36 Hard Cataract Management with Modern Extracapsular Cataract Surgery

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- Hard cataracts require special attention at every stage, including preoperative evaluation, patient counselling, surgical strategy, and postoperative evaluation.
- The concept of “phases” of surgery and the need for different technique as well as machine parameters during phacoemulsification are highlighted.
- Complete division of the leathery base plate in hard cataracts is often one of the most difficult aspects, which prevents surgeons from performing phacoemulsification in these cataracts. The multilevel chopping technique described in the chapter allows surgeons to completely divide the nucleus, irrespective of whether they are using horizontal or vertical chopping technique.
- Safe and predictable removal of the cataract along with refractive precision is the goal of modern cataract surgery in hard cataracts. The chapter highlights surgical strategies that will ensure good outcomes on postoperative day 1 consistently.
- Latest advances in phacoemulsification and manual small incision cataract surgery that have made surgery safer and more effective are discussed.
- The role of newer technologies like femtosecond laser and devices like the MiLoop are highlighted and discussed.

Introduction

Despite all the technical and technological advancements, cataract surgery in dense cataracts continues to pose challenges to surgeons the world over. Having a surgical technique that is effective, yet safe and predictable, is important to ensure consistent outcomes time after time. This chapter aims to highlight and discuss surgical strategies for effectively and safely removing dense cataracts, as well as preventing complications during surgery. It will describe the modern extracapsular surgical techniques for removing these cataracts in a manner that ensures good technical and functional outcomes on postoperative day one.

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Preoperative Evaluation in Dense Cataracts

A detailed examination with and without maximal pupillary dilation should be performed for all patients. Often, subtle changes of pseudoexfoliation or zonular weakness may be detected. Documenting corneal endothelial cell density and morphology is important in these cases as there are greater chances of postoperative corneal edema. It is important with hard cataracts to counsel the patients and their caregivers regarding the potential intraoperative and postoperative difficulties. Getting reliable axial length is often a challenge in these cases, although newer machines with swept source OCT technology are able to penetrate most dense cataracts.

Anesthesia in Dense Cataract Surgery

The choice of anesthesia depends on several factors including the surgical technique (phacoemulsification versus ECCE), surgeon's preference as well as patient co-operation. However, as more and more surgeons perform phacoemulsification for dense cataracts, topical or subtenon's anesthesia are often preferred over injection anesthesia.

Phacoemulsification in Dense Cataracts

Today, phacoemulsification is the standard of care for cataract extraction in most parts of the world. However, an encounter with a dense cataract can be demanding for both the surgeon and the patient, and it is for this reason that phacoemulsification is often not preferred in very dense cataracts. The major difficulties in successful phacoemulsification for hard cataracts are poor visibility, stressful rotation, and incomplete division of the leathery lens fibers. There is an increased risk of thermal damage to the incision (wound site thermal injury) and corneal endothelium by the use of excessive ultrasound energy as well as hard fragments repeatedly hitting the endothelium [1]. The key factors that will often define outcomes in dense cataract emulsification are as follows: achieving a complete division of the leathery lens fibers, maintaining a posterior plane of emulsification, and judicious use of ultrasound energy. To achieve these, the procedure should be governed by the following paradigms:

Incision and Anterior Capsulorhexis

The smallest incision compatible with the surgeon's phaco tip and instrumentation should be created. A square or nearly square configuration of the main incision is crucial in order to for it to be self-sealing (Fig. 36.1). Often, in very hard cataracts, the red reflex is poor, and in such cases, staining the anterior capsule with a vital dye such as trypan blue improves visualization of the capsular flap (Fig. 36.2). Sizing of the anterior continuous curvilinear capsulorhexis is also important – a very small capsulorhexis may increase the chances of anterior capsule split during subsequent maneuvers with the chopper or phaco probe. On the other hand, too large a capsulorhexis may result in fluid-current-induced propulsion of the divided fragments out of the bag, and sometimes dangerously close to the endothelium. Surgeons should aim for an ACCC around 5–5.5 mm in diameter, since this would

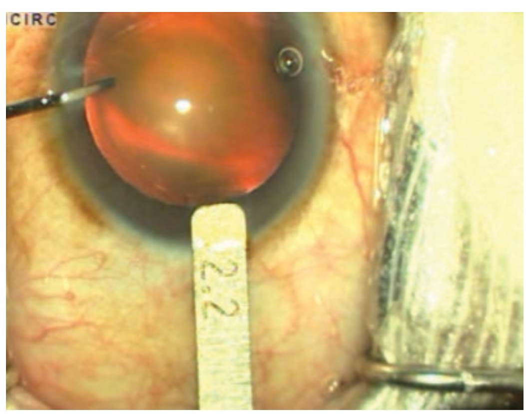

Fig. 36.1 2.2 mm clear corneal temporal incision with internal length and width being similar

confine the mobile nuclear fragments within the capsular bag and facilitate posterior plane emulsification.

Cortical Cleaving Hydrodissection

In hard cataracts, the nucleus is bulky, and often there is not much space within the capsular bag. A forceful cortical cleaving hydrodissection can lead to sudden blow-out of the posterior capsule [2], since the bulky nucleus does not allow egress of the fluid, especially in eyes, where the capsulorhexis is small [3]. In these eyes, careful and gentle cortical-cleaving hydrodissection should be performed. Further, dense cataracts may have strong corticocapsular adhesions [4], making rotation difficult and potentially stressful to the capsulozonular complex. Performing multiquadrant hydrodissection helps surgeons to cleave the corticocapsular adhesions without causing a sudden rise in hydraulic pressure, thereby making nucleus rotation easier.

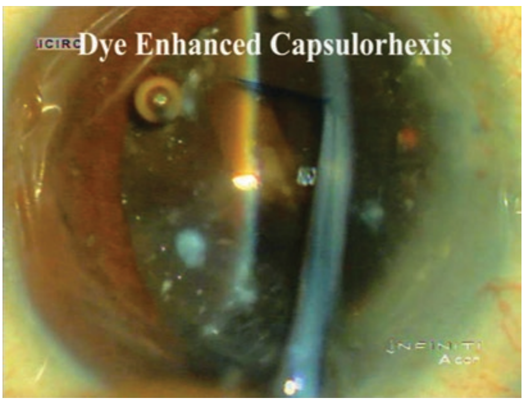

Fig. 36.2 Trypan blue dye injected to enhance visualization of anterior capsule in extremely hard cataract

Principles for Nucleus Division and Fragment Removal

The process of nucleus division and emulsification should be divided into distinct phases, e.g., sculpting, chopping, and fragment removal, depending on the surgeon's preference of technique. This distinction is important to make, since each phase requires a different set of ultrasound and fluidic parameters. Chop techniques, both horizontal and vertical, and their many modifications are very effective for dense cataract emulsification, since they allow complete division of the nuclear fibers. Table 36.1 represents the typical parameters that we prefer during each stage, in terms of ultrasound settings, vacuum, and aspiration flow rate.

Sculpting

The anterior chamber is formed by injecting ophthalmic viscosurgical device (OVD). We prefer the soft shell technique [5], where a dispersive OVD is injected first, followed by a cohesive OVD, which pushes the dispersive OVD toward the corneal endothelium. This helps to protect the

Table 36.1 Representation of the parameters used for emulsification of cataract with dense nuclear sclerosis of ≥ grade 5, on the Centurion Vision System® (Alcon Laboratories, USA)

Surgical parameters			
Stage of surgery	Parameters		
	Torsional ultrasound amplitude – burst mode %	Aspiration flow rate cc / minute	Vacuum mm hg
Sculpting ↓ Approach posterior	70 preset amplitude with linear control, 300 milliseconds on time ↓ 60 amplitude	25 ↓ 20	120 ↓ 60
Chopping	70 preset amplitude with linear control, 300 milliseconds on time	20	650 + (maximum machine vacuum)
1st fragment removal ↓ Last fragment removal	70–80 preset amplitude with linear control, 300 milliseconds on time ↓ 60 ↓ 60	25 ↓ 20 ↓ 18	450 ↓ 300 ↓ 150

endothelium from damage caused by energy dissipation or mechanical trauma. Sculpting creates a central space in the bulky nucleus that acts as a recess for emulsifying the initial fragments within its confines. An ideal space is deep, wide, and steep walled with a very thin posterior plate and is confined within the area of the capsulorhexis (Fig. 36.3). While carrying out sculpting, it is advisable not to mechanically push the nucleus but to scrape the layers gently using optimal energy. A bent tip is better suited to achieve a deep sculpting without undue zonular stress, since it minimizes incision distortion when sculpting is performed in the depths of the crater.

During sculpting, we use ultrasound (U/S) energy in an interrupted mode, with linear foot pedal control, using a preset amplitude of 70–80%. It is important that the surgeon must intermittently change the foot-pedal position from the third to the second position, in order to allow cooling of the phaco tip. The aspiration flow rate is preset to 25–30 cc/min. The end point of sculpting is indicated by a red glow that is visible through the thinned-out posterior plate. An adequate sculpting with a deep, central space is the sheet anchor for dense cataract emulsification.

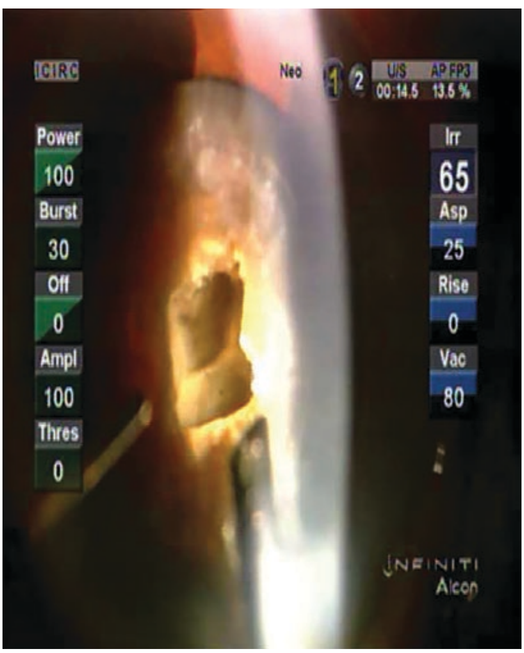

Fig. 36.3 Central, deep trench created in a dense cataract

Chopping

A dense cataract characteristically has extraordinarily tenacious and cohesive leathery fibers that are difficult to separate. Separation of these fibers with forceful lateral movements may produce stress on the capsular bag and the zonules. Also incomplete separation results in multiple fragments held together like the petals of a flower. Fragments attached centrally make posterior plane emulsification extremely difficult and risky and increase the possibility of anterior capsular split, posterior capsular rupture, and prolonged U/S energy dissipation close to the endothelium.

Direct Chop

The direct, or horizontal, chop, originally described by Nagahara, is a very effective technique for division of dense nuclei [6]. No sculpting or trenching is required here. The phaco tip is impaled beyond the midpoint of the nucleus, and a complete vacuum seal is achieved. A sharp tipped chopper is introduced underneath the capsulorhexis margin beyond the lens equator. Once preset vacuum is achieved, the chopper is then moved toward the phaco tip to initiate a crack. However, we have found that using a blunt tipped chopper is equally effective, and yet reduces the risk of mechanical injury to the equatorial posterior capsule. It is important that maximal or supramaximal vacuum is used along with appropriate U/S energy for achieving an effective vacuum seal.

Step-by-Step Chop In Situ and Separation Technique

Our technique of division [7] involves a judicious combination of chop in situ and lateral separating movements. This technique comprises five steps:

Step 1: Vacuum seal – Following a small, central sculpt, the foot pedal is depressed to the third position and the phaco tip is buried inside the trench. If the wall of the trench is arbitrarily divided into 3 equal parts, the tip is buried at the junction of the anterior one-third and posterior two-thirds of the trench (Fig. 36.4). The foot-pedal immediately switches from the third position to the second position and remains there till occlusion (indicated by the machine audio) is achieved.

Step 2: Chop in situ: Initiating a crack – The chopper is placed within the capsulorhexis, just in front of and lateral to the phaco tip. The vertical element of the chopper is depressed posteriorly (toward the optic nerve) (Fig. 36.4). The aim is to only initiate a partial thickness crack and not to divide the nucleus at a single stroke.

Step 3: Lateral separation: In hard cataracts, the initial crack seldom reaches the bottom. Therefore, the chopper is progressively repositioned in the depths of the cracked nucleus (Fig. 36.4) and also repositioned from periphery to the center. Thus, the crack is gently extended from superficial to deep and from periphery to the center. This maneuver allows complete separation of the nuclear fragments without undue zonular stress.

Multilevel Chopping

Often the very dense cataracts will resist complete division of nuclear fragments. In such cases, a multilevel chop technique comes in very handy [8]. For techniques using modifications of the vertical chop technique, an initial crack is initiated, and no attempt is made to extend the crack to the depth. Subsequently, the phaco tip is occluded at a deeper plane, and with each occlusion, fibers adjacent to the tip are chopped with minimal lateral separating movements. This progressive deeper occlusion of the phaco tip allows

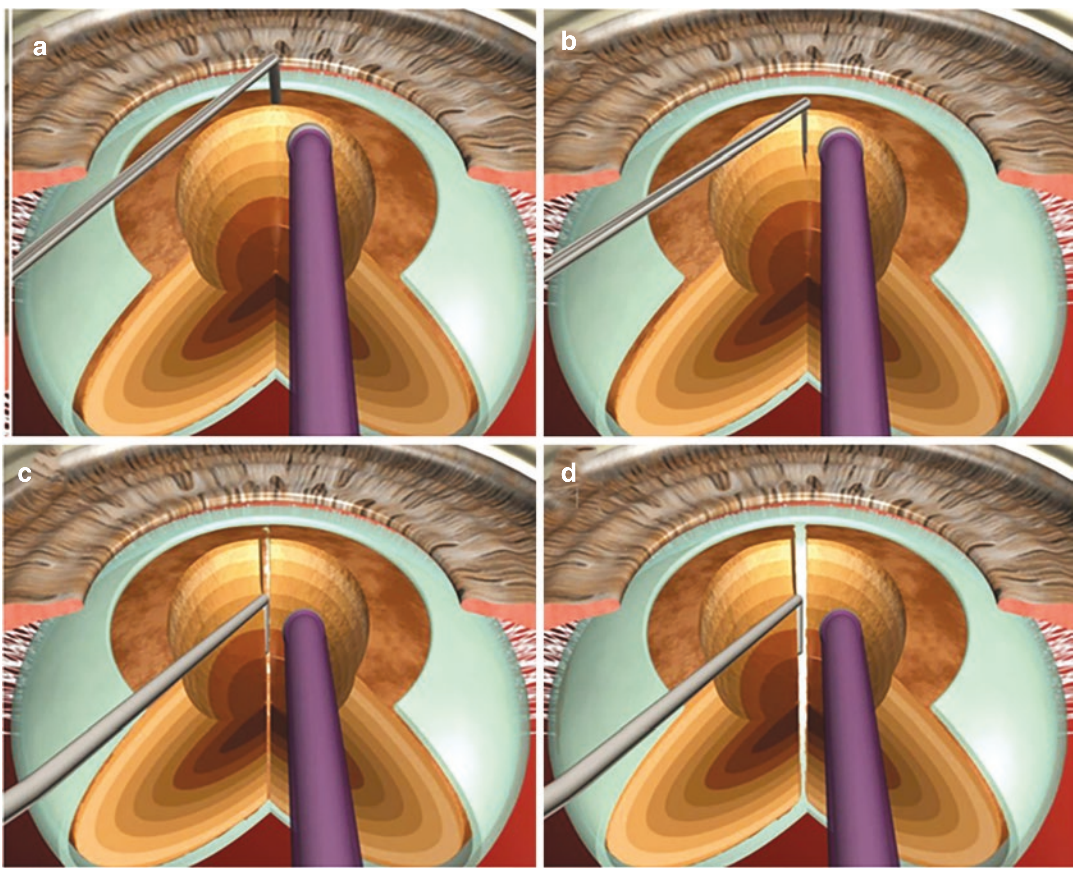

Fig. 36.4 (**a**) Phaco tip buried in the vertical wall of the trench. (**b**) Chopper being placed just in front of and lateral to the phaco tip. (**c**) Initial vertical movement of chopper, aimed at creating a partial thickness crack. (**d**) The chopper is positioned in the depth of the crack, and lateral separating movements are performed

a better vacuum seal and division of the nucleus adjacent to the tip. This facilitates complete division of posterior plate without the need for excessive separation movements. Multiple fragments can be created by repeating this technique every 1–2 clock hours (Video 36.1). The advantages of this technique are safety and efficacy in division of dense, leathery cataracts. The same technique can also be used with direct chop. Here, the phaco tip is first impaled in the periphery and a crack initiated with horizontal movement of the chopper (Fig. 36.5). Subsequently, the phaco tip is brought centrally and occlusion achieved. The crack that was initiated is then extended centrally. The technique can also be employed in cataracts with weak zonules, pseudoexfoliation, subluxated cataracts, hypermature cataracts, as well as in small pupils.

Nuclear Fragment Removal

Creating as many small fragments as possible allows surgeons to emulsify them easily (Fig. 36.6). Surgeons must try to perform emulsification at a posterior plane, in order to avoid thermal and mechanical damage to the corneal endothelium (Fig. 36.7). However, emulsification in the posterior plane increases the risk of inadvertent aspiration of the posterior capsule and iris, especially if a very high vacuum and aspiration flow rate (AFR) are used while removing the last fragments or epinucleus. Therefore, we suggest lowering the vacuum and AFR as progressively more fragments are removed and the posterior capsule is exposed [9, 10]. This allows surgeons to continue emulsifying at a posterior plane without the risk for posterior capsule rupture.

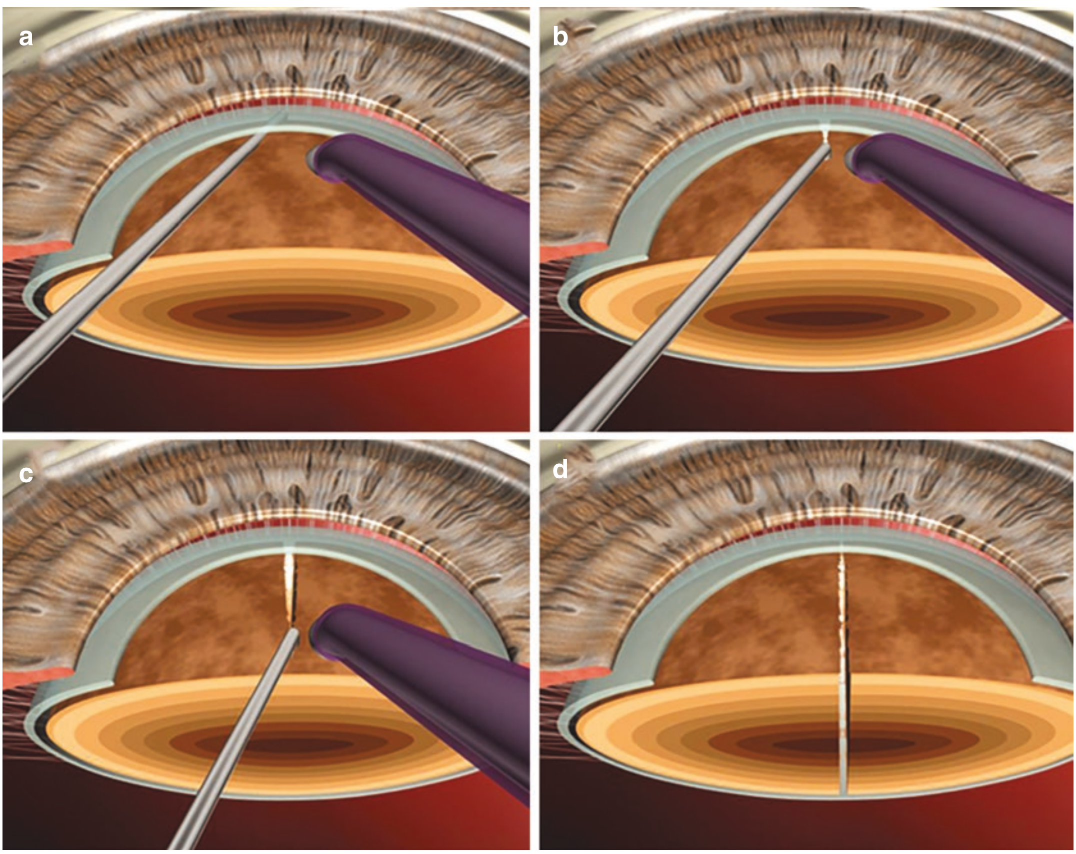

Fig. 36.5 Multiple, small fragments, which become easy to remove during phacoemulsification. (**a**) Phaco tip is occluded beyond the midpoint of the nucleus and chopper inserted beyond the equator. (**b**) The chopper is moved centrally in a horizontal chop action to initiate a crack. At this time, no attempt is made to extend the crack to the centre. (**c**) The phaco tip is then re-occluded more centrally and the initial crack extended more centrally. (**d**) Thus, multilevel chopping ensures complete nucleus division without undue capsulo-zonular stress even in dense, leathery cataracts

Optimal utilization of U/S energy is important for efficient emulsification. Whether longitudinal or torsional ultrasound is used, it is advisable to use interrupted energy as compared to continuous energy. This allows intermittent cooling of the phaco tip, which reduces the chances of wound site thermal injury and corneal endothelial injury. With longitudinal ultrasound, there is a conflict between aspiration forces, on the one hand, which attract the nuclear material, and U/S energy on the other, which tends to repel the fragments. However, with the torsional ultrasound, since there is a constant oscillatory motion at the phaco tip, there is a seamless cutting with minimal repulsion (chatter) of lens material. This makes the U/S energy more efficient, especially in hard cataracts [11, 12]. Whatever the technique or technology used, it is very important to repeatedly inject dispersive OVD during fragment removal to protect the corneal endothelium (Fig. 36.8). It is of utmost importance to closely inspect the incision at the end of surgery to look out for incision distortion / WSTI. In case of doubt, the incision should be sutured.

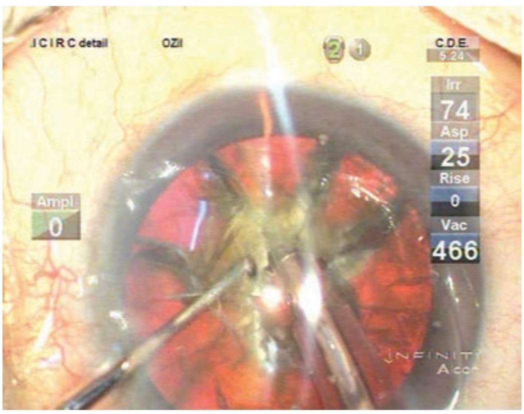

Fig. 36.6 Horizontal multilevel chopping. The phaco tip is first impaled beyond the center of the nucleus and a crack initiated. Subsequently, the tip is occluded more centrally, and the crack is extended centrally, to achieve complete nucleus division without undue capsulozonular stress

Extracapsular Cataract Extraction (ECCE) and Manual Small Incision Cataract Surgery (MSICS) for Dense Cataract Emulsification

Despite the advances in phacoemulsification techniques, there still is a place for ECCE, especially in removal of the very hard cataracts. Not only can this technique be a fallback in cases where phacoemulsification poses difficulties, but it can also be the primary technique of choice in these difficult cases. The disadvantage of ECCE is the large incision required, inability to maintain a closed chamber during surgery, and the need for multiple sutures, with resultant postoperative astigmatism.

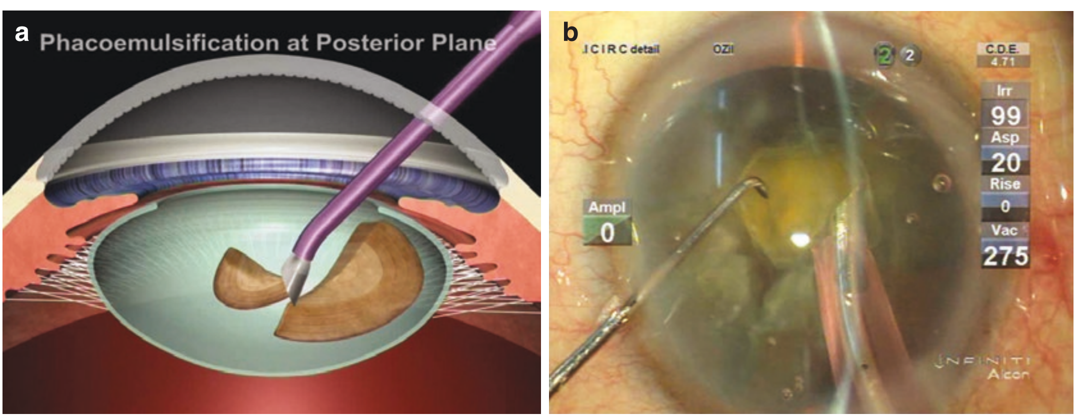

Fig. 36.7 (**a** and **b**) Animation and clinical picture showing dense nuclear fragment being removed away from the corneal endothelium

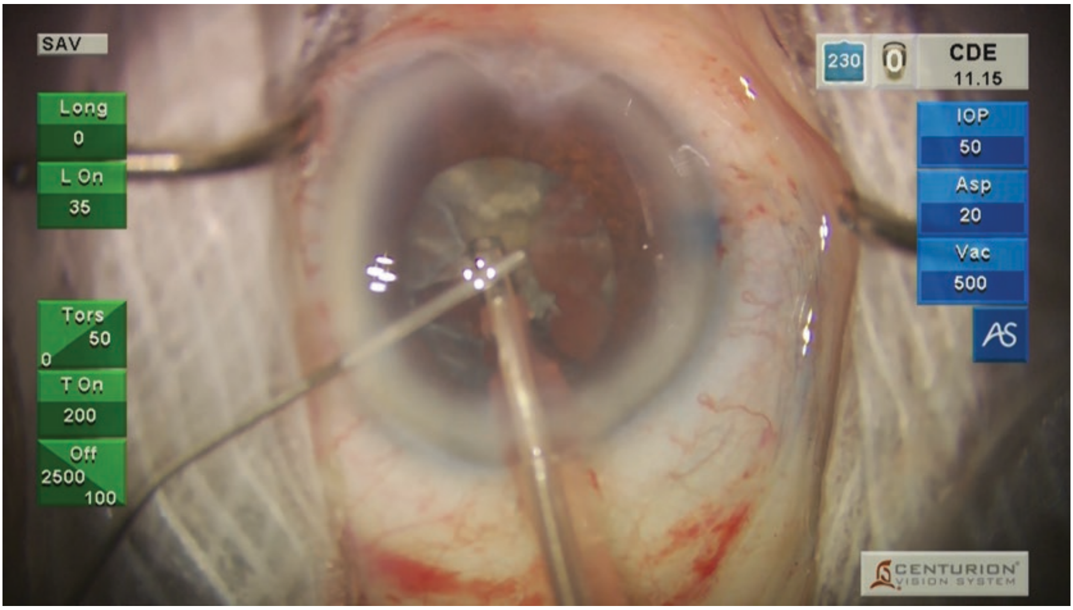

Fig. 36.8 Dispersive OVD being supplemented during fragment removal to protect the corneal endothelium

On the other hand, with MSICS, a self-sealing, 5–6 mm scleral tunnel incision is created. The incision may be superior or temporal. Following a relatively large ACCC, the nucleus is prolapsed into the anterior chamber and subsequently removed from the eye. Now, several modifications such as the use of irrigating wire vectis, nuclear snare, nucleus glides, visco-expression, nucleus fracture, and nucleus bisection are employed by surgeons in order to reduce the size of the nucleus and make delivery out of the eye easier and safer.

There are several published studies in literature that compare outcomes following MSICS and phacoemulsification, and most of the recent ones show that both techniques are safe and effective [13–21]. MSICS and ECCE, however, are more cost effective than phacoemulsification and not dependent on technology. This is the reason why these techniques are often favored in developing nations. Therefore, it would be left to the surgeon's surgical skill and experience, availability of machines, as well as economic viability to choose which is the best surgical strategy in their hands.

Newer Techniques/Devices for Dense Cataract Surgery

Endocapsular Manual Nucleus Fragmentation in Phacoemulsification

Recently, the miLoop, a disposable manual device, has been introduced for endocapsular manual nuclear fragmentation during cataract surgery. Initial reports suggest that this device is safe and effective and that corneal endothelial cell loss as well as intraoperative complications are comparable when performing traditional phacoemulsification versus using the miLoop device [22, 23].

Femtosecond-Laser-Assisted Cataract Surgery (FLACS) – Role in Dense Cataract Removal

With the advent of femtosecond laser technology for cataract surgery, it has been approved for creating corneal incisions, capsulotomy, and nuclear

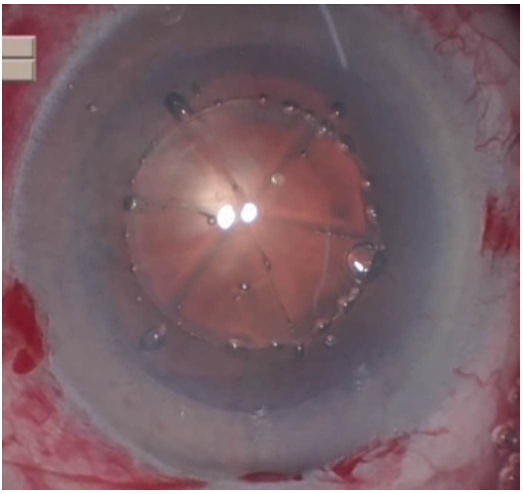

Fig. 36.9 Femtosecond cataract surgery in a dense cataract, capsulorhexis, and chop pattern of nucleus division performed

division. Both the temporal incision and paracenteses incisions can be customized and positioned based on a real-time anterior segment optical coherence tomography view. A centric anterior capsulotomy of a desired size can be created, even in the absence of a good red reflex (Fig. 36.9). Contrary to the initial expectations from the laser, FLACS is able to create various patterns of nucleus division, and even though the division may not extend to the complete depth in very leathery cataracts, it may be useful in reducing the U/S energy consumption during sculpting and chopping. Thus, as this technology continues to evolve, and becomes more cost effective, it may find more use in the surgeons' armamentarium, especially to manage dense cataracts [24–26].

Complications During Dense Cataract Surgery

Common complications that might arise during dense cataract surgery are enlisted below. Although most of them could occur with any technique, some are specific to phacoemulsification or extracapsular cataract surgery:

- Corneal endothelial trauma: surgery in dense cataracts can potentially cause increased endothelial cell loss or even corneal decompensation causes for excessive endothelial cell loss include excessive and continuous use of U/S energy during phacoemulsification, as well as mechanical trauma caused by nuclear fragments/entire nucleus rubbing with the corneal endothelium.

  Preventive measures: repeated use of dispersive OVD to coat the corneal endothelium, being conscious about the plane of emulsification, and the use of interrupted U/S energy delivery/ torsional U/S.
- Incisional thermal damage: caused by excessive and continuous use of U/S energy, especially with a tight wound construction. In ECCE / MSICS, an irregular wound construction can lead to collagen distortion and irregular wound healing.

  Preventive measures: During phacoemulsification, surgeons must make sure to use interrupted U/S energy, which allows for intermittent cooling of the phaco tip. Further a higher AFR should be used during sculpting, so as to allow continuous cooling of the phaco tip. Also, it is very important to create an incision that is not too tight. There should be no compression of the phaco tip at the incision, so that the irrigation flow around the phaco tip is not compressed. For example, if a surgeon uses 2.2 mm incision routinely, he or she should perform a 2.4 mm incision to avoid oar locking and tight wound geometry.
- Posterior capsule rupture: often occurs due to the use of very high flow rate and vacuum settings in these eyes, which may have fragile capsular bags to begin with.

  Preventive measures: adhering to the principles of closed chamber technique and the use of modestly low vacuum and AFR settings will allow the surgeon to avoid inadvertent rupture of the posterior capsule as well as injury to the iris tissue.
- Zonular dialysis/weakness: dense cataracts are very often associated with pre-existing

zonular weakness. Also, stressful surgical maneuvers such as nucleus rotation, excessive lateral separation movements, or forceful nucleus delivery during phacoemulsification / ECCE / MSICS may lead to iatrogenic zonular defects. Many times, dense cataracts may be associated with comorbidities such as glaucoma or pseudoexfoliation syndrome, which can further predispose to zonular weakness.

Preventive measures: it is important for surgeons to detect any zonular weakness preoperatively by performing a thorough and full dilated slit-lamp evaluation.

Conclusion

Dense cataract management has improved dramatically over time. However, technique and technology must complement each other for consistent and predictable outcomes. Surgeons need to be extra careful during preoperative evaluation, paying special attention to the corneal endothelial health, pupillary dilatation, and zonular weakness. During surgery, the judicious use of U/S energy, adhering to posterior plane phacoemulsification, optimal use of U/S energy such as the use of torsional U/S, interrupted energy, and repeated use of dispersive OVDs will ensure intraoperative efficacy and safety and good postoperative outcomes (Fig. 36.10).

- Hard cataracts pose two major challenges to surgeons during surgery: (a) effective division of the lens and (b) safe and predictable removal of fragments without causing any damage to the corneal endothelium or uveal tissues.
- Both manual extracapsular cataract surgery and phacoemulsification are viable options in hard cataract management. Surgeons should choose their approach based on surgical experience, comfort, and availability of technology.
- Chop techniques tend to work better during phacoemulsification of hard cataracts. Select a technique that ensures complete nucleus division before the fragments are removed.
- Understanding your machine and modulating the ultrasound energy and fluidic parameters will help surgeons optimize their technique.
- The use of adjuncts, such as dispersive ophthalmic viscosurgical devices during surgery, is critical to ensure least corneal endothelial damage.

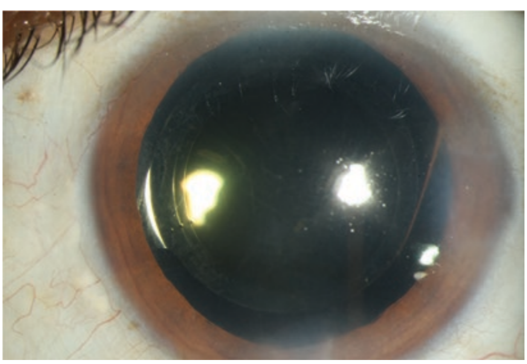

Fig. 36.10 Clear cornea on postoperative day 1 in a dense cataract

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