Innovations in Torsional Phaco and Micro-Coaxial Technologies

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The Paradigm Change in Lens Removal: Sideways is Forward

by David Dillman, M.D.

Despite its introduction in 1967, phacoemulsification technology did not emerge at the forefront of cataract surgery until the introduction of foldable lenses. After much innovation and redesign over twenty years, phaco technology has evolved to provide cataract surgeons with multiple options to accommodate cataracts of varying density. Of particular note are current power options. Originally, ultrasound energy was delivered continuously to the cataract with only an "on/off" option. Since then, energy delivery has progressed from fixed continuous power or linear continuous power to noncontinuous pulses or bursts of power, to micropulsed or hyperpulsed power.

Torsional phaco requires an ultrasonic phacoemulsification handpiece, which cataract surgeons have used for many years. However, when you’re performing torsional ultrasound, there’s the possibility of a totally new paradigm in phaco. With the phaco tip oscillating 32,000 times a second, torsional is really transforming how we perform cataract surgery.

The interesting thing about torsional is what’s now happening at the end of the phaco tip. With a standard Kelman-style tip, the ultrasonic movement within the hand piece then translates into a horizontal or side-to-side excursion as opposed to a longitudinal excursion at the tip end. The maximum horizontal excursion is 3.5 mills or 90 µm with the tapered tip, which is almost exactly the maximum excursion with longitudinal phaco.

Why Torsional?
The greatest advantage of torsional phaco is that it significantly reduces the repulsion that is inherent in traditional longitudinal phaco. Traditional repulsion is evident in all types of longitudinal phaco, regardless of the manufacturer, pulse program, or phaco tip used.

As a result, with torsional, there is better followability, less lens chatter, less “lollipopping” of the lens, and a lot less turbulence. That translates into a significant amount of additional control for the surgeon. That is a very real component of torsional phaco.

I believe the side-to-side motion inherent in torsional phaco is a forward motion for phaco technology, and I believe that torsional phaco is a better technology than any form of modulated or pulsed longitudinal phaco that I have experience with. The INFINITI® Vision System and the advent of OZil® Torsional Handpiece (Alcon Laboratories, Fort Worth, Texas) has made me a better cataract surgeon, and it will make even the novice surgeon a better cataract surgeon.

I believe there are other reasons why torsional phaco is more advantageous than longitudinal phaco. One advantage is the increased efficiency of emulsification. With traditional longitudinal ultrasound, there’s a cutting action with the forward motion of the jackhammer effect, but there is no cutting action as the tip moves backward away from lens material. Therefore, in longitudinal...

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phaco, only 50 percent of the cycle is devoted to the emulsification process.

In torsional phaco, however, there is a totally new cutting effect—almost shearing—as the tip moves to the right. As the tip moves to the left, the same cutting or shearing effect is also taking place. In other words, 100 percent of the cycle is devoted to the emulsification process.

**Preferred Techniques**

In my practice, I primarily do phaco pre-chopping technique. If I cannot do a pre-chop because of lens density, I’ll perform a quick-chop technique. I try to perform a pre-chop whenever I begin phaco. If I determine that I won’t be successful, I’ll convert to a quick-chop and check it by feeling for resistance. If there’s too much resistance, there will be added stress on the zonules, which surgeons should try to avoid.

I prefer to use micro-coaxial phaco with a 2.2-mm incision. With torsional phaco and the mini-flared Kelman® ABS® tip (Alcon), the tip is easily inserted in the micro-incision without additional instrumentation needed. I often had to use a second instrument with my prior phaco system based on longitudinal phaco. My present settings are an aspiration flow rate setting of 40 cc/min and a vacuum limit of 400 mm Hg with torsional amplitude set at 100 percent. I’m a proponent of keeping a second instrument out of the eye whenever possible. I do this to avoid the potential leakage from the side port—my vast experience has shown that the incisional leakage caused by any instrument is my enemy.

If I have to use my quick-chop, I have found that I can bury and occlude the phaco tip easily using torsional alone for the chopping maneuver rather than starting with longitudinal ultrasound and switching to torsional. The key to efficient quadrant removal with any phaco technology is to keep the phaco tip on its side, and in the central zone of safety in the eye. This helps avoid any post-occlusion surge or unexpected ocular movement as well as protect the corneal endothelium.

**Summary**

The real advantages of torsional and why I believe that sideways is forward:

- Significantly reduces the repulsive forces inherent to longitudinal phaco
- Much better followability
- Much less chatter
- Much less lollypopping of the lens
- Overall less turbulence
- More control of your ocular environment
Clinical, I found that torsional ultrasound is more efficient when applied continuously. There are several methods of optimizing various phaco tips with torsional ultrasound to get the best results possible."

Lincoln Freitas, M.D.

There are two questions we are now addressing in phacoemulsification: What happens if we modify the ultrasound, and what happens if we modify the tip?

Longitudinal or traditional ultrasound inherently provokes a chattering effect—the lens undergoes a jackhammer effect that causes an increase in the amount of energy released inside the eye. Additionally, as the lens is emulsified, small fragments of the cataract are released, increasing the turbulence that is caused by the chattering effect while emulsifying lens material.

Lens chatter can be reduced by using high levels of vacuum and aspiration rates along with burst or pulse mode. The thermal temperature and energy released inside the eye can also be controlled by using micropulse software but torsional ultrasound eliminates these issues almost completely. It eliminates the lens repulsion so there is limited chattering effect.

In my experience, the dispersion and turbulence are also reduced, while also increasing the thermal safety profile of ultrasound phacoemulsification. The result is that it gives surgeons a new “shearing effect,” which allows us to grab small pieces of fragments without pushing the fragment away and improve the efficiency of the surgery.

Optimizing Phaco Tips with Torsional Phaco

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ideal tip for torsional ultrasound because it allows for efficient occlusion with negligible chattering effect.

The regular 1.1mm flare tip has a funnel shape that enhances the area of capture of the lens fragment. You can enhance this area, but there is a disadvantage with this type of tip and torsional ultrasound: There is typically a 1.24-mm aperture sloping to a 0.57-mm tube inside the shaft of the tip. The new mini-flared tip has a smaller mouth or inner bell—0.80 mm—with the same size aperture inside the shaft, which makes it ideal for torsional and micro-coaxial phaco.

Finally, there is a tapered tip, which also is shaped like a more gently sloped inner funnel. The difference is that the funnel-shaped tapered tip is less severe (0.66 mm aperture in the shaft), so there is a smaller area to occlude with fragments, but fragments might still cause occlusion on very hard lenses that is hard to displace with torsional ultrasound alone.

In my experience with the extremely dense lenses, it’s better to use a 0.9-mm MicroTip ABS. The inner bore of the MicroTip is the same throughout the tip, so lens material is more easily aspirated when using torsional alone.

When working with the flared tip and mini-flared tip, because of the size of the interior shaft, we need to compensate the fluidics of torsional ultrasound with higher levels of flow or vacuum and use longitudinal ultrasound to maintain the efficiency of the surgery on very dense lenses.

### Personal Pearls

Using the Kelman MicroTip at 30 degrees is my preference for all types of lenses, but a 45-degree angle can be more efficient if the surgeon is comfortable with the bevel. I would recommend mini-flared and tapered tips for most types of mature or dense lenses, except for the very hard ones.

Lincoln Freitas, M.D.
High ultrasound power is needed to enter deep into the nucleus according to its hardness, and high aspiration and vacuum are needed to grab the nucleus. The left hand is used to chop and separate the nucleus. Both the chopper and the phaco tip should be as deep in the nucleus and as close to the posterior plate of the nucleus as possible.

Once the nucleus is divided, you can do the emulsification with torsional ultrasound alone to aspirate the nuclear sections.

Every quick-chop cataract case involves two important steps: dividing the nucleus, which should be done quickly and completely, and then emulsification and aspiration of the nuclei pieces.

Complete division of the nucleus is mandatory; if we don't manage it from the beginning, problems may crop up, or you could be looking at a prolonged surgery. I use a combination of torsional and longitudinal ultrasound for this step of the procedure.

Using a combination of longitudinal ultrasound with torsional ultrasound for dividing the nuclei.
but still good efficiency.

With a brown mature cataract, I always use Viscoat® (Alcon), which protects the cornea extremely well. In these cases, the first step to dividing the nucleus is the same. The values of the U/S settings are higher than with typical cataracts. With brown cataracts, I use a combination of torsional and traditional longitudinal during the pulse phase. Two or three (maximum) pulses are enough; it’s even more efficient in small pulse because it helps you enter the nucleus.

If it’s a small pupil, I’ll work in the center of the pupil and allow material to be drawn to the phaco tip. With torsional ultrasound, I have not found the need for mechanical dilation of the pupil. There’s much less chatter and much better followability of the pieces of the nucleus, so sometimes I don’t really need my left hand in the anterior chamber to bring the nucleus pieces onto the phaco tip; more often than not, it is sufficient to remain in the middle and aspirate the pieces of the nucleus.

If you have good ophthalmic viscosurgical devices, there’s no reason to be afraid to stay and work in the pupillary plane with torsional. In addition, there’s much lower energy output and turbulence with torsional than with longitudinal ultrasound. And because of the efficient quick-chop technique, I can keep the settings lower—even for an advanced cataract. All this can help the surgeon perform a more effective and safe procedure.

Both the Infiniti Vision System and OZil Torsional technology can be customized to emulsify the nucleus regardless of its hardness and associated pathologies, such as small pupils and weak zonules or other previous surgery on that eye.
Innovations in Torsional Phaco and Micro-Coaxial Technologies

I have had much success with premium IOL’s over the last several years. These premium lenses offer us a unique opportunity to enjoy new found success and increased patient satisfaction than ever before. I have found that there are four principal pre-op steps that I recommend to ensure the highest level of success when implanting premium IOLs such as the AcrySof® ReSTOR® and Toric® IOLs (Alcon, Fort Worth, Texas): seek motivated patients and inform them well, evaluate pupil diameter, evaluate keratometry readings, and customize the incision sizes to treat astigmatism.

Evaluating Pupil Diameter and Keratometry
It is important to measure the pupil diameter prior to ReSTOR lens implantation. This is especially important while reading the accommodative pupil diameter (APD). It’s simple to accomplish, and can be done with a pupil gauge. The optimal APD is 2.5 mm or less with this IOL; if the APD is larger than that, the patient may experience a ghost image and require long-term topical miotic treatment. K-readings must also be carefully evaluated because optimizing outcomes with this lens requires post-op astigmatism levels of 0.50 D or less in most patients.

Post-op Keys
The major key to success with multifocal IOL implantation after surgery hinges on ensuring that the patient’s spherical equivalent is somewhere between +0.50 and −0.25 D, and astigmatism is 0.50 D or less.

Samuel Masket, M.D. (University of California at Los Angeles) presented a study of surgically induced astigmatism at the 2006 ASCRS ASOA Symposium and Congress. He found that patients who underwent micro-incisional surgery and received 2.2-mm incisions had a mean surgically induced astigmatism of 0.11 D. This compared favorably to those who received 3.0 mm incisions and had a mean induced astigmatism of 0.33 D. This may seem trivial, but remember that a patient may be satisfied with 0.50 D with a multifocal IOL and dissatisfied with 0.75 D with a cylindrical lens.

Torsional or micro-coaxial phaco can be used to virtually eliminate surgically induced astigmatism. Although the diameter of the Ultra infusion sleeve is less than 2 mm, the...
procedure is extremely efficient because relatively aggressive fluidic parameters (40 cc/min flow rate, 400 mm Hg vacuum) can be routinely employed with this technology.

**Reducing Pre-existing Astigmatism**
Reducing post-op astigmatism is obviously a component of successful surgery, and there are two possible ways to accomplish this.
1. Operate on the steep axis with an incision that will flatten that meridian.
2. Operate with a 2.2-mm micro-coaxial incision that is astigmatically neutral and either add limbal relaxing incisions (LRIs), peripheral corneal relaxing incisions (PCRI), or “penetrating” LRIs (PLRIs). The latter are simply phaco incisions placed on the steep meridian, and you don’t have to be experienced at performing an LRI in order to do them well. They obviously do not require pachymetry either. I believe they are best done with an I/A tip in the eye and the foot pedal in position 1 (infusion). I usually do this just before removing viscoelastic after IOL implantation. The incisions do not need to be hydrated; they self-seal immediately.

**PLRI Effects**
I have developed nomograms for this technique. There is a mean effect but, as with any incisional astigmatic procedure, there is also a significant range of effect for both single and paired incisions. There is a small but significant percentage of patients that will not get any astigmatic effect, or the effect will be transient.

**Toric IOL Success**
Success with an AcrySof Toric IOL obviously depends on identifying the correct axis. To ensure this, the patient should be in upright position and limbal marks should be made at 3, 6, and 9 o’clock. I have found the 6 o’clock mark to be the most reliable because the human eye can easily determine the 6 o’clock position.

The simplest way to determine if the axis marking for IOL placement has been done in a manner that is concentric with the limbus is to imagine a line connecting the two marks. This line should
pass through the geometric center of the cornea. If it does not, this indicates that the axis marker has been eccentrically placed on the cornea. In this situation, when the Toric IOL is subsequently inserted, it will not be possible to align the three dots on it with both of the axis marks on the cornea. The Toric IOL marks will be left and parallel to the imaginary line connecting the corneal axis marks.

Calculating the Correct Toric IOL Power

There are two options when calculating the toric portion of the IOL power depending on the size and location of the phaco incision. One method is to make the incision in the surgeon’s customary location and insert the known astigmatic effect of the incision into the Toric IOL Calculator (Alcon). After the K-readings are entered, the calculator will compensate for the surgically induced astigmatism and select the correct toric lens model and axis location.

The second option is to simply locate the incision on the steep axis and subtract the known astigmatic effect of the incision from the pre-op astigmatism. The appropriate toric IOL is then placed at the axis of the incision.

My preference is to use a more astigmatically neutral incision (2.2-mm incision with the Ultra sleeve) and rely entirely on the IOL to correct the astigmatism whenever possible. By doing so, I am more likely to get a greater accuracy.

I highly recommend that all cataract surgeons utilize this technology for astigmatic patients who desire better uncorrected visual acuity. Toric IOLs are highly accurate and easy to insert. If a surgeon can perform phacoemulsification, he/she can easily insert a toric IOL. Fully 20 to 30 percent of patients have one or more diopters of astigmatism. The vast majority wants better uncorrected distance vision, which is certainly attainable. I have implanted more than 600 Alcon Toric IOLs, and I use this lens about 15 times a week.

“...My preference is to use a more astigmatically neutral incision (2.2-mm incision with the Ultra sleeve) and rely entirely on the IOL to correct the astigmatism whenever possible.”

Richard J. Mackool, M.D.
Before any nuclear pieces enter the tip during phaco, a steady state of fluid movement exists, flowing out the infusion sleeve and going into the phaco aspiration port. As the tip begins to occlude with nuclear material, the pressure begins to rise in the anterior chamber and cassette tubing. When the tip becomes occluded, the vacuum level in the tubing will quickly rise until it reaches the maximum level. Once the occluding piece is emulsified, there will be a sudden drop in ocular pressure within the anterior chamber as fluid in the eye rushes into the aspiration port to satisfy the high vacuum that was created in the tubing. This is known as post-occlusion surge.

Any significant post-occlusion surge is a dangerous situation. The anterior chamber shallows, and the iris moves toward the phaco tip. The suddenness of such an event may not allow the surgeon time to prevent posterior capsule rupture or significant iris trauma. Post-occlusion surge is less significant today with modern phaco technologies that incorporate newer fluidic management strategies, but it still occurs to varying degrees with all phaco platforms.

Micro-Incisional Phaco Limits Irrigation

With standard-size incisions (2.5 mm and above)—even with high-infusion sleeves—we still can see some small amounts of surge. But controlling surge is more important with micro-incisional phaco because small incisions restrict the amount of irrigation that can enter into the eye even if the balanced salt solution (BSS) bottle is raised very high.

Raising the BSS bottle higher is not innocuous. One downside of raising the BSS bottle is a concomitant increase of pressure in the eye. Another more potentially damaging side effect is an increase in anterior chamber turbulence from the high-pressure stream coming into eye. High turbulence can induce miosis during surgery and can adversely affect the corneal endothelium.

Another strategy to combat post occlusion surge during micro-incisional phaco is lowering the fluidic settings by decreasing vacuum levels and aspiration flow rates to decrease the amount of post-occlusion surge.
The problem with this strategy is that you end up decreasing your surgical efficiency as a consequence.

**Less Compliant Design**

The Intrepid Fluid Management System, or Intrepid FMS, (Alcon, Fort Worth, Texas) is a less compliant (more rigid) tubing system than even the existing Infiniti FMS. The less compliance you have in a system, the less post-occlusion surge you’ll have. Lab tests demonstrate that the volume of fluid that rushes into the tip during occlusion breaks (surge) was markedly reduced with the Intrepid FMS.

To determine if clinical experience would match the lab results, I compared, in masked fashion, chamber stability to the standard FMS to stability with the Intrepid FMS in approximately 100 patients. I used a rating scale from one to 10, on which a score of six or less represented some element of significant surge and a score of 10 was not possible to achieve with any fluidic system within a compliant chamber of the eye. A rating of 10 meant that nothing moved, that the surgeon would not

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**Rating Distribution**

(%age of total cases)

Rating of 10 not possible; 8 = barely perceptible movement

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be able to see any iris fluctuation or any shallowing of the chamber or posterior capsule movement. A rating of eight meant that I could barely see iris movement or posterior capsule movement and that the safety margins during phaco were excellent. With the Intrepid FMS, we had twice as many ratings of eight than with the existing system.

**The Importance of Confidence with Micro-Coaxial**

As I moved to torsional micro-coaxial phaco, surgery felt no different than with a 3.2-mm incision, so the transition was nearly seamless. Now, I no longer make an incision larger than 2.2 mm yet I still have great confidence in ocular stability using the Intrepid FMS.

With the Intrepid FMS, I found that the posterior capsule routinely doesn’t normally budge, even when you’re working on the last quadrant. When aspirating that quadrant, even if I’ve reached vacuum levels at or near 400 mm Hg, the posterior capsule is quite stable even without raising the BSS bottle. The Intrepid cassette has stiffer aspiration tubing, so some ergonomic compromise is noticeable, mostly during I&A, when the handpiece typically is moved, twisted, and rotated more than during phaco.

I can evaluate stability in even more detail when I look at Flomax cases in which any fluctuation in the chamber causes tremendous movement of the iris. With the Intrepid system, there is very little iris movement following an occlusion break. There are occasions of marked iris movement with the standard cassette cases.

Micro-incisional surgery results in less irrigation flow; therefore, surge suppression is even more important in these cases. Raising the bottle does not solve the cause of post-occlusion surge and can actually result in increased turbulence as well. The Intrepid FMS is designed to tackle the root cause of post-occlusion surge by implementing stiffer aspiration tubing to suppress surge even better than the existing Infiniti cassette.

Intrepid FMS limits iris movement following occlusion break in my Flomax patients.
Innovations in Torsional Phaco and Micro-Coaxial Technologies

We find that energy and aspiration work in harmony with OZil and micro-coaxial because the lens substance is not pushed away; it stays at the tip.

Abhaykumar Vasavada, M.D., F.R.C.S.

Dense Cataract Emulsification Using OZil and Micro-Coaxial

by Abhaykumar Vasavada, M.D. and Shetal Raj, D.O., M.S.

We see a lot of dense cataracts in India, and I believe torsional technology and micro-coaxial phaco are immensely beneficial in their effective removal.

When I began using the torsional hand-piece, the first thing I noticed in my first and second case was OZil’s outstanding cutting ability. We know now it’s because of the non-stop left-to-right action of the torsional tip, which cuts nuclear material all the time. That’s very important when removing dense cataracts. The cutting ability is good, even in these difficult cases, because all three components—Kelman, the 45-degree bevel, and OZil—allow me to emulsify these dense lenses without stressing the sub-incision zonules.

We know lens removal involves energy that emulsifies the lens into small pieces. Aspirating can be problematic with longitudinal or conventional ultrasound because aspiration has to overcome the repulsive energy. The rationale behind using the interrupted energy principle or micro pulse software, using longitudinal ultrasound is to reduce repulsion and facilitate aspiration. The combination of OZil and micro-coaxial is an entirely new concept for us as surgeons. We need to rethink some important principles of phaco that we have been taught for many years.

Fluidic Harmony

With micro-coaxial, there is reduction in irrigation—20 or more percent—and we need to have those lower fluidic parameters to be more effective if we really want to perform posterior-plane emulsification. Dense cataracts can cause turbulence and come into the anterior chamber and tumble close to the endothelium.

Performing phaco in the posterior plane is more critical with dense cataracts than when removing general cataracts.

I have found that energy and aspiration work in harmony with OZil and micro-coaxial because the lens substance is not pushed away; it stays at the tip. That means surgeons can use lower fluidic parameters. I believe that is the way to go in dense cataract because of the safety it imparts. That, in turn, makes the combination effective.

When I’ve got a fairly dense cataract, and I’ve started with a micro-incision of 2.1-
Innovations in Torsional Phaco and Micro-Coaxial Technologies

mm or 2.2-mm, it’s striking to note the incision end is not enlarged during phaco. There’s little to no distortion. Typically, you would see a distortion at the internal entry in a dense cataract, and you’d see a lot of hydration and incisional stress, but you don’t with the combination of OZil and micro-coaxial.

**Pearls for Difficult Cataract Extraction**

When dealing with a dense cataract, the central trench is important because it acts as a recess where you can bring the fragments before removal; therefore, I always make a point to make a deep trench, though not very wide or long. I suggest using the Kelman tip with the 45 degree bevel with torsional phaco.

Once the deep trench is created, my technique depends on a step-by-step approach. I don’t aim for a total division of the nucleus in one stroke because I worry about creating more distortion of the capsular bag. Instead, I use the combination of the chop principle and then the separating principle. We need to combine both principles judiciously. Keep the chopper adjacent to the fibers. Aim for multiple and small fragments.

Now that they’ve been divided, the most important phase of the surgery begins: fragment removal. Torsional is outstanding at this phase because it removes the substance through surface shearing, not by coring.

A principle I call “car OZil-ing” brings the fragments into the tip. The tip works to bring the fragments to the vibrating tip even when activated, so you don’t need to core and fully occlude the phaco tip as may be necessary with longitudinal phaco.

I’m very conscious of the plane of emulsification. I want to limit that removal process and keep it away from the endothelium. I can do that by car OZil-ing these lens substances into that tip. I need to keep the tip horizontal to get the best effect, so I use a 45-degree bevel. This way, I don’t have to worry about endothelial clarity.

To a clinician, the combination of micro-coaxial and OZil is important because it controls the intra-operative performance and ensures more consistent clear corneas on day one.

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because that is optimized every time in this density of cataract.

We did a randomized, prospective evaluation trial comparing OZil and conventional longitudinal ultrasound in these dense cataracts. We found that OZil worked favorably for the surgical efficiency, the fluid usage, and the clarity of the clear cornea on day one. There was less increase in the corneal thickness in the OZil group. Also, the change in the coefficient of variation (CV) and endothelial cell loss was less in the OZil group, and we generated no more thermal energy.

To a clinician, the combination of micro-coaxial and OZil is important because it controls the intra-operative performance and ensures more consistent clear corneas on day one. And the combination allows patients to resume their daily activities from day one. I don’t think it’s an exaggeration to say that this combination of torsional technology and micro-coaxial is a true revolution.

Included with this supplement is a CD that contains surgical footage and detailed discussions of many important aspects and applications of torsional phaco and micro-coaxial technology. Panel participants discuss, use, and demonstrate torsional phaco and micro-coaxial so you can better visualize the exciting potential and benefits of these unique lens removal modalities.