division does not appear in the middle of the nucleus, and two different-sized fragments result, one should refracture the larger piece.

I prefer to use cracking forceps in patients with soft nuclei. These forceps have two flat paddles that apply lateral separation onto a larger area of tissue, allowing the perfect division of two equal fragments—even if the groove has not been well performed or if the nucleus is particularly soft. The most recent cracking forceps models can be easily inserted into the anterior chamber through a 2.2-mm incision. Furthermore, the lower part of the two paddles has a fine edge so that if the groove is not sufficiently deep, they can be used to perform a type of karate chop.

Medium cataract. Separating the lens material from the capsule (ie, hydrodissection) and the nucleus from the epinucleus (ie, hydrodelineation) represent the most crucial steps in patients with a medium-hard cataract. These cataracts are considered the easiest to remove; however, the surgeon should avoid beginning phacoemulsification before the nucleus is mobilized with these two maneuvers and then rotated. When a good separation between the lens layers is obtained, difficulties aspirating the cataract are avoided.

Avoid initiating hydrodissection if the anterior chamber is over-inflated with an ophthalmic viscosurgical device (OVD). When performing microincision cataract surgery (MICS), be aware of the risk of increased pressure in the anterior chamber.

To perform hydrodissection, a cannula is inserted into the anterior chamber, under the capsulorrhexis border and between the capsule and lens cortex. This is done in an attempt to slightly raise the capsule and direct the fluid stream along the inner surface of the capsular bag. Balanced saline solution is injected to separate the lens from the capsule. It is necessary to continue injecting fluid until the wave completely crosses behind the nucleus. The center of the nucleus is pushed gently backward to allow the fluid to pass through the capsular equator and obtain complete separation from the capsule. This maneuver is repeated as many times as necessary to facilitate good lens rotation.

Using a straight cannula, the surgeon then injects balanced saline solution into only the contraincisional portion of the bag. It is preferable to use a 90º angled cannula to inject fluid in the right and left portions of the bag, guaranteeing complete hydrodissection.

To facilitate aspiration of a medium-hard cataract, the nucleus is separated from the epinucleus with hydrodelineation. The cannula is inserted deeply inside the periphery of the nucleus, and balanced saline solution is injected until a golden ring appears between the nucleus and epinucleus.

After hydrodissection and hydrodelineation have been well performed, the surgeon can easily aspirate the nucleus, epinucleus, and cortex without moving the phaco tip from the pupillary field. This technique decreases surgical time and increases efficiency and, above all, safety.

Hard cataract. Often with the brunescent cataract, we are dealing with a nucleus of enlarged dimension and increased density. There is no epinucleus and often no cortical layer. Hard cataracts are somewhat like a pillow in that they absorb the transmission of force applied to the posterior capsule and zonula. Therefore, mechanical forces applied during sculpting, cracking, and rotation are transmitted straight to the posterior capsule and the zonula, which may already be weak in these patients. The nuclear fragments are often hard and sharp, increasing the risk for a break in the posterior capsule.

The enlarged depth and width of the cataract can create a number of problems, whether we perform a divide-and-conquer or horizontal chop technique. Breaking the most posterior layers of the nuclear plate requires digging deep and close to the posterior capsule. If one performs horizontal chop, inserting the chopper as deeply as possible can be dangerous because of the absence of an epinucleus. However, it is often difficult to obtain a clean fracture with horizontal chop because tissue bridges connecting the two fragments can remain intact. A vertical chop technique is generally more successful in breaking these bridges, so this may be the best technique for patients with brunescent cataract.

With both the divide-and-conquer and horizontal chopping techniques, we cut only part of the nucleus to avoid breaking the posterior capsule. To complete the fracture, we separate the two heminuclei; however, the force of either technique only partially spreads the nuclei posteriorly. In the case of very hard nuclei, the propagating fracture may continue only horizontally without advancing further posteriorly. This is the reason the tissues bridges remain together.

Alternatively, the backward-and-forward vertical movement applied during vertical chop favors propagation of the fracture to the most posterior layers. In patients with a white cataract with a very hard nucleus, vertical chop is the best choice in terms of efficiency and safety, making it possible to work only in the pupillary field without concern for where the posterior capsule is located.

MIKIO INAMURA, MD

Soft cataract. The Infiniti OZil Torsional phaco on the Infiniti Vision System (Alcon Laboratories, Inc., Fort Worth, Texas) is the instrument of choice for all my cataract procedures. Soft cataract cases can be completed without any problems, regardless of how I approach the nucleus. In cases in which the nucleus is extremely soft, I use the Akahoshi Prechopper (ASICO, Westmont, Illinois) or the Inamura Eagle Prechopper (ASICO) to divide the nucleus in half (Figures 5A and B), or into quadrants if that is not too difficult, before emulsifying the nucleus with low power torsional phaco. To treat soft cataracts, a high power setting with torsional phaco is unnecessary because too much power would result in dislodgment of the nucleus fragments (Figure 5C).

The settings I use are pulse mode, 30 pulses/second, torsional amplitude 80% (linear), on time 80%, aspiration flow rate 25 mL/minute (linear), and maximum vacuum 400 mm Hg (linear). I recommend using the Kelman Mini flared tip (Alcon Laboratories, Inc.) because it allows superior followability together with the ability to maintain anterior chamber stability with ease.

Medium cataract. Torsional phaco also demonstrates efficiency when dealing with medium density cataracts. In medium cataract procedures, I like to use the Inamura Eagle Prechopper to divide the nucleus. This prechopper can easily divide most nuclei (from very soft to hard); rotating the nucleus inside the capsule is easy with this device.

It is important that hydrodissection be performed completely, making the nucleus easy to rotate. The double nozzle Inamura Hydro Cannula (Duckworth & Kent [Hertfordshire, England] and ASICO) makes accomplishing hydrodissection easy.

After hydrodissection, I reinject the OVD, preferably Healon5 (Abbott Medical Optics, Inc., Santa Ana, California), into the anterior chamber. Then, using the Inamura Eagle Prechopper, I divide the nucleus in half. The Eagle Prechopper has a sharp tip, somewhat like an eagle's beak, which I insert into the middle of the nucleus to chop it in half. Its sharp tip will penetrate and chop even highly

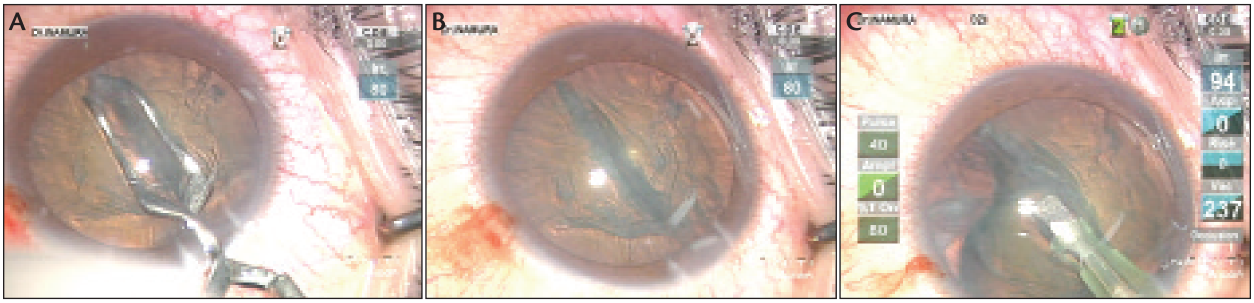

Figure 5. (A) Dividing the nucleus into two pieces with the Inamura Eagle Prechopper. (B) Two nucleus halves after division. (C) Aspirating soft nucleus without longitudinal phaco.

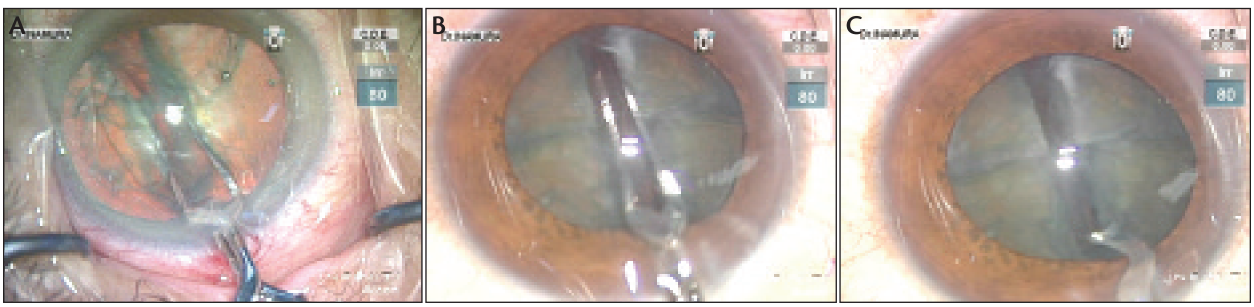

Figure 6. (A) Dividing the nucleus into four pieces with the Inamura Eagle Prechopper. (B) Four nucleus quadrants after division. (C) Four quadrants are emulsified in torsional pulse mode.

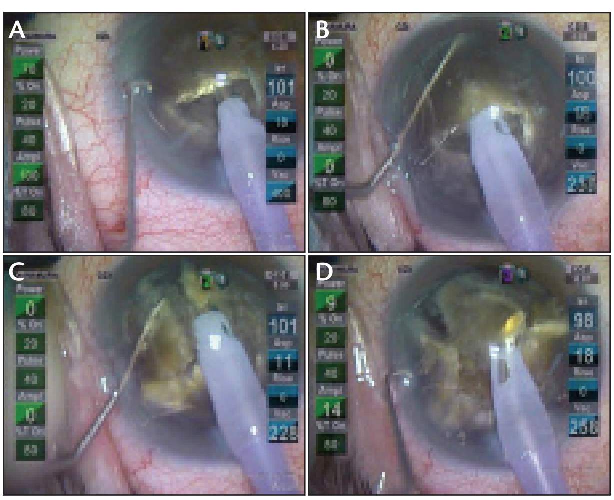

Figure 7. (A) Semicircular crater is dug with phaco and torsional ultrasound. (B) Chopping with phaco tip and a second instrument. (C) Dividing by chopping into four pieces. (D) Emulsifying four quadrants.

dense nuclei. I then use the tip to snag the divided halves of the nucleus, rotate them 90° inside the capsule, and divide them further into quadrants (Figures 6A and B). The procedures after this are more efficient if the nuclear fragments are divided even more.

For torsional phaco in these cases, I use the 45° beveled Kelman Mini Flared tip, and more recently the 12° Partial Kelman Mini Flared tip (OZil 12). Alternating traditional longitudinal phaco and torsional phaco pulses makes removal of the first quadrant of the nucleus efficient. After the first quadrant is removed, I switch to pulse mode torsional phaco. Use of the foot pedal makes the transition smooth. Note that the phaco tip bevel is positioned parallel to the nucleus fragment, so that the fragments rotate as if they occlude the phaco tip and there is no chattering.

The settings I use for removal of the first nucleus quadrant are 30 pulses/second, longitudinal oscillation 70% (linear), on time 20%, torsional amplitude 100% (linear), on time 80%, aspiration flow rate 30 mL/minute (linear), and maximum vacuum 300 mm Hg (linear). For removing the rest of the nucleus quadrants, settings are 40 pulses/second, torsional amplitude 100%, on time 80%, aspiration flow rate 28 mL/min (linear), and maximum vacuum 350 mm Hg (linear; Figure 6C).

Hard cataract. If the nucleus is so hard that the Inamura Eagle Prechopper does not penetrate, I immediately switch to the phaco-chop method. With this method, I can approach the hardest cataract cases safely, even when the zonules are in a weakened state. After hydrodissection, I dig a semicircular crater on the proximal surface of the nucleus (Figure 7A). I then insert the phaco tip into the opposite side of the nucleus and, using a second instrument to hold the nucleus from the other side, I divide the nucleus (Figure 7B) very surely. Further, I rotate the nucleus 90°, insert the phaco tip into the opposite wall and similarly divide the nucleus (Figure 7C).

After dividing the nucleus in this way, I set about to remove the fragments with torsional phaco (Figure 7D). Aspirating dense nuclear material with torsional phaco alone can cause clogging, but when torsional is combined with longitudinal oscillations, clogging can be minimized. Another way to prevent clogging is by slowly emulsifying the nuclear fragments piece by piece. It is most important to avoid completely occluding the phaco tip with nucleus fragments. This is strikingly different from traditional longitudinal phaco and must be observed.

The settings for removal of the first nucleus quadrant are 30 pulses/second, longitudinal oscillation 70% (linear), on time 20%, torsional amplitude 100%, on time 80%, aspiration flow rate 30 mL/minute (linear), and maximum vacuum 300 mm Hg (linear). For removal of the rest of the nuclear quadrants, settings are 40 pulses/second, torsional amplitude 100%, on time 80%, aspiration flow rate 28 mL/minute (linear), and maximum vacuum 350 mm Hg (linear).

If clogging occurs, I get rid of it by switching the setting to longitudinal oscillation, declogging mode at 20 pulses/second, longitudinal oscillation 100% (linear), on time 20%, aspiration flow rate 25 mL/min fixed, and maximum vacuum 300 mm Hg (linear).

Recently I have been using the Akahoshi Bent wobble square tip (ASICO), and I found it to be efficient for removing the nuclear fragments. It causes less injury to the cornea and iris compared to the Kelman Mini Flared tip, and it is easier to use because of its straight tip. It can be used on cataracts of all densities. It is also not prone to clogging. This tip is not yet on the market, but I feel there is great potential for its use.

BJORN JOHANSSON, MD, PHD

Soft cataract. If the soft cataract goes unnoticed preoperatively, you will recognize it as you initiate hydrodelineation after cortical cleaving hydrodissection—two crucial steps in every safe cataract procedure. Your blunt cannula will not meet resistance, or you will find a very small nucleus when balanced saline solution is injected into the deeper layers of the lens.

Attempts to crack or chop soft nuclei are, of course, seldom fruitful. In these cases, aspiration without ultrasound is usually enough to evacuate the lens, either by stopping at position 2 on a monolinear pedal or activating only vacuum/aspiration on a dual-linear foot control. I consume the central nucleus first and then catch the anterior rim of the remaining bowl opposite the phaco tunnel, flipping it upside-down with help from the second instrument. This makes it easy to aspirate efficiently at a safe distance from the posterior capsule in the center of the pupil.

Medium cataract. Several years ago, I transitioned from a stop-and-chop technique to a direct horizontal chop with the Nagahara chopper (Katena Products, Inc., Denville, New Jersey). Earlier, I was a traditional four-groove divide-and-conquer surgeon. Creating four grooves is advantageous for the beginning surgeon because it allows you to get a good grasp of the anatomy of the lens and capsule in various scenarios, including exfoliation and shallow or deep chambers. I found it a helpful precursor to chop techniques.

When I first tried direct horizontal chop, it was a bit difficult. If you wish to progress to chopping, first master stop-and-chop: Create one initial groove; crack the nucleus into halves, which can usually be mobilized; capture one half of the nucleus with the phaco tip, with vacuum increased from the groove setting; and chop it with the side instrument. This technique allows you to try various choppers on lens pieces that are freed from the capsule, which I think makes learning easier.

Hard cataract. With hard nuclei, I often have a problem getting a chop completely down through to the back side of the nucleus, which can be fibrotic and leathery. In these cases, my tactic is one of the following: Either I use the side instrument and viscoelastic cannula, inserted through the phaco tunnel, to separate the nuclear pieces (after divide-and-conquer, stop-and-chop, or direct chop); or, if the instrument is available, I use an Akahoshi prechopper. Both methods allow one to easily apply forces at the deepest possible point in the nucleus and to direct the splitting force in the most efficacious directions.

RAMÓN LORENTE MOORE, MD, PHD

Soft cataract. Although often considered an easy surgery, the soft cataract may pose refractive and technical challenges. As a refractive cataract procedure, there is the demand to achieve accurate biometry and uneventful surgery, leading to extra pressure for the surgeon. Technical problems when handling the soft nuclei during phacoemulsification are twofold: First, there is difficulty rotating the nucleus-cortex complex because cortical fibers tend to stick to the capsule. Second, there is an inability to divide the nucleus due to its softness. The following points summarize my strategy to overcome these problems.

An adequate hydroprocedure is mandatory to achieve complete nuclear rotation. First, cortical cleaving hydrodissection must be performed to detach the cortex from the capsule so that the cortex remains attached to the epinucleus. It may be helpful to repeat the same maneuver in the opposite distal quadrant. Given that an excessive amount of OVD can increase the resistance to fluid egress from the capsular bag via the capsulorrhexis, an important step before starting hydrodissection is to evacuate some of OVD from the anterior chamber. After hydrodissection, the nucleous-cortex complex is rotated bimanually (using the two-Sinskey hook method) to confirm that there is no adherence between the cortex and the capsule. The next step is hydrodelineation, which by cleaving the central nucleus from the epinucleus, facilitates phacoemulsification. A golden ring of the delineated nucleus is its hallmark sign.

My preferred method for nuclear emulsification of soft nuclei is the chip-and-flip technique using AquaLase technology (Alcon Laboratories, Inc.). It is not only the safest technology but it could also be associated with a lower rate of posterior capsule opacification.

The rest of the procedure is the same that will be described for medium cataracts.

Medium cataract. My surgical technique in medium cataracts corresponds to the procedure I perform in standard cases. Thus, I will describe my personal technique in this setting. I use topical anesthesia with intracameral preservative-free lidocaine 2%. The anterior chamber is filled with a viscoadaptative OVD (DisCoVisc; Alcon Laboratories, Inc.) through the paracentesis, and a temporal clear corneal incision (2.2 x 1.75 mm) is made. Should a multifocal IOL be implanted, the incision is placed at the steepest meridian. A circular, well-centered, 5.25-mm capsulorrhexis is perfomed with Utrata forceps. The hydroprocedures are performed as previously described for soft cataracts.

During phacoemulsification, I usually work with torsional ultrasound technology for two main reasons: it is easier and safer. These advantages are related to its shearing action, which minimizes repulsion and allows use of lower vacuum parameters to decrease surge. To optimize the torsional effect, achieve better holdability, and reduce clogging, a Kelman Mini flared 45º bevel tip is strongly recommended. My preferred technique is vertical chop using a Rosen chopper to divide the nucleous into four or five fragments with the following parameters: 90% torsional amplitude with burst mode (50 milliseconds [mSec] on, 150 mSec off); vacuum, 420 mm Hg; flow, 35 cc/minute; and bottle height, 95 cm.

Once the nucleus is divided, parameters are adapted to emulsify the fragments: continuous torsional ultrasound (maximum amplitude, 90% and starting amplitude, 20%); vacuum, 320 mm Hg; flow, 25 cc/minute; bottle height, 95 cm. The footpedal set-up is adjusted to 18% to shorten the range of footpedal position 3. There is no need for longitudinal ultrasound.

During irrigation and aspiration, the cortex is aspirated with a curved silicone I/A tip (Alcon Laboratories, Inc.) due to its greater levels of safety—the incidence of posterior capsule rupture is lower than using metal tip. Whenever subincisional cortex removal becomes difficult, it may be a good option to use two separate cannulas, one for irrigating the anterior chamber and another for aspirating cortical material. This bimanual I/A technique requires two paracentesis placed approximately 50º apart from the main incision. I routinely polish the posterior capsule with the silicone tip or with an irrigating polisher.

I typically implant the AcrySof IQ (Alcon Laboratories, Inc.) using the Monarch III injector and Monarch D cartridge (Alcon Laboratories, Inc.). I do not need to enlarge the incision. Residual OVD trapped under the IOL is then removed. Cefuroxime is used both for intracameral administration and stromal hydration at both edges of the clear corneal incision.

Hard cataract. Handling the hard nucleus is a major challenge, even for the experienced surgeon. It requires higher power ultrasound and prolonged phaco time. Preoperative evaluation is of paramount importance. We must consider the following points: endothelial cell count, anterior chamber depth, zonular instability, pupil dilation, and a B-scan if there is no view of posterior fundus.

Phacoemulsification in hard cataracts requires the use of specific strategies that differ from routine phacoemulsification. The main modifications of each surgical step to successfully operate such cataracts are as follows. Local anesthesia is recommended in cases of weak zonulas, poor collaboration, or risk of intraoperative complications. When the red reflex is poor, we must stain the capsule with trypan blue 0.06% to enhance capsular visualization enough to perform capsulorrhexis and also visualization of the edge of the rhexis during phacoemulsification.

OVD plays an important role in protecting the endothelium in hard cataracts. For this reason, I use Steven Arshinoff´s soft shell technique, using Viscoat to coat the endothelium and a highly cohesive OVD (Provisc; Alcon Laboratories, Inc.) to maintain the anterior chamber.

Phacoemulsification for hard lenses poses two main risks: higher endothelial cell loss and increased risk of posterior capsule rupture. Furthermore, dividing the hard nucleus becomes difficult. Posterior layer fibers can be cohesive and tenacious and resist to all conventional methods of division. Extra precautions must be taken to protect the endothelium and the posterior capsule.

Torsional ultrasound is the best technology to protect the endothelium due to minimal repulsion and less turbulence in the anterior chamber. My preferred technique is vertical chop because it causes less endothelial cell loss and less stress on the zonules versus divide and conquer. I do not change many parameters with respect to medium cataracts, apart from elevating the starting torsional amplitude setting to 30%. However, there are a few variations to my technique in hard cataracts: (1) I use a karate chopper, which is longer and sharper, to facilitate embedding the dense nucleus without displacing it. (2) The irrigation sleeve must be retracted more than usual. This will expose a longer segment of the metal needle and maximize penetration of the tip, which is crucial to divide the nucleus. It is easier to begin by sculpting a small, deep, pit centrally. This pit allows the nucleus to be impaled more deeply. (3) It is more efficient to alter the angle of the vertical chop slightly and approach the embedded phaco tip more diagonally. This provides more of a horizontal vector that pushes the nucleus against the tip while the vertical vector initiates the downward fracture, combining the mechanical advantages of both strategies. (4) If there are leathery fibers at the posterior layer, it is best to transect them with the chopper while the nucleus is engaged and stabilized by the vacuum of the phaco tip. (5) The nucleus should be divided in smaller fragments to emulsify them securely. (6) To maximize endothelial protection, we should refill the anterior chamber with Viscoat during fragment emulsification. (7) A dispersive OVD injected behind the last remaining fragments creates and artificial epinucleus that will restrain the lax and fragile posterior capsule from trampolining toward the phaco tip, minimizing the risk of rupture.

SIMONETTA MORSELLI, MD; AND ANTONIO TOSO, MD

Soft cataract. We use very high vacuum and very low ultrasound power to remove soft cataracts. We suggest using a manipulator rather than a chopper, avoiding damage to the posterior capsule during nuclear fragment removal with high vacuum.

Medium cataract. We use the Stellaris (Bausch & Lomb, Rochester, New York), a phacoemulsification platform created specifically for MICS. This system is exceptionally fast and safe. Its capability for high vacuum allows quick removal of nuclear fragments while the chamber remains perfectly stable. This machine gives one the ability to set the ultrasound in two different modes, burst and micropulse. By changing the duration and the duty cycle of the ultrasound, we can adapt the power to any type of cataract.

We set sub mode 1 for cataracts of 2+ to 3+ hardness; sub mode 2 for 3+ to 4+ cataracts; and sub mode 3 for 5+ to 6+ cataracts.

Our parameters for sub mode 1 for normal or medium 2+ to 3+ cataracts are: dual foot pedal system; 10% linear ultrasound, pulse mode 80 pps; 35% duty cycle.

Hard cataract. Even with very hard cataracts, we are able to remove pieces with not more than 10% ultrasound power.

Our parameters for sub mode 2, used for 3+ to 4+ cataracts, are: dual foot pedal system; 10% linear ultrasound; fixed burst 160 millisecond duration; 320 millisecond interval of pulse duration.

Our parameters for sub mode 3, used for 5+ to 6+ cataracts, are: dual foot pedal system; 10% fixed ultrasound; multiple burst 40 millisecond burst duration; 60% duty cycle.

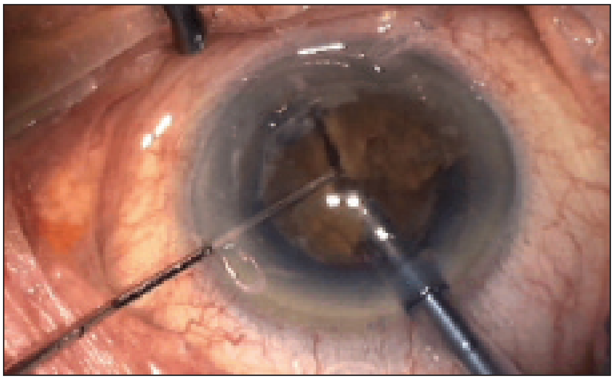

Figure 8. MICS with very hard cataract.

With these multiple modes set, we are able to change to any of these parameters during surgery. For example, to chop the nucleus at the beginning of surgery, we might use sub mode 3. To remove the final little pieces floating into the anterior chamber toward the end of the case, we might use sub mode 1.

Our machine is set so that we can change sub modes during surgery using the left foot pedal on the dual foot pedal system. With the right foot pedal, we control ultrasound power with a lateral motion and vacuum by depressing the pedal. The surgeon can change the sub mode at any moment during surgery.

With this system we can remove very hard cataract using MICS (Figure 8) with low trauma to the intraocular structures. The most important thing is to know the capabilities of the machine to obtain high efficacy with minimal trauma for the patient.

Another pearl to manage hard cataracts is to use a chop technique with a new OVD, Ovidio (Sifi, SpA, Aci S. Antonio, Italy). This new viscoelastic substance contains sodium hyaluronate 2% with a molecular weight of 2.3 million daltons, giving it dispersive properties with a medium viscosity. It provides good anterior chamber stability and reliable adhesion to the corneal endothelium, protecting the intraocular structures. This OVD gives the surgeon the option to perform a large and well-controlled capsulorrhexis. Unlike other dispersive OVDs, this one does not allow adhesion of cataract fragments to the posterior surface of the cornea. For these reasons, this OVD provides better visualization for the surgeon during phacoemulsification.

To remove a hard cataract we perform a large capsulorrhexis (6–6.5 mm), allowing us to move the nucleus out of the capsular bag and into the anterior chamber for hydrodissection. This allows us to safely fracture the nucleus with a chop technique. The chopper is positioned at the equator of the nucleus without the risk of damaging the capsular bag, even in case of pseudoexfoliation or zonular weakness. A small amount of OVD is injected under the nucleus and over the capsular bag. The phaco tip, with bevel down, impales the nucleus as deeply into the center as possible. The sleeve must be retracted to obtain as much as 1.8 to 2 mm of tip length, thus penetrating the center of the nucleus. A deep nuclear fracture is then obtained with the chopper. After the first crack, the nucleus is divided into small slices and emulsified; using the manipulator avoids damage to the capsular bag. During these maneuvers, it is necessary to refill the anterior chamber with OVD to protect the endothelium and maintain stabilization of the nucleus.

MILIND V. PANDE, DO, FRCS, FRCOPHTH

Soft cataract. Adjust your flow and vacuum settings down when you want move the nucleus in one piece. If the vacuum or flow is too high, it will nibble away at the nucleus rather than enable you to move the whole nucleus. It is a bit like moving a blob of jelly without breaking it up; it requires just the right amount of force.

Medium cataract. When you are chopping a medium cataract, your angle of attack with the phaco probe must be acute. A shallow angle will drive the phaco tip superficial and into the peripheral (and thinner) aspect of the nucleus, increasing the risk of capsular rupture. An acute, almost vertical angle of approach will embed the phaco probe into the central part of the nucleus, engaging it securely on the phaco tip for a chop.

Hard cataract. The key in these cases is to be patient and dismantle the nucleus bit by bit. A combination of horizontal and vertical chop will allow segmental dismantling, much like removing the petals of a flower one by one, leaving the central posterior leathery core to be emulsified at the end. Chipping safely in these nuclei means taking smaller bites; using lots of OVD protection; and adopting a patient, methodical approach.

ISABEL PRIETO, MD

Soft cataract. Whether one faces a soft, medium, or hard cataract, it is important to have a plan preoperatively. Under the microscope light, many dense cataracts appear like soft cataracts, so it is important to know ahead of time what you are facing for each case and have the right handpiece, the right phaco tip, the right technique. The goal in all cases is to customize cataract surgery depending on the needs of the patient.

My specialty is complicated cases, so often the cases I see are not soft cataracts. However, it is possible for cataracts to be very soft and yet still complicated. An example of a soft but difficult cataract could be, for instance, a posterior polar cataract, which may be more challenging than a harder nuclear cataract.

My preferred technique is microcoaxial phaco with a 2.2-mm incision. For soft cataracts, I like to use the AquaLase mode on the Infiniti phacoemulsification system (Alcon Laboratories, Inc.). This is a safe mode because it has a lower risk of capsule rupture. Normally in soft lenses I use a modified chip-and-flip technique with a Barraquer spatula (Moria, Antony, France) as my second instrument. To remove cortical material, I use bimanual irrigation and aspiration because of improved cleaning, especially of the subincisional cortex. It is important in these patients to clean the capsular bag thoroughly of cortical remnants to reduce the postoperative inflammatory response.

Medium cataract. In both normal and hard cataracts, I favor a chopping technique. There are many names for the various chopping techniques, but as David F. Chang, MD, of California, has pointed out, there are basically two types of chop: horizontal and vertical. I favor quick chop, which is a vertical chop technique. This approach reduces stress on the zonulas, which can be important in complicated cases. Currently, I use torsional phaco with the OZil handpiece on the Infiniti, with a 12° reverse phaco tip. This works well with the quick chop technique because the end of the tip is pointed down. To perform the quick chop, I impale the nucleus deeply using a little phaco energy. I do not need much energy because I use high vacuum to secure the nucleus. I chop the nucleus into several pieces with a quick chopper, and then I emulsify and aspirate the nuclear pieces. This technique allows me to work most of the time in the center of the bag, which is useful in nondilating pupils or difficult cases like subluxated cataract. I like to work fast because the less time spent inside the eye, the better. But with complicated cases sometimes a slower approach is necessary. I am careful to create a good incision, perform a good capsulorrhexis, and maintain the structures of the eye with as much balance of fluid dynamics as possible. It is important to avoid surge. Although I prefer a vertical chop, sometimes it is necessary to use a horizontal chop approach. You must be flexible and respond to what you encounter in the eye.

Hard cataract. In hard cataracts, I use the same basic techniques as in medium cataracts, but in these cases it is more difficult to break the nucleus. Sometimes there may be problems with capsular bag. In more elastic cataracts, I use high-density OVDs to help crack the nucleus (ie, viscocrack). If there is no capsular bag instability, I still use high vacuum and high flow, and I combine longitudinal and torsional phaco energy to break the nucleus in pieces. Then, I remove the pieces with torsional energy only.

For me, there is not a great difference between soft, medium, and hard cataracts, as long as I am prepared. Of course in soft cataracts usually the surgical time is shorter, and in very hard cataracts it is longer. Also, in softer cataracts we do not need a great amount of phaco energy, using mostly mechanical force and aspiration. In hard cataracts we need more energy to impale and secure the nucleus and to emulsify the pieces. The surgical approach is decided preoperatively, so that we know what we are facing.

One concern for me is the patient's expectations. Some young patients with soft cataracts have great expectations about quick visual recovery and excellent postoperative vision, while older patients with very hard cataracts may not have such high visual demands. They want to see well, of course, but perhaps not 20/20 uncorrected, especially if they are used to wearing glasses.

Every cataract is different, so the best approach is to be prepared. Know beforehand what you are doing and how you are doing it. Know the platform well, know the patient well, and know how to approach complications that you may encounter.

MARIE-JOSE TASSIGNON, MD

Soft cataract. Only in children or young adults one can be sure that the cataract will be soft. Cataract surgery in most patients in this age group is performed under general anesthesia. In these cases, it is my preference to use two incisions of 1 mm each to remove the lens. Prior to performing anterior capsulorrhexis, a ring caliper is positioned on top of the lens capsule. Because of the elasticity of the lens capsule in this group of patients and the important regenerative power of the lens epithelial cells (LECs), a 4.5 mm in diameter capsulorrhexis is performed to tightly seal the bag-in-the-lens (BIL; Morcher GmbH, Stuttgart, Germany), the standard lens that I use. This lens can incorporate a toric correction when needed.

Hydrodissection is performed except in eyes with posterior polar cataract. In these cases, hydrodelineation is preferred.

The principle of the BIL implantation is based on a twin capsulorrhexis. After protecting the anterior vitreous hyaloid by injecting a low molecular weight OVD into Berger's space, a posterior capsulorrhexis is performed of the same size as the anterior capsulorrhexis. Both capsules are glided into the groove on the edge of the IOL optic, defined by the elliptical anterior and posterior flanges (haptics). Anterior vitrectomy is not performed unless the anatomy of the anterior vitreous presents abnormalities such as persistent hyperplastic primary vitreous or in case of vitreous loss, as may happen in posterior polar cataract.

Lens centration is performed based on the first and fourth Purkinje reflexes from the microscope light.

The BIL implantation technique requires perfect control of the pressure of both intraocular compartments: anterior chamber and vitreous body. The use of adequate OVD is therefore crucial. The posterior capsulorrhexis can be performed only after the anterior chamber has been filled with high molecular weight cohesive OVD and the capsular bag is in a horizontal position. The capsular bag is not inflated. Both the anterior and posterior capsules must stick to each other to allow them to glide simultaneously into the lens groove.

Once the BIL is injected into the anterior chamber, it is positioned on top of the anterior capsule, and in front of both rhexis openings. The lens is kept in this position with the use of low molecular weight cohesive viscoelastic material. It is then moved slightly laterally in order to allow the posterior haptic to be positioned behind the posterior capsule and to insert the peripheral capsular bag in the lens groove by exerting small pressure on the four cardinal points of the lens optic at the level of the groove (the transition between haptic and optic).

Medium cataract. In adult eyes with low density cataracts of approximately 25% as measured with the Scheimpflug lens densitometer, an incision of 2.5 to 2.8 mm is performed. Surgery is performed under topical anesthesia unless patients have neurological problems, are mentally challenged, or at the patient's specific request. The incision size will depend of the power and thickness of the IOL to be inserted.

Anterior capsulorrhexis is calibrated at 5 mm diameter using a ring caliper. Centration of the ring on the anterior capsular surface is based on the first and fourth Purkinje reflexes. The fourth Purkinje reflex corresponds to the reflection of the microscope light at the level of the posterior face of the lens. The first Purkinje reflex corresponds to the reflection of the microscope light on the anterior surface of the cornea.

Hydrodissection is performed in all cases. Rotation of the lens within the capsular bag is mandatory before phacoemulsification begins. Exception is made for posterior polar cataracts, in which case only hydrodelineation is performed.

A one-piece phaco and irrigation-aspiration technique is used. The lens pieces are aspirated out of the capsular bag, and ultrasound is applied at the iris plane. The fragments are aspirated with very little phacoemulsification.

A posterior capsulorrhexis of the same diameter as the anterior capsulorrhexis allows insertion of a monofocal BIL with or without toric component, depending on the residual corneal astigmatism.

A high molecular weight cohesive OVD is used to fill the anterior chamber and ensure proper counterpressure for the posterior segment. A light molecular weight cohesive OVD is used to fill Berger's space behind the posterior capsule.

Hard cataract. In very hard nuclei, the surgical steps are similar to those for medium cataracts. However, there are slight differences. The anterior capsulorrhexis is 5 mm in diameter, no smaller, and again measured with a ring caliper. Centration of the ring caliper on the Purkinje reflexes is not possible because the lens is too dense. The microscope light is absorbed by the lens, prohibiting the light to be reflected from the posterior lens surface. As a result, it cannot be observed by the surgeon. Centration is based on the pupil instead.

Hydrodissection is performed, and rotation of the lens material is again mandatory.

All cracking maneuvers and emulsification of lens fragments are performed at the lenticular plane, within the capsular bag. The reason is basically to avoid endothelial damage due to the prolonged and high power ultrasound that must be used.

Again a BIL with or without toric component depending on the corneal astigmatism is used following the techniques previously described. Because in hypermature cataracts the capsule is often very thin and large, a capsular tension ring is inserted to avoid capsular donesis.

The golden rule in cases with hard nuclei is, Take your time and be patient.

KHIUN F. TJIA, MD

Soft cataract. Often inexperienced surgeons complain about removal of very soft cataracts. All sideport instruments to manipulate or crack the lens tend to slice through the very soft lens instead of moving it. Actually, these very soft lenses are quite easy to deal with, but one should not try to manipulate the lens within the capsular bag.

Instead, after initial complete hydrodissection, the surgeon should create several hydrodelineation planes from the periphery inward, like the layers of an onion. In a very soft lens, the volume of the injected balanced saline solution will push the overlying material out of the bag. With subsequent hydrodelineation maneuvers, a significant part of the lens will be prolapsed into the anterior chamber, from which it can be aspirated easily with any moderate fluidics settings.

Medium cataract. A yellow nuclear cataract is easiest to crack or chop. Careful manipulation will normally result in a successful outcome. A not-so-soft, but also not really nuclear cataract, however, can sometimes be bothersome. After hydrodissection with or without hydrodelineation, and then nucleus removal, an epinuclear bowl can remain in the capsular bag. Multiple attempts to engage the anterior edge of the epinucleus, with potential risk for anterior capsule ruptures, may only result in nibbling away at the edge of the bowl circumferentially, leaving a nuclear soup dish on top of the posterior capsule. It is important to have a specific epinucleus setting with moderate vacuum and aspiration flow in linear mode. In this way, you can engage the edge of the epinucleus gently and gradually by pressing the footswitch down slowly (with therefore low fluidics parameters). By slowly increasing the vacuum, you can pull at the epinucleus, subluxate it from the capsular bag, and emulsify it with low power ultrasound. High fixed vacuum and flow will only take direct bites from the epinucleus edge and result in the frustrating nibbling away of the edge.

If this strategy ultimately fails, do not try to attack the nuclear plate with the phaco tip within the capsule. This carries a high risk for capsule rupture. It is almost always possible to subluxate the epinucleus by hydroexpression—similar to hydrodissection—and then attempt emulsification with the epinucleus setting.

If this strategy also fails, viscoexpression is the ultimate gateway to successfully finishing the case. I prefer a dispersive OVD for this purpose because it tends to move more easily posterior to the epinucleus.

Hard cataract. Very dense nuclei require good surgical skills. You will learn from all experienced surgeons that the leathery fibers in the posterior plate of the nucleus are extremely difficult to separate. Additionally, all mature cataracts, whether nuclear or cortical, also include the risks of weak zonules and fragile capsules. Referring the patient to a more experienced colleague is the best option for a beginning surgeon.

In this article, other surgeons have provided several tips and tricks on how to completely crack or chop a hard and rubbery nucleus. It all comes down to carefully and meticulously moving forward step by step. Patience is the key to success.

I would like to add one pearl: Repeated injection of a dispersive OVD should be performed to protect the corneal endothelium. Emulsification of a very dense cataract always involves elevated levels of dissipated ultrasound energy and prolonged high turbulence in the anterior chamber. Both can affect the endothelium significantly, and corneal decompensation is not rare after phacoemulsification of a very hard cataract.

I also recommend a low aspiration flow rate setting (eg, 15 mL/minute) which will not aspirate the dispersive OVD quickly, leaving the protective OVD layer intact. With torsional ultrasound, such a low aspiration flow does not affect the efficiency of emulsification efficiency.

My preferred phaco tip for a very dense nucleus and torsional phaco is the 45° Kelman Microtip, which has no tapered lumen, eliminating potential tip obstruction.

Lastly, I also recommend injecting a dispersive OVD behind the nucleus when you have succeeded in obtaining an initial crack in the periphery. This will provide a certain safety zone for subsequent cracking or chopping maneuvers. ■

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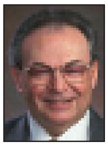

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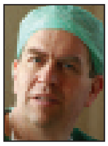

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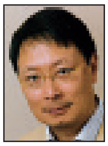

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