The Basics of Phaco Chop Techniques

Part 2: Surgical techniques for horizontal and vertical phaco chopping.

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The first part of this two-part article, published in the January 2012 issue, described the principles of phaco chopping and explored the technologies involved. In this second part we describe the techniques used in phaco chopping and explore how to choose the best technique for a particular patient. As noted in part 1, there are two basic approaches to chopping: horizontal and vertical (Table 1). Each has the same goal—the fracture of the nucleus with minimal expenditure of phaco energy—but each achieves this end with different maneuvers.

SURGICAL TECHNIQUES

Horizontal phaco chop. With horizontal phaco chop techniques, the nucleus is divided into two fragments using a chopper moving in the horizontal plane. After being placed at the lens equator under the anterior capsule, the chopper moves toward the phaco tip, which has been impaled in the center of the nucleus. When the chopper reaches the phaco tip, both instruments are moved apart, leading to mechanical division of the nucleus.

During horizontal chopping, the nucleus is secured between the chopper and the phaco tip, which makes this technique less dependent than others on vacuum level. The capsulorhexis must be 5 mm wide to allow surgical maneuvers to be performed without causing damage to the capsule. Hydrodissection is mandatory, and hydrodelineation is advisable.

The sleeve of the phaco tip must adapt perfectly to the incision size to avoid fluid leakage through the main incision, an important issue when using high vacuum. The sleeve must be retracted backward to expose at least 1 mm of the metal tip so that it can penetrate the nucleus. Before the tip is impaled, the superficial epinucleus should be aspirated. The chopper is introduced through the paracentesis by turning it laterally, as the tip length measures 1.25 to 2.00 mm. Once the chopper is in the anterior chamber, it is placed in the capsular bag at the lens equator, opposite the main incision and in the same meridian. To place it safely at the equator, first it must be turned left with its distal end parallel to the anterior capsule. When the dull end reaches the equator, the chopper tip should be turned to the right so that the distal end embraces the lens. It is important to ensure that the chopper is located beneath the anterior capsule; otherwise, the zonules or the anterior capsule will be torn during chopping.

To impale the phaco tip, the surgeon should start stabbing the nucleus from the proximal edge of the capsulorhexis, pointing toward the nucleus center without going beyond the proximal half of the nucleus. During this step, high vacuum and flow and burst ultrasound are used. Once maximum prefixed vacuum is reached and the tip is occluded, the footpedal is changed to position 2 (Figure 1A). Next, the
Chopper is moved toward the phaco tip until they are close (Figures 1B). The instruments are then pushed apart laterally (from each other), leading to the mechanical division of the nucleus (Figure 1C). Subsequent divisions are accomplished after the progressive rotation of the nucleus so that the face of the fragment to be impaled is parallel to the transverse surface of the phaco tip. The harder the nucleus, the smaller the fragments and, consequently, the higher the number of fragments. For a medium nucleus, four to six pieces should be created. The fragments are then emulsified.

The most common complications of horizontal phaco chop, and possible solutions, are listed below:
- Failure to divide the nucleus in the first chop. This complication is generally caused by a superficial location of the tip. A new chop can be tried.
- Zonular dialysis caused by improper location of the chopper over the anterior capsule. Staining of the capsule with trypan blue is helpful to visualize the rhexis edge.
- Capsulorhexis tear; an adequate rhexis size and trypan blue staining can help prevent this complication (Figure 1D).

**Vertical phaco chop.** In vertical phaco chop techniques, the chopper and the phaco tip move toward each other in the vertical plane, inducing a shearing effect. Unlike with horizontal chop, during vertical chop opposing forces are created that never trap the nucleus, and therefore vertical chop relies on a high and consistent level of vacuum while the nucleus is being divided.

The paracentesis is located 60º away from the main incision. The chopper is turned to introduce it parallel to the paracentesis, and, once in the anterior chamber, it is turned again to place it vertically. The size of the capsulorhexis has less importance in vertical chopping because surgical maneuvers can be performed in the central 3.00- to 4.00-mm pupillary area. Proper hydrodissection is mandatory.

The sleeve of the phaco tip must be retracted to leave 2.00 mm of exposed metal tip. Using high vacuum and burst mode, the phaco tip must be embedded deeply into the center of the nucleus, pointing toward the optic nerve, without going beyond the proximal half of the nucleus. Because high vacuum levels cannot be reached without a well-occluded phaco tip, burst mode is particularly advantageous for chopping, as it minimizes the cavitation effect, allowing an effective seal of tissue around the tip. Once the phaco tip has reached the desired depth and has become occluded, the footpedal is held in position 2 to stabilize the nucleus.

In horizontal chop, the movement of the chopper toward the phaco tip creates a horizontal vector of force that compresses the nucleus against the phaco tip, so it is difficult to lose occlusion. By contrast, in vertical chopping, the movement of the chopper creates a downward vector action that opposes the upward force induced by the occlusion, so the nucleus can become disengaged from the phaco tip. For this reason, achieving proper occlusion with high vacuum is very important in vertical chop techniques.

After the phaco tip is impaled, the chopper is placed 1.00 mm in front of it. The tip of the chopper is then stabbed into the nucleus and moved toward the phaco tip in the vertical plane. The chopper moves downward while the phaco tip moves upward (Figure 2A). When the chopper and phaco tip are close to each other, they are pushed laterally apart, leading to the initial split, which propagates downward until complete nucleus fracture is achieved (Figure 2B). The location of the chopper is important; if located too close to the phaco tip, it can break the seal around the tip, but, if too far, the induced lever force can release the nucleus from phaco tip. The process of chopping is repeated on the two halves of the nucleus until four to six fragments are obtained. The most common complications of vertical chop are listed below:
- Failure to divide the nucleus in the first chop, which usually occurs due to the superficial location of the phaco tip. Another chop can be tried; however, after several attempts, central nucleus mass decreases, making it more difficult to obtain a good grip.
- The sharp point of vertical chopper may tear the capsulorhexis. Again, trypan blue staining can be helpful to prevent this complication.

**CHOOSING A TECHNIQUE**

Phacoemulsification must be tailored to provide the most effective and safe technique for each patient. In routine cases, the type of technique—horizontal or vertical chop—does not make a great deal of difference; therefore, the surgeon should use the one with which he or she is most familiar. There are, however, a variety of cases in which one technique may be superior to another.

**Small capsulorhexis.** If a small capsulorhexis has been created, a vertical chop is preferable because the surgeon can work in the central 3.00- to 4.00-mm area of the pupil. The risk of a capsulorhexis tear will be higher.
with a horizontal chop technique in these eyes.

**Deep anterior chamber.** Eyes with deep anterior chambers, such as those in patients with high myopia or previous vitrectomy, are more easily managed with a horizontal chop technique. With vertical chop, the phaco tip must be positioned too vertically to be sufficiently stabbed into the nucleus.

**Zonular weakness.** Either horizontal or vertical phaco chop is superior to a divide-and-conquer approach in eyes with weak zonules, as the mechanism of division is centripetal. As explained in part 1 of this article, during horizontal chopping, the movement of the chopper toward the phaco tip compresses the nucleus against it, and the tip receives all the stress generated during surgical maneuvers. During vertical chopping, opposing forces are generated, and, although rare, slight rotation or movement of the nucleus can lead to the transmission of some of the stress onto the zonular apparatus.

**Small pupils.** Although for a skilled surgeon a small pupil is not a contraindication for horizontal chop, it is not advisable or safe to take the horizontal chopper peripheral to the equator. Vertical chop is more easily performed in eyes with small pupils, as all surgical maneuvers are performed within the central 3.00- to 4.00-mm pupillary area.

**Brunescent cataracts.** In eyes with hard, brunescent cataracts, horizontal chop does not effectively divide the posterior nuclear plate. Additionally, the absence of an epinucleus is considered a limitation for performing horizontal chop. Thus, a vertical chop technique is recommended in these eyes. Our preferred technique for brunescent cataracts is vertical chop using torsional ultrasound. We do not change many parameters from our technique for medium cataracts, apart from elevating the starting torsional amplitude setting to 30%. There are, however, a few variations to our technique in hard cataracts. First, we use a karate chopper, which is long and sharp, to facilitate embedding the dense nucleus without displacing it. Also, the irrigation sleeve must be retracted more than usual. This will expose a longer segment of the metal needle and maximize penetration of the phaco tip, which is crucial to divide the nucleus.

For hard cataracts, it is easier to begin by sculpting a small, deep pit centrally (Figure 3A), which allows the nucleus to be impaled more deeply. It is also 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 (Figure 3B). If there are leathery fibers in 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. The nucleus should be divided into smaller fragments to emulsify them securely. To maximize endothelial protection, one should refill the anterior chamber with a dispersive ophthalmic viscosurgical device (OVD) during fragment emulsification. A dispersive OVD injected behind the last remaining fragments creates an artificial epinucleus that will restrain the lax and fragile posterior capsule from trampolining toward the phaco tip, minimizing the risk of rupture.

### OTHER VARIANTS

**Stop-and-chop technique.** The stop-and-chop is a hybrid technique that begins with sculpting, followed by chopping. A groove is sculpted across the nucleus, which is divided into halves by pushing the chopper and the tip apart, as in the standard divide-and-conquer technique. After that, each half is further divided using chopping. There are two advantages to this hybrid technique. First, the groove creates a space that facilitates surgical manipulation of fragments during phacoemulsification; with techniques using chop exclusively, once the nucleus has been divided, fragments fill in the capsular bag like a puzzle, making it difficult to take them out of the bag during phacoemulsification. Second, the technique skips the first chop, which is more difficult to perform, and thus this technique may be suitable for beginners.

**Prechop techniques.** The term prechop was coined for techniques in which the phaco tip is replaced by other instruments during nucleus fracture, such as the Akahoshi technique, the preslice technique, and, more recently, the Ultrachopper technique. We use the Ultrachopper (Alcon Laboratories, Inc.) technique with excellent results in hard cataracts. Designed by Luis Escaf, MD, the Ultrachopper is an ultrasonic knife (Figure 4A) that cuts the nuclear substance. This blade can be used with any phaco system by connecting it to the handpiece. The Ultrachopper

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combines the mechanical force of the blade displacement with ultrasound energy, making it effective for cutting lens fibers. The depth of the cut is directly related to the excursion of the blade. This depends upon ultrasound power, which can be adjusted according to the density of the cataract.

A nucleus sustainer is used to exert counterpressure on the motion of the Ultrachopper. The sustainer is introduced through the auxiliary incision, placed in contact with the nuclear material, and slid underneath the edge of the rhexis, guaranteeing that it will never be placed above the anterior capsule. Once inside, the sustainer is placed at the equator of the nucleus, holding it firmly. The foot-pedal is then pressed to position 3, and the Ultrachopper is placed in the proximal area of the nucleus. While the Ultrachopper slides, the sustainer exerts counterpressure (Figure 4B). If the initial groove does not have adequate depth, the Ultrachopper may be slid through it again, either forward or backward. A nucleus splitter can be used to separate the two pieces. The Ultrachopper is especially useful in hard cataracts. With the counteraction of the nucleus sustainer, it minimizes zonular stress.

In a prospective comparative study of the efficacy of standard vertical chop compared with prechop with the Ultrachopper, we observed better outcomes in total phaco time and aspiration time in the prechop group.

**CONCLUSION**

With the proper maneuvers applied in appropriate cases, phaco chopping techniques can lead to good outcomes in cataract surgery. The principal benefits of these techniques are the reduction of total ultrasound energy and phacoemulsification time and decreased stress on the zonules. It is hoped that the points outlined in this two-part article on chopping basics will help the reader adopt phaco chop techniques in his or her practice and improve cataract outcomes for patients.

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