The Basics of Phaco Chop Techniques

Part 1: The principles of chopping, types of chopping, and the instruments used.

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The phaco chop technique was first described in 1993 by Kunihiro Nagahara, MD, at the American Society of Cataract and Refractive Surgery (ASCRS) Annual Meeting in Seattle, Washington, where his film Phaco Chop received an award. Phaco chop and its many variants subsequently revolutionized the approach to nucleus-fracture techniques in cataract surgery. This two-part article examines the basics of phaco chop techniques. In this first part, we summarize the principles of chopping, the types of chopping, and the technologies it entails. The second part will explore chopping techniques and how to pick the best approach based on case-by-case variables.

PRINCIPLES

Phaco chopping techniques take advantage of the natural cleavage planes of the lens to divide the nucleus using minimal mechanical forces instead of ultrasound energy. The main benefits of the technique are twofold: (1) reduction of total ultrasound energy and phacoemulsification time and (2) decreased stress on the zonules.

If we consider a wooden log, there are two strategies to cut it in half. The first method consists of sawing the log transversely until the last connection bridge is cut. Alternatively, the piece of wood can be placed vertically and chopped longitudinally with an axe. If the initial split involves more than 50% of the section, the cleavage plane can be extended through the remainder of the log by mechanically pushing the two sections apart.

This wood-chopping analogy illustrates the main difference between the two most popular nucleofractis techniques, divide-and-conquer and chopping. The divide-and-conquer technique requires sculpting a deep groove to achieve a nucleus fracture, similar to the transverse sawing of the log. Chopping, however, achieves a complete fracture by the mechanical extension of an initial split through the nucleus using minimal mechanical force, the same way the initial breach of an axe is propagated through the remainder of the wood by prying the two sections apart.

Chopping takes advantage of the natural cleavage planes of the lens (Figure 1). Because mechanical energy is applied parallel to the lens lamellae, little force is needed to obtain the first split, and this initial breach easily propagates through the remaining nucleus, like chopping a log with an axe. Mechanical forces replace ultrasound energy, and, in contrast to divide-and-conquer, centripetal forces replace centrifugal ones.

CLASSIFICATION

Many variations of chopping have since been described; however, all of them are modifications of one of two concepts. For simplification, David F. Chang, MD, proposed a classification into two main categories, horizontal and vertical. Both techniques share the chopping principle of being able to fracture the nucleus mechanically, but they achieve this objective in different ways.

Horizontal chop. In this technique, the chopper moves toward the phaco tip in the horizontal plane, as in the original technique described by Nagahara (Figure 2A). Vertical chop. Here, the chopper and the phaco tip move...
toward each other in the vertical plane to induce the fracture (Figure 2B).

Paul S. Koch, MD, described a hybrid technique called stop and chop, in which a deep groove is sculpted across the nucleus to divide it in half. Chopping is then performed in each of the two halves to further divide them. Finally, the term prechop was coined for techniques in which the phaco tip is replaced by other instruments during nucleus fracture: the Akahoshi technique, the preslice technique, and, more recently, the ultrachopper technique. The techniques used in performing these chopping variants will be explored in more detail in the second part of this article.

ADVANTAGES AND DISADVANTAGES OF CHOPPING

Phaco chop has important advantages over divide-and-conquer that have contributed to its popularization, despite its being a more difficult technique. Phaco chop takes advantage of the natural cleavage planes that exist within the nucleus to fracture it in several fragments with minimal energy. Compared with sculpting, the advantages of phaco chop include the following:

- Reduced phaco power and time, saving ultrasound energy;
- Decreased stress on the zonules, which is particularly important in cases of zonular weakness (because the nucleus is held by the phaco tip, it receives all of the stress induced by surgical maneuvers); and
- Less reliance on the red reflex.

In divide-and-conquer techniques, the nucleus is held and fixed by the capsular bag and the zonules, so the centrifugal forces induced by the sculpting of the nucleus are transmitted toward them. Any movement of the nucleus induces stress on the zonules, particularly in hard cataracts without epinucleus. In contrast to these techniques, mechanical forces during chopping are centripetal because it is the phaco tip element that fixates the nucleus. The zonules do not, therefore, receive the stress of the process.

Another minor advantage of chopping is that surgery time is shorter, particularly in hard cataracts. Additionally, the technique is less dependent on the red reflex because there is no need to judge the depth of the groove. Finally, grooves are difficult to accomplish in eyes with small pupils, whereas vertical chop in particular can be safely performed in the central 3 to 4 mm of a constricted pupil.

In summary, phaco chop is more efficient than divide-and-conquer in routine cases. Additionally, it is particularly helpful in complicated cases with hard nuclei, small pupils, or zonular weakness. The annual Learning surveys of preferred practice patterns reflect the increasing popularity of this technique.3,4

The disadvantages of chopping are easily addressed because they are rooted in the learning curve. The performance of phaco chop requires expert understanding and management of fluidics and an effective phacoemulsification platform. The surgeon must understand and properly use the parameters of his or her platform; during chopping, high vacuum and flow rates are used together with power modulation in burst mode to impale the nucleus. It is a more demanding technique, requiring skill in the use of the footpedal and both the right and left hands.
CHOPPERS AND PHACO TIPS

The chopper plays an important role in chopping. Many variations of choppers have been developed, but they can be classified into two main categories, depending on the technique for which they were developed: (1) choppers with horizontal action and (2) choppers with vertical action.

All choppers share a general structure. They consist of a handle, which is similar for all types, and a distal portion with a tip that is 1 to 2 mm long and angled 90°. The shape of the tip varies depending on the technique for which it was designed, and the choppers are named accordingly.

Horizontal choppers. The tip of a horizontal chopper (Figure 3A) should be approximately 1.25 mm to 2.00 mm in length to embrace the lens equator. If the chopping maneuver is too superficial, the nucleus will not be completely fractured. For hard cataracts, a chopper with a 2-mm tip should be used. The inner surface of the shaft must have a sharpened edge to cut the nucleus during the movement of the chopper toward the phaco tip, which is impaled in the center of the nucleus. The tip is angled 45° in relation to the remaining distal portion so that the inner cutting edge faces the phaco tip—this detail explains the need to design choppers for both right- and left-handed surgeons. Because of the angle of the tip, the paracentesis must be performed 45° away from the main incision so that the position and movement of the chopper do not induce any distortion of the paracentesis. Additionally, the very end of the tip must be dull, or even olive-shaped, to protect the capsular bag.

Vertical choppers. Vertical choppers are simpler than horizontal models. A long tip is not required because the instrument does not have to penetrate the nucleus completely and, in contrast to the dull distal end of a horizontal chopper, the end of a vertical chopper must be sharp to penetrate the nucleus easily. The longest and sharpest choppers, such as the Chang, Nichamin, and karate (Figure 3B), are intended to be used in the hardest nuclei, whereas the shortest and less sharp models, such as the Rosen (Figure 3C), are to be used in routine cases.

Phacoemulsification tips. Phaco tips can be classified according to caliber, tip angle, bevel position, bevel angle, and shape of the distal end. They may incorporate an aspiration bypass system to decrease surge. Any phaco tip can be used given the proper parameters, which differ according to the characteristics of the tip.

The role of the phaco tip during chopping maneuvers is to fixate the nucleus while the chopper divides it. The force with which the tip grasps the nucleus is proportional to the vacuum and to the transverse surface area of the tip ($F = V \times S$). With modern phaco platforms, which are able to create vacuum levels as high as 600 mm Hg, proper fixation can be accomplished with 0.90-mm diameter tips. Flared tips increase the surface area, and parameters should be adjusted to prevent occlusion. Angled tips (Kelman) are more convenient for chopping. A small bevel angle facilitates occlusion; however, the surface area increases proportionally with the angle of the bevel, and an increased bevel angle is compensated for by the tip angle.

The type of ultrasound energy delivery—whether conventional, longitudinal, torsional, or transversal—must also be taken into account when choosing the tip. The efficiency of torsional energy is optimized with the use of Kelman tips with a 45° bevel. The key point is to place the bevel parallel to the surface that is to be divided, thereby obtaining effective and rapid occlusion. With other types of energy, the 30° bevel tip is more efficient for achieving occlusion.

In the second part of this article, we explore the techniques used in phaco chopping and discuss the reasons to prefer one technique over another in particular cases depending on the type of cataract and other variables.

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