Crack and flip phacoemulsification technique

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ABSTRACT

The crack and flip phacoemulsification technique combines the advantages of circumferential division of the nucleus and nucleofractis techniques. As such, it adds safety and control to the procedure. We describe each of the surgical maneuvers, including machine settings, and explain the rationale for maneuvers and machine settings.

Key Words: capsulorhexis, chip and flip, cortical cleaving hydrodissection, cracking, epinucleus, grooving, phacoemulsification

The crack and flip phacoemulsification technique is a systematic approach to endolenticular phacoemulsification for nuclei of all densities, other than the most soft. It combines cortical cleaving hydrodissection[1] with maneuvers from the chip and flip phacoemulsification technique[2] and in situ fracture technique.[3] By combining the advantages of sectoral and circumferential division of the nucleus, this technique provides added safety and control during endolenticular phacoemulsification.[4]

MATERIALS AND METHODS

Incision

A sideport incision is made to the left two to three hours from the phaco incision; aqueous is replaced by viscoelastic (Figure 1). Three different incision techniques are routinely used. The self-sealing corneal tunnel incision[5] from the temporal approach, used routinely by one of us (I.H.F.), eliminates conjunctival incisions, cautery, and scleral dissections and thereby eliminates bleeding. It also facilitates the use of topical anesthesia and seems to be astigmatism neutral. In this technique, the surgeon uses a 3 mm wide diamond knife, which makes a uniplanar beveled incision temporally starting at the anterior edge of the corneal vascular arcade and proceeding for 2 mm centrally before entering Descemet's membrane (Figure 2). A standard scleral tunnel incision from the 12 o'clock position is per-

formed routinely by Dillman.[6] The scleral tunnel approach, used by Maloney,[7] is called the universal small incision.

Cortical Cleaving Hydrodissection and Hydrodelineation

Cortical cleaving hydrodissection dramatically improves the maneuverability of the nucleus, allowing it to rotate freely and easily within the capsular bag. If this does not occur, hydrodissection should be repeated. This technique, designed to cleave capsular cortical connections rather than nuclear cortical connections, leaves most of the cortex attached to the epinucleus.[1]

After cortical cleaving hydrodissection, hydrodelineation is performed by placing the same 26-gauge cannula used for hydrodissection deep into the nucleus until resistance starts to move the nucleus. The cannula's direction is then changed to tangential and a tract is created within the nucleus.

Balanced salt solution is injected when the needle is withdrawn nearly to the entrance to the tract so that the fluid flowing into the tract can find the plane of least resistance and circumferentially traverse the nucleus in that plane. This creates an epinuclear shell surrounding a more compact central nuclear mass. The delineation usually results in a golden ring or a dark circle, but it may sometimes only occur segmentally and an arc of the circle will be seen, in which case additional injections at the end of the arc will be required. Cortical cleaving hydrodissection ensures easy nucleus rotation and ac-

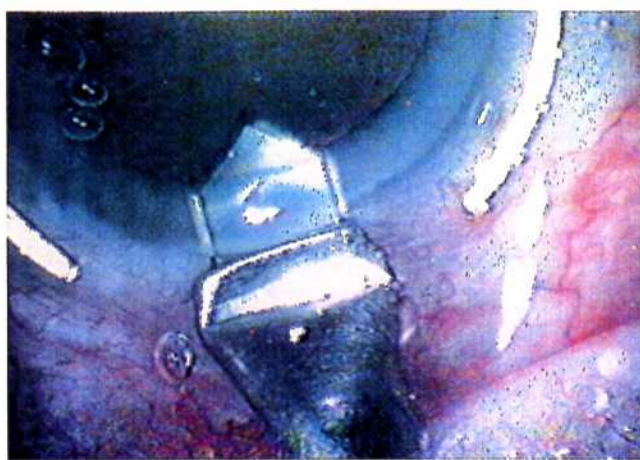Fig. 1. (Fine) The sideport incision.

Fig. 2. (Fine) Diamond blade within corneal tunnel incision.

cess to the end of the arc for repeated hydrodelineation injections.

After circumferential division, the same cannula is used to rock the nucleus' central portion within the epinuclear shell, further cleaving the nuclear epinuclear interface and rupturing any residual connections between these two masses. This makes removing the quadrants easier after cracking.

There are many advantages of circumferential division of the nucleus into a hard central mass and an epinuclear shell. The central mass of nucleus to be emulsified can be reduced by as much as 50%. As a result, grooving is less peripheral and less deep than in other cracking procedures and it creates smaller, bite-sized quadrants after cracking that are much easier to emulsify than larger ones. The epinucleus keeps the capsular bag on a stretch throughout the procedure, making it less likely that a portion of the capsule will come forward, occlude the phaco tip, and rupture. The epinucleus contains all of the phacoemulsification and the mechanical forces of cracking within cushioned space, thereby minimizing potential injury to the posterior capsule, capsular fornices, and endothelium.

Grooving

The grooving process has much in common with sculpting in other phacoemulsification techniques. However, certain principles should be adhered to for optimal function. It is important to stay in foot position 2 or 3 throughout the procedure to stabilize fluid dynamics and avoid trampolining of the anterior chamber with its attendant amoeboid iris movements, which may cause intraoperative miosis. Similarly, one should avoid bringing instruments in and out of the eye once the procedure has begun.

The grooving should be a shaving technique. Tip occlusion can damage the posterior capsule during grooving. Low flow, adequate only for tip cooling, is used during grooving because the shaving technique

creates nuclear sand that easily flows through the aspiration port of the phaco tip at very low flow rates. We prefer flow rates of 15 ml/min to 20 ml/min with peristaltic systems and a low vacuum setting on Venturi (Storz [Premier], St. Louis, MO) and diaphragmatic systems; approximately 30 mm Hg to 50 mm Hg. The vacuum on peristaltic systems is set at 115 mm Hg, but this is not achieved during grooving because occlusion of the tip is avoided. The power is set on surgeon control or linear mode.

The procedure starts centrally and the first groove is made toward 6 o'clock (Figure 3). It is important to stay central (i.e., sculpting can take place entirely within the central compact mass) and avoid actually reaching the golden hydrodelineation ring during sculpting. As one groove is completed, the nucleus is rotated clockwise 90 degrees and the next groove is started. The grooves are deep enough so all the horizontal striations within the trough have been removed, indicating that the surgeon has passed through the nucleus' hardest central portion. In general, the first and second tracts have to be redeepened because the nuclear mass between the center of the nucleus and the incision prevents going deep enough until these areas of the nucleus have been grooved and allow the phacoemulsification tip shank to recede deeply.

For hard nuclei, it is important to use countertraction with the second handpiece, holding the nucleus in position as one grooves. If this maneuver is not used, the hard nucleus moves a lot and stress is put on the zonules when the nucleus moves away from the incision and when the surgeon must press down on the nucleus to try to purchase nuclear material for traction. Countertraction dramatically reduces phacoemulsification time of hard nuclei (P. Crozafon, M.D., personal communication, March 4, 1992). Grooving is customized for each nucleus. Depth of shaving, rate of movement of the phaco tip in the groove, and power are optimized by
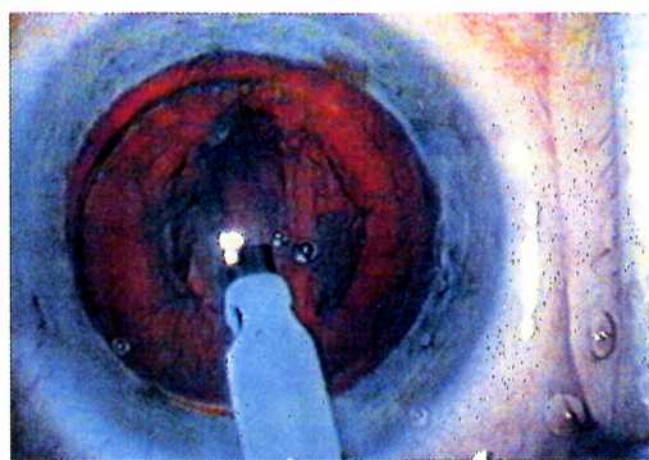
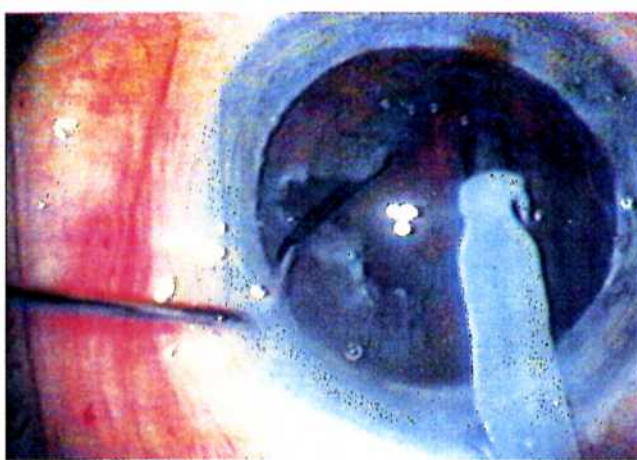Fig. 3.   (Fine) Nucleus being grooved central to the hydro-delineation demarcation circle.

Fig. 4.   (Fine) Cracking the distal groove.

responding to the hardness of the nucleus, rate of consumption of nuclear material, and efficiency of cutting and emulsification by the phaco tip.

Cracking

Many techniques indicate that grooving must be deep for cracking to occur.[3] It is impossible to tell the percentage of depth achieved when grooving unless the groove goes completely through the nucleus. Other clues to achieved depth include the smoothing of striations in the groove, brightening of the red reflex, and the comparison of the depth of the groove to the 1 mm phaco tip. Depth testing is possible because the concept that the nucleus must be sufficiently deeply grooved to crack has a corollary; that is, if the nucleus does not crack, it is safe to groove more deeply. If the surgeon thinks he or she has sculpted deeply enough to crack and if cracking does not occur with reasonable intraocular forces, redeepening is safe.

Cracking is best done after four grooves are placed dividing the nucleus into quadrants; this facilitates rotation before cracking because the central mass remains one piece. Once cracking has occurred in any of the grooves, the other grooves need only be as deep as the initial groove, which can usually be ascertained visually.

There are two basic methods of cracking. In cross-action cracking, the groove to be cracked should be perpendicular to the second handpiece to maximize forces. The phaco tip is put into the groove and pushed to the left (if the surgeon is right-handed) while the second handpiece is put into the groove perpendicular to the groove and pressure is placed against the opposite wall of the groove with the second handpiece. The nucleus can then be rotated and this maneuver repeated in each of the three remaining grooves.

In parallel cracking, the groove is lined up with the point midway between the main incision and the side port. The second handpiece should be laid deep within the groove and the phaco handpiece laid on top of that.

Then the handpieces are moved away from each other in a parallel position, resulting in easy cracking. The nucleus can be rotated so that each groove can be aligned and cracked in exactly the same manner.

Nonrotational cracking can be done by combining these techniques so that after grooving each groove can be cracked by placing the two instruments in it so that either parallel or cross-hand cracking can be done within the nucleus without further rotation (Figures 4 to 6). As the surgeon becomes more skilled in cracking, maximizing cracking forces by orienting the grooves is not necessary. When there is a tear in the capsulorhexis, nonrotational cracking helps the surgeon crack the nucleus without extending the tear. This can only be done by cracking in locations that do not stress the tear. If grooving was contained centrally and did not reach the epinuclear shell, then the cracking process will extend only to the hydrodelineation circle and will leave the epinucleus entirely intact.

Quadrant Removal

After cracking, the phacoemulsification unit is placed in pulse mode (10 pulses/sec), which alters the balance between the repulsive action of vibration and the attractive action of flow in the direction of increased attraction of nuclear material to the phaco tip. For peristaltic pumps, the vacuum is set at a high level (115 mm Hg to 125 mm Hg) throughout the procedure but because occlusion does not occur in grooving, the vacuum is never achieved. After cracking, the flow is increased to 20 ml/min to 25 ml/min. The increased flow helps bring the fragments to the phaco tip. In Venturi and diaphragmatic pump systems, the vacuum is turned from its lower level during grooving to a higher level during removal of the quadrants—from 70 mm Hg to 100 mm Hg. The higher vacuum allows a stronger attraction of the quadrants to the phaco tip.

The quadrants are removed in a systematic manner by working on the quadrant in the 5 o'clock position if

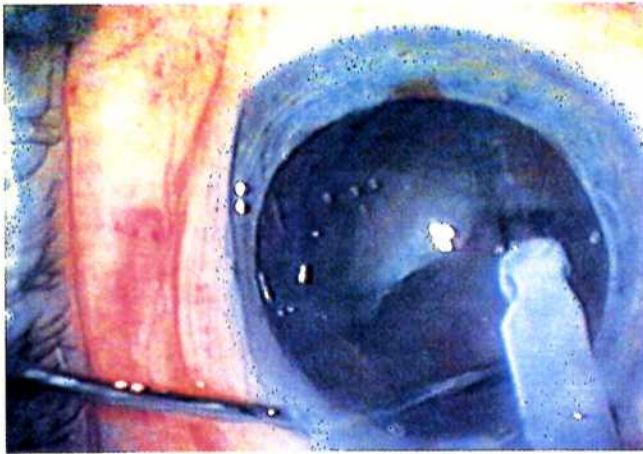Fig. 5.   (Fine) Cracking the right groove.

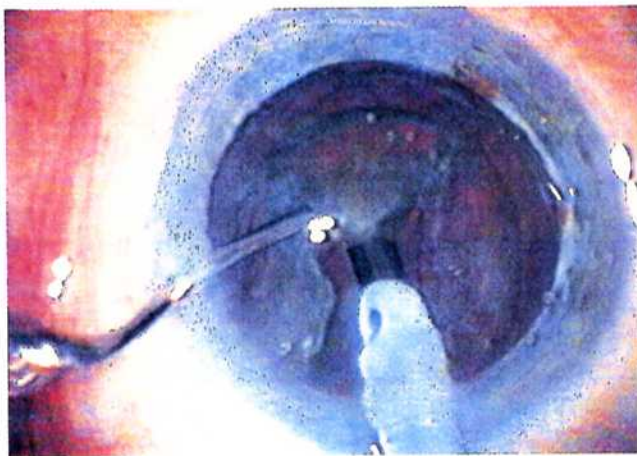
Fig. 6.   (Fine) Cracking the left groove.

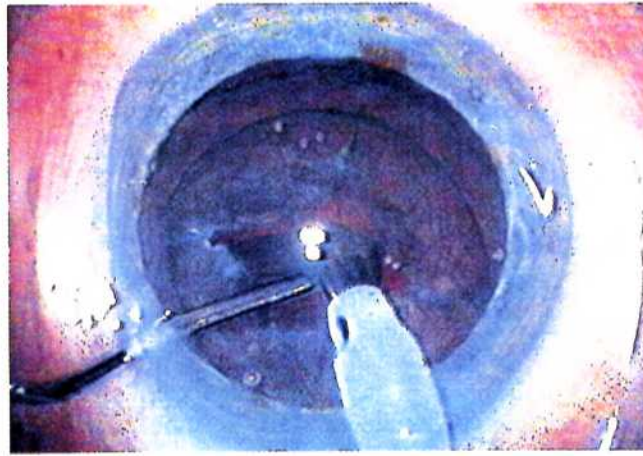Fig. 7.   (Fine) Elevating the apex of the quadrant by rotating its blunt periphery down.

Fig. 8.   (Fine) Using a second handpiece to keep the quadrant within the epinucleus.

working from 12 o'clock or in a corresponding position if working from the temporal periphery. Pressure by the second handpiece is brought against the upper aspect of the quadrant's apex, rotating the blunt periphery of the quadrant down and elevating the quadrant's sharp apex (the only portion of the quadrant that may be a threat to the posterior capsule).

Once the apex is elevated, it is engaged deeply within the epinuclear shell by the phaco tip (Figure 7). The second handpiece is brought under the tip to support it until tip occlusion occurs. As occlusion occurs, the quadrant is brought toward the middle of the epinuclear shell and the tip is kept in occlusion. The second handpiece can be used to hold the quadrant down, to mash it toward the phaco tip, or to crack it into eighths. Once the quadrant is broken through by the phaco tip, the second handpiece holds the remaining fragments deep within the epinucleus and then they are sequentially removed by the phaco tip from within the epinuclear shell (Figure 8). The remaining quadrants are rotated to

bring another quadrant to the distal position for removal in the same manner.

Each quadrant is sequentially removed in this manner, working in the central portion of the epinucleus distal to the incision. Every attempt is made to keep a quadrant or any of its fragments from coming up into the anterior chamber. After removal of the quadrants, an empty but intact epinuclear shell remains (Figure 9).

Epinuclear Shell and Cortex Removal

The surgeon uses the phaco handpiece to engage by occlusion the distal roof of the epinucleus in foot position 2 and to pull the rim toward the center of the capsule at the capsulorhexis level (Figure 10). The roof and the rim of the distal portion of the epinucleus are removed with aspiration or low powers of phacoemulsification, and the epinucleus is then allowed to fall back completely within the capsular bag. It is rotated 180 degrees and the same maneuver is performed on the distal por-
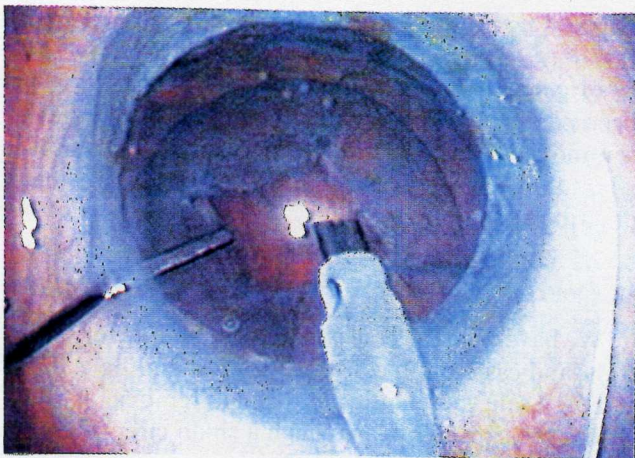
Fig. 9.   (Fine) The epinuclear shell after removal of the quadrants.
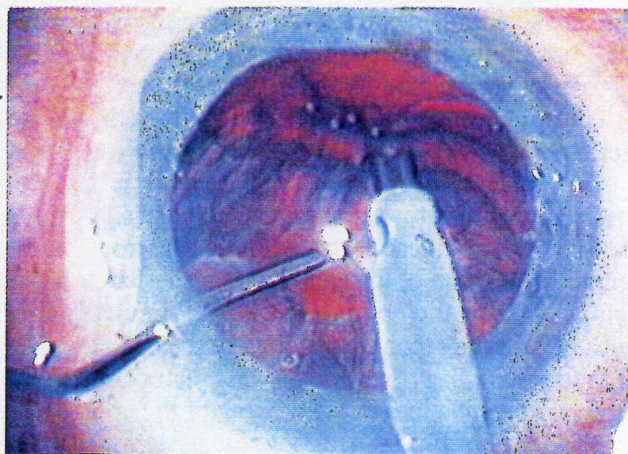

Fig. 10.   (Fine) Aspiration of the rim of the epinucleus up to the level of the capsulorhexis.

Fig. 11.   (Fine) Engaging the distal edge of the epinucleus in phaco mode, foot position 2, and pulling it toward the incision.

Fig. 12.   (Fine) Continued traction on the edge of the distal epinucleus toward the incision while pushing in the center of the epinuclear bowl toward the distal periphery.
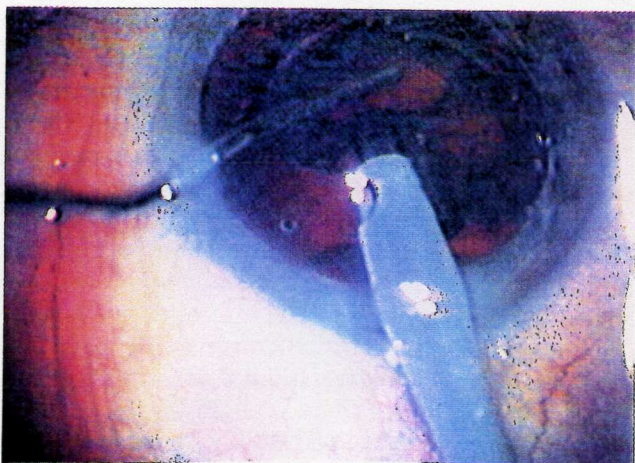

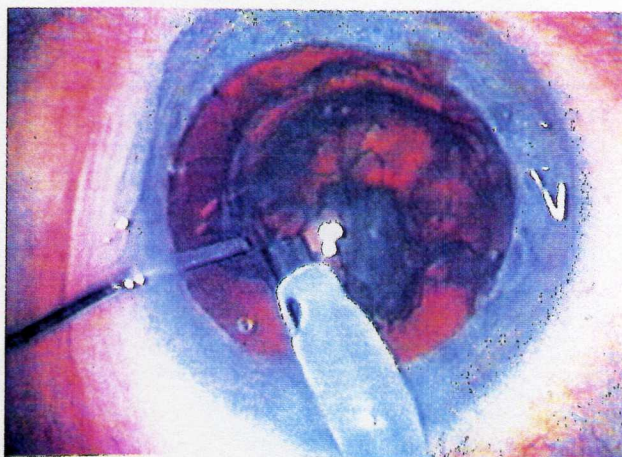Fig. 13.   (Fine) Flipping the epinucleus with the cyclodialysis handpiece now under the epinucleus.

Fig. 14.   (Fine) Everted epinuclear shell floating freely.

tion of the epinucleus. In this manner, the epinuclear bowl has been converted into a rectangle with the rim removed at the proximal and distal portions.

The epinucleus is then rotated so the long axis of the rectangle is allied with the incision. Again the distal portion of the roof or the rim is purchased in foot position 2 and pulled toward the incision (Figure 11), while the second handpiece is placed in the bottom of the remaining portion of the epinucleus at the center of the epinucleus and the epinuclear floor is simultaneously pushed with the second hand toward the distal portion of the capsular bag (Figure 12). This creates antiparallel forces and results in an easy flipping of the epinucleus, removing it from its proximity to the posterior capsule. The previous removal of the rim at the sides results in a rectangle that fits easily through the capsular bag once it is flipped and brought into the plane of the iris for removal by aspiration or low powers of phacoemulsification (Figures 13 and 14).

In general, if cortical cleaving hydrodissection has been performed properly, the epinucleus, cortex and all, is removed (Figure 15). Any residual cortex is removed after the IOL has been implanted, as previously described.[1]

DISCUSSION

We have used the crack and flip technique for several thousand cases of phacoemulsification and have found it to be a safe, systematic approach to removal of nuclei within the capsular bag through a small circular capsulorhexis. It is easy to learn and highly reproducible, and provides added safety and control.
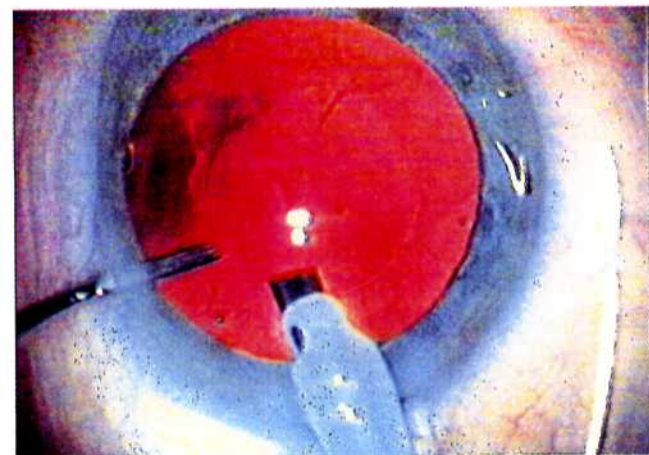

Fig. 15.   (Fine) Capsular bag after aspiration of the epinucleus, which is free of cortex.

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