Advanced Phaco Techniques

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Divide And Conquer

In 1986 I coined the term "Divide and Conquer" for my technique of in-situ phacoemulsification, which derives from the Latin *"Divide et Impera".* These techniques evolved because of my observation that a cataract that has been systematically divided and fragmented, rather than impaled by the phaco tip in a random fashion, is more easily conquered. To describe this fashion of fracturing or fragmenting the nucleus into pieces, I coined the term "Nucleofractis", which comes from the prefix *"nucleo"* (nucleus) and the Greek suffix *"fractis"* (to fracture). Divide and Conquer Nucleofractis (DCN) now describes my technique of phacoemulsification.

This radial fracturing of the lens, as well as its lamellar separation by hydrodissection into nucleus, epinucleus, and cortex, is somewhat analogous to other objects in nature. For example, a log can have many lamellar separations of bark and annular rings corresponding to the cortex and the epinucleus being separated by lamellar hydrodissection. However, the core of the log is also split with radial fractures, many of which are seen as natural cleavage planes as the wood dries. Likewise, the watermelon has radial as well as circumferential cleavage planes.

When sculpting through the nucleus of the cataract, one often can see the natural radial cleavage planes in the nucleus of the lens corresponding to the Y-sutures seen on slit-lamp examination. While the radial fractures often follow these natural cleavage planes, the instruments can easily create other radial cleavage planes.

The differing densities of cataracts have spawned two different methods of sculpting that I use as broad variations of DCN.

Trench Divide And Conquer (Tdc) Nucleofractis

(Employed in soft to moderately hard nuclei)

After nudging the lens inferiorly with the second instrument, the technique starts with a trench sculpted to just past the center of the lens surface. This "down slope" sculpting is accomplished directly parallel and close to the posterior capsule. More on this method later. With the instrument tips deep in the center of the lens, a fracture can be obtained very easily and early.

The "down slope" technique is used to sculpt the majority of the upper part of the lens and employing the bimanual technique again, a second crack is made. Following the removal of the isolated pie-shaped section of nucleus, a third crack is made. The remaining piece of nucleus is subsequently fractured and emulsified.

Down-Slope Sculpting

The key to down-slope sculpting is to nudge the lens inferiorly with the second instrument and to sculpt very deep centrally. Although sculpting is completed very deep, one avoids impaling the capsule as nuclear material is always ahead of the tip. Down-slope sculpting thus facilitates sculpting to the posterior pole where the instruments can be held to obtain the first fracture.

Fracturing can follow a number of patterns, including the standard trench method, which can be followed by the creation of an L-shaped fracture. An alternative method is to first create a horizontal fracture thereby facilitating a similar L-shaped split.

Down-slope sculpting has made any pre-grooving of the lens unnecessary in all but very dense nuclei. One simply needs to get deep into the center to fracture through the radial fault lines of the lens. With traditional sculpting techniques, the deepest part of the sculpting will end up inferiorly to the center of lens. If one rotates the lens 90 degrees with each quadrant's sculpting, the plate of nuclear material deep in the center or posterior pole of the nucleus will impede complete fracturing to the center and the sections will tend to hang together at the center. However, with down-slope sculpting, complete and efficient fracturing and subsequent emulsification can be accomplished by sculpting deep and fracturing through the entire posterior plate of the nucleus.

Multidirectional Divide ad Conquer (Mdc)

Down-slope multidirectional nucleofractis is begun by debulking the superior part of the lens. The technique usually involves a trench or a trough sculpted slightly to the right of the lens at the center. Nudging the nucleus inferiorly with the second instrument, down-slope sculpting is accomplished sculpting very deeply to the posterior pole of the lens. By nudging the lens inferiorly with the second instrument the upper central part of the nucleus can be sculpted very deeply, to the point of sculpting directly parallel and close to the posterior capsule. This allows the phaco tip to remove more of the upper part of the nucleus during sculpting and to reach the posterior pole of the lens very early for effective fracturing. With the lens nucleus nudged towards the 6 o'clock position the surgeon can sculpt very deeply down the slope of the posterior curvature of the upper part of the capsule.

The Kelman tip works very well for this side-to-side movement getting a deep groove horizontally. The phaco tip is then used to stabilize the upper portion while the spatula pushes inferiorly against the wall, creating a horizontal fracture. A vertical fracture is then created by pushing to the right of the vertical trough with the phaco tip and to the left with a spatula.

Crater Divide and Conquer (Cdc) Nucleofractis

(Employed in moderately hard to very hard and even dense, brunescent nuclei)

In dense and brunescent cataracts, nucleofractis is facilitated by emulsification of a deep and wide central crater of nucleus. Using the cyclodialysis spatula and the phaco tip, the resultant peripheral nuclear rim is fractured. The nucleus is rotated and a second fracture is made. The section is left in place, insuring stabilization of the nucleus and capsule. The remaining "donut" of nucleus is systematically fractured using the bimanual technique. Individual sections are brought into the center for emulsification. Alternatively, the first section may be isolated and emulsified to allow space for subsequent fracturing.

Phaco Sweep

Another variation on the theme of "Nucleofractis" is a technique I call phaco sweep. In traditional sculpting techniques the phaco probe is moved from the superior to the inferior portion of the nucleus to create a groove. By using the phaco probe in a lateral motion (nasal to temporal and back again) the central nucleus can be sculpted quickly and deeply while maintaining constant visualization of the tip of the instrument. I prefer to use a 30-degree Kelman phacoemulsification tip to perform phaco sweep. With this tip, the removal of lens material is more efficient and easier to perform. However this technique is also possible with standard straight tip phacoemulsification handpieces. This difference can be explained on the basis of a three dimensional propagation of the ultrasound wave front from the bent Kelman tip. Standard handpieces tend to direct their ultrasound power primarily in the forward direction, somewhat limiting their cutting efficiency for this technique.

As sculpting proceeds to deeper layers the phaco tip is moved in a lateral sweeping motion. It is important to avoid occlusion of the tip during this procedure. The lens is stabilized inferior to the groove with a second instrument through the paracentesis. After lateral sculpting is sufficiently deep, a horizontal fracture is created as the upper portion of the nucleus is stabilized with the phaco tip while the second instrument pushes against the inferior wall of the groove. Multidirectional nucleofractis may then proceed after the nucleus has been rotated 90 degrees, to create multiple wedge-shaped sections. These pieces are then emulsified within the central pupillary zone. Phaco sweep is a variation of down slope sculpting which enhances visualization of the phaco tip and results in increased safety for the removal of central nuclear material. In addition, the motion of the probe remains parallel to the posterior capsule, diminishing the risk of its inadvertent rupture.

Polar Expeditions

Deep sculpting of the posterior pole of the lens facilitates the fracturing of the nucleus because it provides for safe and efficient segmentation, and removal of the nuclear segments by taking advantage of the natural fault lines of the lens. The natural lens has lamellar planes that lend themselves to hydrodissection and hydrodelineation, but lens fibres are oriented in a radial fashion, creating the familiar Y suture lines. It is these radial bulk lines that one can take advantage of in nucleofractis techniques.

Deep sculpting allows one to obtain mechanical advantage required to effectively fracture through the entire lens. After hydrodissection and hydrodelineation one attempts to fracture the hard nucleus through its entirety. The expedition to the posterior pole can be accomplished with forward sculpting or phaco sweep lateral sculpting to thin the posterior plate before fracturing is attempted. Once having reached the posterior pole, the segments fracture very easily with the two-handed technique even without a phaco chop instrument because the segments are small. When the lens material is brunescent then the phaco chop instrument is used to fracture these segments in the crater chop technique. Deep central sculpting is recommended in these dense nuclei even with crater chop so that the segments are smaller and more easily managed.

A second instrument is used to manage the segments to keep them down within the lens and from floating up to the cornea. The Kelman microtip with the Makool sleeve is very efficient for the removal of epinucleus. The vacuum and aspiration flow rate are reduced for epinucleus removal when doing irrigation aspiration. I use surgeon control of aspiration which allows one to grasp the material at low vacuum, and efficient control of lens material when engaged by the port.

The sculpting should be deep enough to be right through the nucleus into the epinucleus. The bent Kelman tip facilitates this deep sculpting. The parameters for the Legacy with the Makool system are as follows: ultrasound power is

40% for sculpting, and 50 to 60% for segment removal, and then 40% again for epinucleus removal. Aspiration flow rate varies in foot position 2 and 3, from 23 - 27 cc a minute and the vacuum is 250 - 340 mmHg for the nucleus removal, and only 210 for epinucleus removal.

Down-slope sculpting toward the posterior pole is used for the multidirectional divide and conquer technique. The upper part of the nucleus is removed, and then with phaco sweep polar expedition involves sculpting of the posterior pole before the horizontal fracture. The lens is stabilized and nudged inferiorly, and the sculpting is done with forward passes until one is deep in the lens. Then phaco sweep is used to delicately sculpt through the deepest part of the nucleus to the epinucleus before the horizontal fracture is made.

This horizontal fracture is a combination of separation, and sheering. The second instrument pushes toward the 6 o'clock, and the phaco tip pushes down and away so that these opposing forces result in the splitting of the nucleus as the horizontal fracture. Then the multidirectional fracturing is accomplished without rotating the lens. With the natural fault lines in the lens, this can be accomplished very easily without the chopping technique through the use of two-instrument separation. The fracturing is enhanced by not only separation but again by sheering (pushing down on one segment) down and away so that it is two planes. The upper hemisection can be rotated 180 degrees for similar fracturing, or it can be simply slid down into the central part of the capsule and approached from the equatorial side, and fracturing accomplished.

In trench divide and conquer, polar sculpting is limited to a central trough or trench. This works best in a very soft nucleus where one has to maintain most of the nuclear which is firm enough to fracture. The nucleus is nudged slightly inferiorly and stabilized with the second instrument. Then the polar expedition for the posterior pole of the lens begins. The trench has to be wide enough to allow the phaco sleeve to get down into the nucleus. Once deep enough, the fracture is obtained with the two instruments. The segments are broken away, similar to the other nucleofractis techniques. Once the fracture is through the posterior plate of the lens the fractured segments fracture completely without being tied together at the apices, and small segments are easier to manage than large segments. Only low ultrasound power is necessary for these small nuclear segments to be emulsified. With the new technology of the Alcon Series 2000 and the Makool system microtip and max vac cassette the chamber remains deep and stable with the lack of postocclusion surge. The different memory settings on the machine also allow one to quickly change from one parameter to another.

Challenges of Phaco

Small Pupil

The most important goal in small pupil cataract surgery is to limit serious surgical complications. Relatively complication-free surgery in small pupil cases can be achieved with phacoemulsification techniques. These techniques also help to attain other goals such as the use of a small incision, the minimal use of pupil enlarging surgery, and certain verification of in-the-bag placement of a posterior chamber intraocular lens. This placement, verification, long-term stability, and centration can be virtually assured by obtaining and maintaining a continuous curvilinear capsulorhexis opening in the anterior capsule. The lens nucleus, even though dense and large, can be fractured into small segments and removed by emulsification through relatively small capsule openings, small pupil openings, small scleral incisions and small conjunctival incisions. These are important considerations in many glaucoma patients who have small pupils from long term miotic therapy and who have had or may in the future require filtering surgery.

I developed the down-slope sculpting method in small pupil cases to quickly reach the posterior pole of the nucleus for efficient fracturing. The lens is nudged inferiorly, using a second instrument and the phaco tip sculpts down the concave posterior capsule towards the posterior pole, parallel to the capsule as opposed to perpendicular to it. Once the pole is reached the two instruments are held deep in the center. The spatula pushes inferiorly while the phaco tip pushes superiorly to create a horizontal fracture. The two instruments are repositioned to create a vertical fracture. The fractured segments can remain in the bag to stabilize it or be removed piece by piece. The second instrument holds back segments while other segments are emulsified in the center of the lens. As well, the spatula brings nuclear material to the phaco tip to be emulsified. The phaco tip itself, stays mainly in the center of the lens. Once the inferior hemisection has been emulsified, the superior hemisection can be brought up to the center of the lens with the second instrument, and further fractures can be created.

Small pupil cases demonstrate the distinct advantage of nucleofractis techniques in that the phaco tip does not have to be put under the iris or under the small openings in the capsule, and there is little risk of iris or capsule flowing unexpectedly with the lens material into the tip of the phaco port. One should use a lower flow when the pupil is small. This may reduce efficiency, but certainly increases safety. Again, epinuclear material is brought to the phaco port using the second instrument. The phaco port itself does not go searching for this material in a small pupil case.

Intumescent Lens

The nucleus in an intumescent lens can be safely and efficiently fractured and phacoemulsified using my down-slope sculpting technique. In intumescent cases with primary, small capsulorhexis openings, the nucleus is nudged inferiorly with a second instrument. The upper portion of the nucleus is sculpted very deeply because the sculpting is done parallel rather than perpendicular to the posterior capsule. This nudging manoeuvre allows the phaco tip to get very deep onto the nucleus for subsequent fracturing. The phaco tip should be maintained centrally to avoid stress on either the can small capsulorhexis rim or a can-opener margin. Mechanical stress to the ring of the can opener with the use of the phaco handpiece, or by a second instrument, should be avoided. This is where the down-slope sculpting nucleofractis is advantageous for safe emulsification, because the phaco tip always stays in the center of the lens. The second instrument is used to rotate, manoeuvre, and help fracture the nuclear rim.

The depth of the sculpting is quite easy to gauge in an intumescent lens due to the whiteness of the nucleus and the red reflex exposed during fracturing. In doing phacoemulsification out near the periphery or up near the capsule in the epinucleus, low flow and low vacuum should be used so that a sudden breakthrough with a high flow and high vacuum can be avoided. This will avoid engaging the equatorial capsule with the phaco tip. He intumescent lens is usually easy to fracture and quite often the lens will fracture spontaneously just with the attempt at rotation.

Series 2000 Legacy Parameters

	SOFT CATARACT Memory 1		**TRENCH DIVIDE MULTI DIRECTIONAL Memory 2**		**CRATER CHOP Memory 3**		**CORTEX REMOVAL**	
Mode	**U/S**	**U/S Pulse**	**U/S**	**U/S Pulse**	**U/S**	**U/S Pulse**		
U/S Power %	40	50	50	60	70	70	Asp. flow rate	60 cc/min
U/S Pulse rate	N/A	0	N/A	0	N/A	0	Vacuum	500 mmHg
F.P. 2 cc/min	12	17	20	23	23	26	Bottle Height	65 cm
F.P. 3 cc/min	12	21	24	27	27	30		
Vacuum mmHg	0	70	150	150	160	160		
Bottle height cm	72	72	75	75	75	75		
Footswitch control	Soft	Soft	Soft	Soft	Soft	Soft		

Microtip Memory Parameters (2.7 mm incision)

Program	**Memory 1**	
Mode	**U/S**	**U/S Pulse**
U/S Power %	40	50
U/S Pulse rate	N/A	0
F.P. 2 cc/min	20	17
F.P. 3 cc/min	24	21
Vacuum mmHg	190-210	70
Bottle height cm	75	75

Further Reading

1. Gimbel HV. Divide and conquer nucleofractis phacoemulsification: Development and variations. J Cataract Refract Surg 1991, 17: 281-291.
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3. Gimbel HV. Continuous curvilinear capsulorhexis and nucleus fracturing: evolution, technique, and complications. Ophthalmology Clinics of North America 1991, 4: 235-249.
4. Gimbel HV. Nucleofractis through a small pupil. Can J Ophthalmology 1992, 27: 115-119.
5. Gimbel HV. Down slope sculpting. J Cataract Refract Surg 1992, 18: 614-618.
6. Gimbel HV. Evolving Techniques of cataract surgery: Continuous curvilinear capsulorhexis, down slope sculpting and nucleofractis. Seminars in Ophthalmology 1992, 7: 193-207.
7. Gimbel HV, Chin PK: Phaco Sweep. J Cataract Refract Surg 1995, 493-496.