We describe a nondividing, nonchopping phacoemulsification technique for nucleus removal with minimal zonular stress. It can be applied in any type of cataract surgery, regardless of nuclear color or density, as long as the anterior chamber is stabilized and properly maintained and there is sufficient followability using torsional modality. This technique uses less phacoemulsification energy, thereby avoiding zonular stress, and does not require an initial division of the nucleus, which is another advantage for beginners. The procedure is safe and easy to learn and is most advisable for beginners as it can prevent complications.

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Since Gimbel first described the nucleofractis technique,1 known as divide and conquer, various techniques have been described, including phaco chop and stop and chop.2 Initial division of the nucleus poses a challenge for those learning to perform cataract surgery, particularly in the presence of zonular weakness, a hard nucleus, and/or a small pupil. In cases with a soft nucleus, complete fracturing of the nucleus is not easy because of the nucleus’ pliability. In these cases, phacoemulsification should be performed with minimal ultrasound energy and minimal zonular stress.

Torsional ultrasound and an advanced fluidics system can reduce fluidic surges and fluctuations in the anterior chamber, even in a high vacuum setting. This technology can reduce repulsion and allow nuclear material to stay at the phaco tip, even at low vacuum levels and flow rates. In addition, torsional phacoemulsification is more effective than longitudinal phacoemulsification when the same amounts of applied fluid and ultrasound energy are used.3 With this technology, an innovative phacoemulsification technique that would allow easier control of the nucleus with minimal risk could be devised.

The phaco windmill technique comprises 3 essential steps and does not involve a nucleus-dividing procedure. The first step is hydrodissection and hydrodelineation to separate the inner nucleus and epinucleus shell from the capsular bag. The second step is aspiration of the epinucleus to secure the space and isolate the inner nucleus. The third step is removal of the entire inner nucleus through rotation and aspiration with a high vacuum setting, using no or minimal phaco energy. We believe this is an easy and efficient method for surgical management of cataracts of various densities, particularly those with a soft nucleus, thus eliminating the need for chopping and dividing.

SURGICAL TECHNIQUE
The surgery is initiated under topical anesthesia with a clear corneal incision. Two side-port incisions are
created at 60 degrees on either side of the main incision. Sodium hyaluronate 2.3% (Healon5) is placed in the anterior chamber. A continuous curvilinear capsulorhexis (CCC) is performed with a forceps, and the anterior capsule is opened to a 5.0 mm to 5.5 mm diameter. Complete and thorough cortical cleavage hydrodissection and hydrodelineation are then performed to loosen the inner nucleus and allow it to be easily rotated later (Figure 1).

The phacoemulsification procedure uses the Ozil torsional ultrasound and the Intrepid Fluidics Management System on the Infinity Vision System (Alcon Laboratories, Inc.). The phacoemulsification parameters are vacuum, 350 to 500 mm Hg; aspiration flow rate, 30 mL/min; and infusion bottle height, 95 to 100 mm. A slightly high vacuum setting is used, and the phacoemulsification power is set at zero for removal of a typical soft cataract. If the nucleus is dense, as in a brunescent cataract, ultrasound power is titrated up to 30%.

The mobility of the inner nucleus can be checked by moving it with a chopper. When the nucleus rotates with little resistance, one can go directly to the next step of engaging the phaco tip in the nucleus. When the nucleus does not rotate freely, epinucleus removal is performed. First, a superior portion of the epinucleus opposite the main corneal incision is aspirated (Figure 1). Following partial removal of the epinucleus, the inner nucleus core is exposed without fragmentation and space for mobilization is obtained. The phaco tip is engaged in the nucleus at the midperiphery and held with a relatively high vacuum setting (approximately 350 mm Hg) so the entire mass of the nucleus can be spun like a windmill in the plane of the capsular bag and phacoemulsified from the periphery to the center. When the nucleus is small and soft, the entire nucleus can tumble instead of rotating in the capsular bag. The midperipheral part of the inner nucleus is removed (Figure 2), followed by aspiration of the central part of the nucleus and the remnants of the epinucleus. This entire process is carried out using torsional power with an Ozil phaco handpiece with no or minimal longitudinal phaco energy, while the phaco tip is embedded in the nucleus and moved only slightly. The chopper is also placed beside the phaco tip, which pulls the nucleus toward the phaco tip. After completion of nuclear phacoemulsification, the remaining cortex and epinucleus are eliminated by irrigation and aspiration (Figure 3). The video (available at http://jcrsjournal.org) illustrates this technique. A posterior chamber intraocular lens (IOL) is implanted in the bag, and the procedure continues in the surgeon’s routine fashion.

Results

Since December 2009, the phaco windmill technique has been performed in our clinic in approximately 90% of our cataract cases (more than 200 cases). In all cases, phacoemulsification was safely and quickly completed and an IOL was implanted in the bag with the posterior capsule intact. This technique has been used primarily in cases with a soft nucleus; however, successful outcomes have been demonstrated in eyes with weak zonules (ie, pseudoexfoliation syndrome), a small pupil, a dense cataract, and in previously

**Figure 1.** Following a CCC, hydrodelineation and hydrodissection are performed to separate the inner nucleus from the cortex and epinucleus. This step lays the groundwork for freely mobilizing the inner nucleus. The epinucleus and cortex (gray) located on the side opposite the incision are removed with a high vacuum setting to provide a space for phacoemulsification of the inner nucleus (yellow).

**Figure 2.** With the handpiece tip located at the midperiphery of the nucleus, the entire mass of the inner nucleus is spun similar to a windmill and is easily aspirated in a peripheral to central manner using no or minimal ultrasonic energy without fragmentation.
vitrectomized eyes. No intraoperative complications such as posterior capsule rupture, anterior capsule tear, or zonulysis occurred in any case. No postoperative complications such as synechiae or endophthalmitis have been observed in any patient, and in no case was it necessary to convert to another phacoemulsification technique.

**DISCUSSION**

The phaco windmill technique is considered one of the most suitable techniques for surgery in cases with a soft cataract as it does not require nucleus fragmentation. A small and soft nucleus is quite challenging because it is difficult to support or anchor during re-cracking and rotation of the nucleus. Traditionally, the stop-and-chop method has been used for soft cataracts; however, significant phaco power and time are used to create the initial groove. Additional in-the-bag maneuvers for nuclear disassembly increase the risk for injury to surrounding tissue and provide little space for efficient phacoemulsification. Flipping techniques have been described for removing soft cataracts; however, this maneuver poses a risk to the endothelium, especially in eyes with a shallow anterior chamber. Under these conditions, proceeding with phacoemulsification may result in greater harm to the capsule and/or zonules.

Pseudoexfoliation syndrome is commonly complicated by zonulysis, vitreous injury, posterior capsule rupture, or lens dislocation. Vitrectomized eyes are also difficult to operate on due to posterior displacement of the posterior capsule and fluctuation of the anterior chamber depth. In patients with a compromised endothelium, as in Fuchs dystrophy, or in patients with previous keratoplasty and a low endothelial cell count, endocapsular phacoemulsification is preferred to prevent endothelial damage. The phaco windmill technique, which requires minimal manipulation of the lens, can provide relative ease in dealing with these challenging cases by using an endocapsular approach and avoiding damage to the zonules.

Torsional phacoemulsification is essential, as it significantly reduces the repulsion of nuclear material from the phaco tip. Less chattering at the tip means the lenticular material stays on the tip; therefore, the tip is kept in an occluded or nearly occluded state. This greater occlusion in turn decreases turbulence in the anterior chamber and increases the followability and efficiency of phacoemulsification compared with traditional longitudinal phacoemulsification. The shearing action of the tip makes the removal of material more efficient than the forward movement of longitudinal phacoemulsification.

Using the phaco windmill technique, the surgeon can continuously observe the phaco tip and the chopper at the center of the microscopic field, allowing the procedure in the capsular bag to proceed safely. The chopper helps move the nucleus toward the phaco tip; however, unlike in the peripheral chopping technique, it never passes beneath the nucleus. The surgeon can therefore safely protect the integrity of the capsular bag from inadvertent movement of the chopper. The limited movement of instruments can reduce the risk for capsular tear, which usually occurs during the phacoemulsification portion of the surgery.

In cases with a shallow anterior chamber, excessive tilting of the nucleus may lead to skimming over the corneal endothelium. However, using the phaco windmill technique, manipulations are performed below the pupillary plane to protect the surrounding structures. Specifically, the capsular bag and zonules are protected from excessive stress and the corneal endothelium is protected from the deleterious effects of phacoemulsification energy. This technique also shortens surgical time compared with conventional methods such as divide and conquer and phaco chop. Moreover, aspiration of the nuclear mass contributes to shortening the surgical time as the sections of the epinucleus and cortex attached to the nucleus are removed together. Finally, this technique saves time and effort by avoiding initial division of the nucleus, which can be the most difficult step for beginners learning cataract surgery. This technique can be applied to almost any case, including complicated ones.

We are currently working on a study that compares the intraoperative parameters in the conventional phaco-chop technique and our phaco windmill
technique. The parameters include the amount of phaco power consumed, the amount of balanced salt solution used, phaco time, and the rate of postoperative complications such as zonular injury, posterior capsule rupture, and change in endothelial cell count. Although analysis of the final data is not complete, we have noticed tendencies toward less energy consumption and fewer postoperative complications with the phaco windmill technique. We have found that besides being suitable for soft nuclei, the technique can be useful in most types of cataracts, including dense cataracts and some complicated cataracts, as in cases with weak zonules or a small pupil.

In conclusion, this new technique is a safe and fast procedure that enables lens removal without division or chopping. Compared with previous techniques, the phaco windmill technique presents shortened surgical and phacoemulsification time, reducing endothelial damage. This finding must be replicated in future studies. The technique is particularly effective for cataracts with small soft nuclei and weak zonules. It is highly recommended for trainees, as well as for expert surgeons.

REFERENCES