Phaco Chop Techniques – Comparing Horizontal vs. Vertical Chop

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Since Kunihiro Nagahara's original presentation more than ten years ago at the 1993 ASCRS meeting, many different variations of chopping have evolved. Each method carries a different name, which creates a significant amount of confusion over nomenclature and technique. Conceptually all chopping methods can be divided into two main categories[1]. I call the classic Nagahara technique horizontal chopping, because the instrument tips move toward each other in the horizontal plane during the chop. In vertical chopping, the two instrument tips move towards each other in the vertical plane in order to create the fracture. Among the early proponents, Vladimir Pfeiffer's "Phaco Crack" was renamed "Phaco Quick Chop" by David Dillman. However, Hideharu Fukasaku's "Phaco Snap and Split" was the first to utilize this concept.

All chopping techniques utilize manual instrument forces to segment the nucleus, thereby replacing the ultrasound power otherwise needed to sculpt grooves. Such energy efficiency is possible because the lamellar orientation of the crystalline lens fibers creates natural fracture planes within the hardened nucleus that are exploited by the chopping motion.

These smaller nuclear segments are eventually elevated into the supracapsular space for phaco-assisted aspiration at a safe distance from the posterior capsule. Because of this, I believe that phaco chop provides the same advantages as supracapsular phaco flip – namely efficiency, safety, and reduced stress on the capsular bag – without the challenge of prolapsing the entire nucleus out of the bag in one piece.

Advantages for Challenging Cases

During sculpting, the nucleus is fixated by the capsular bag. In comparison, chopping applies much less force against the zonules because the phaco tip secures the nucleus, and the manual instrument forces are directed centripetally against each other. This difference in zonular stress is very evident when chopping and sculpting are compared from the Miyake-Apple viewpoint in cadaver eye surgery.

In chopping, the critical instrument maneuvers are primarily kinesthetic, and are performed with the chopper tip. One does not need the red reflex to visually gauge the depth of the instrument tips. This is advantageous when dealing with mature cataracts. Because the phaco tip is relatively stationary and always remains in the central 2-3 mm pupillary zone, phaco chop is an excellent technique for small pupil cases as well.

These universal benefits of both horizontal and vertical phaco chop are particularly important for complicated cases – those with brunescent nuclei, white cataracts, weak zonules, capsulorhexis tears, and small pupils[2] **[Figure 1]**.

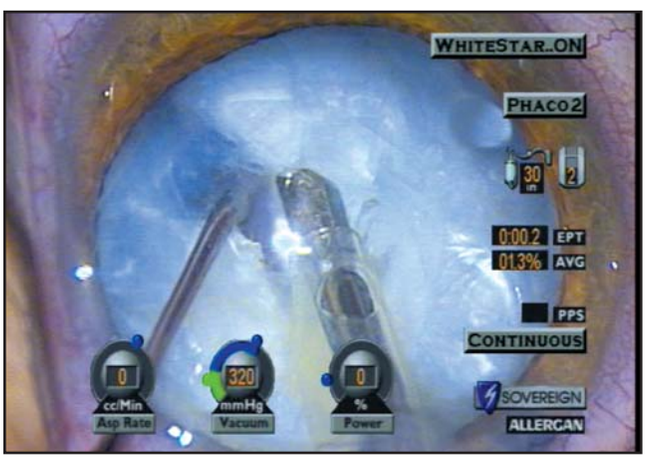

Fig. 1: Horizontal chop divides nucleus in a mature white cataract. Note trypan blue stained anterior capsule, and high vacuum purchase of the nucleus.

Horizontal Phaco Chop

After the endonucleus has been fragmented and removed, the remaining epinuclear shell will be aspirated and flipped as the final step. In horizontal chop, the chopper tip must hook the equator of the endonucleus peripherally beneath the anterior capsule. Several steps and principles facilitate proper placement of the chopper tip.

There are many different horizontal chopper designs, but all feature an elongated tip, which is blunt in order to avoid capsule perforation. A relatively long is necessary in order to transect thicker, dense nuclei, and the inner cutting surface of the tip may be sharpened for this purpose. I designed a modified Lieberman microfinger for horizontal chopping because its slender, curved tip is ideally shaped for hooking and cupping the lens equator **[Figure 2]**. Right-angled chopper tips do not conform as well to the natural contour of the equator and can result in more distention of the peripheral capsular bag.

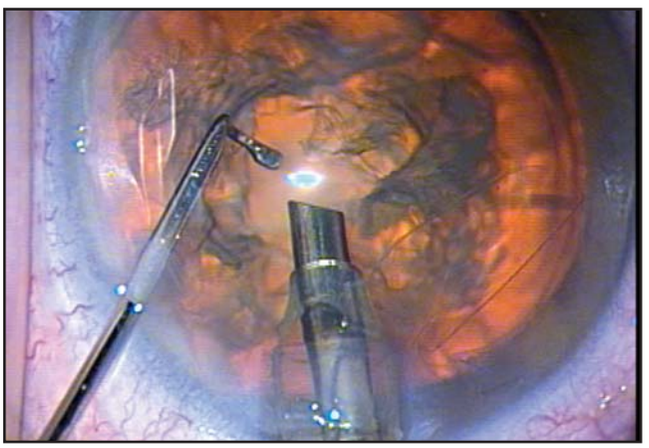

Fig. 2: Horizontal chopper tip is an elongated, modified microfinger - Chang combination chopper *(Katena, ASICO, Stronger)*

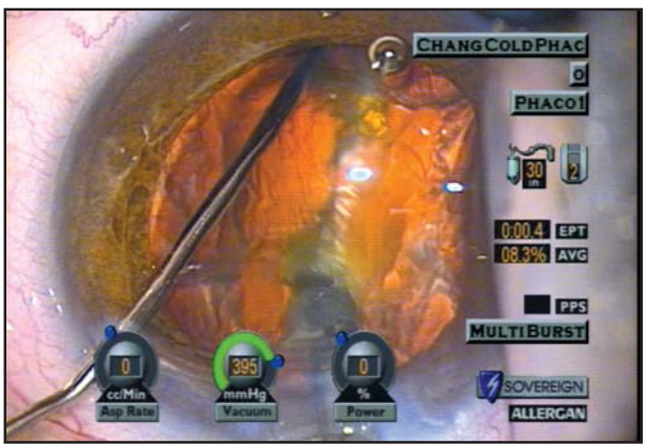

Fig. 3: Horizontal chopper hooks equator of a brunescent endonucleus. Phaco tip is impaled proximally with burst mode and high vacuum. The horizontal chopper tip maintains contact with the endonuclear surface as it moves peripherally beneath the capsulorhexis rim to the epinuclear space. The track made by this contact is visible.

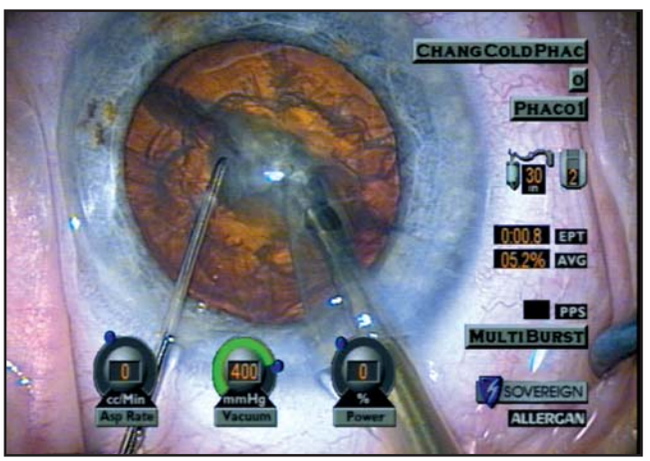

Fig. 4: Vertical chopper incises in front of the centrally impaled phaco tip (burst mode, high vacuum) to create the cleaving fracture.

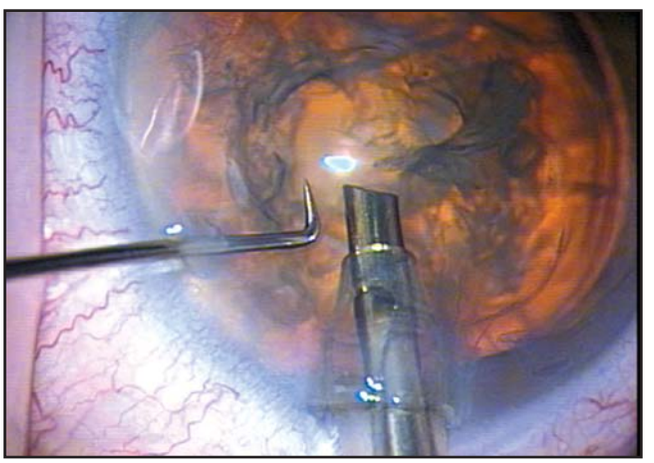

Fig. 5: Vertical chopper tip is very sharp to facilitate incising brunescnet nuclei - Chang combination chopper *(Katena, ASICO, Stronger)*

As an initial step, the central anterior epinucleus should be aspirated with the phaco tip. This helps the surgeon to better estimate the size of the endonucleus, and the amount of separation between the endonucleus and the capsular bag. The chopper tip touches the central endonucleus, and maintains contact as it is passed peripherally beneath the capsulorhexis edge **[Figure 3]**. This ensures that the tip stays inside the bag as it descends and hooks the endonucleus peripherally. Because the chopper tip drops into and occupies the epinuclear space, it does not overly distend or stretch the capsular bag fornix. Although not approved in the US, capsular dye improves visualization of the capsulorhexis for this step and is a useful teaching adjunct[3, 4].

Once it has hooked the nuclear equator, gentle palpating motions with the chopper can confirm that the tip is internal, and not external to the capsular bag. Next, the nucleus is deeply impaled with the phaco tip. The phaco tip should be directed downward and positioned as proximally as possible in order to maximize the nuclear mass sandwiched between the two instrument tips. The chopper tip is pulled directly toward the phaco tip, and upon contact, the two tips are moved slightly apart. This separating motion propagates the fracture across the entire nuclear diameter.

During execution of the chop, if the phaco and chopper tips are not kept deep enough, the maneuver will not succeed. The thicker and denser the endonucleus is, the deeper the chopper tip must pass. A tendency to ele-

vate the chopper tip during the chop results from a fear of perforating the posterior capsule. Instead of dividing the nucleus, the chopper tip will merely score the superficial nuclear surface.

The nucleus is rotated in a clockwise direction, and the same maneuver is repeated in order to create a pie-shaped fragment. This is elevated out of the bag using high vacuum. Once the first heminucleus has been chopped and evacuated, there is enough room to pull the second heminucleus to the center of the bag. The subsequent chops can then be performed with improved visualization, and without having to place the chopper tip beneath the anterior capsule.

Vertical Phaco Chop

With denser nuclei, a horizontal chopper must exert a greater compressive force in order to fracture the nucleus along its natural lamellar cleavage plane. In contrast, vertical chopping utilizes a shearing force to split the nucleus into pieces **[Figure 4].** The vertically chopped edges appear sharp - like pieces of broken glass - because there is no crushing force involved. Whereas a horizontal chopper moves centripetally inward from the periphery, the vertical chopper is used like a spike to impale downward into the nucleus just anterior to the centrally buried phaco tip. This action creates the fracture line that is propagated further posteriorly when the embedded instrument tips are moved apart. Common to all vertical chopper designs is a short, but sharpened tip that is able to penetrate the nucleus **[Figure 5**]. If the chopper tip is too dull, it will displace the fragment from the phaco tip, instead of incising into it.

The key to a successful vertical chop is to impale the phaco tip as deeply into the central nucleus as possible. Like spearing a potato, it must gain enough of a purchase to be able to lift the entire nucleus upward. By immobilizing the nucleus against the incoming sharp chopper tip, enough shearing force is generated to fracture the material. High vacuum is invaluable for vertical chop, where a maximally strong purchase is needed. With brunescent lenses, burst mode helps to maintain a tight seal around the phaco tip, which is a prerequisite for accessing high vacuum.

Comparing Chopping Techniques

In horizontal chop, sequentially removing each newly created fragment provides the chopper with increased working space within the capsular bag. Because there is no need to hook the equator with vertical chopping, I prefer to fragment the entire nucleus in-situ before removing any pieces when employing this method. Like interlocking puzzle pieces, the adjacent segments add stability to the portion being chopped.

Vertical chopping requires that the nucleus be brittle enough to be snapped in half. Therefore, horizontal chopping is better suited for the softer nucleus. I prefer vertical chopping for brunescent nuclei since it is more consistently able to fracture through the leathery posterior plate. In these cases, the chopper tip should approach the phaco tip from more of a diagonal angle. This contributes a slight horizontal vector force that compresses the nucleus against the phaco tip. However, if mobile brunescent pieces must be subdivided, horizontal chopping is more effective since this maneuver traps and compresses the fragment between the two instrument tips.

Horizontal chopping is also better suited for the highly myopic or vitrectomized eye. With the nucleus assuming a more posterior position, and with the phaco tip oriented nearly vertically downward, the ergonomics are more favorable for horizontal chop. I also prefer horizontal chopping when the zonules are extremely weak. In these situations, the compressive force of a horizontal chop is less likely to cause tilting or excessive movement of the nucleus.

Horizontal and vertical chopping are complementary variations employing different strategies, but providing common benefits. I utilize both chopping techniques routinely depending on the nuclear density. With dense lenses, I may employ both strategies during the same case, so I designed the Chang double-ended combination chopper (Katena, ASICO) to provide both tips on a single instrument. Detailed written and video instruction of both chopping methods appears in my recently released textbook on phaco chop with the accompanying teaching DVD[2].

References:

1) Chang DF: Converting to Phaco Chop: Why? Which Technique? How? Ophthalmic Practice 1999; 17(4): 202-210.

2) Chang DF: Phaco Chop: Mastering Techniques, Optimizing Technology, and Avoiding Complications. 2004, Slack, Inc.

3) Horiguchi M, Miyake K, Ohta I, Ito Y: Staining of the Lens Capsule for Circular Continuous Capsulorhexis in Eyes with White Cataract. Arch Ophthalmol 1998; 116: 535-537.

4) Melles G, de Waard P, Pameyer J, Beekhuis,W: Trypan Blue Capsule Staining to Visualize the Capsulorhexis in Cataract Surgery. J Cataract Refract Surg 1999; 25:7-9.

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