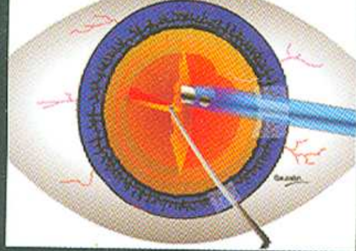
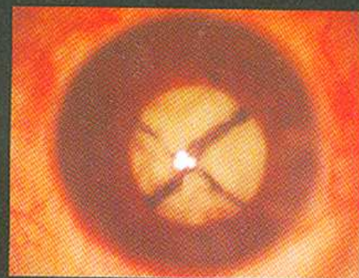
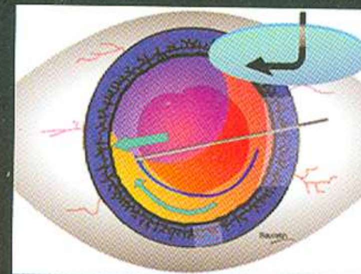
AIOS, CME SERIES (NO. 21)







A Guide to PHACOEMULSIFICATION

Harbansh Lal

FROM DARKNESS TO LIGHT

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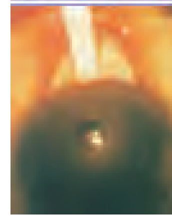

About the CME...

Cataract surgery by Phacoemulsification is the standard of care today and there are a lot of books and journals as well as an equal number of sessions in conferences covering this subject. However, most of them are exhaustive in content and complex in comprehending.

The basic purpose of the AIOS–CME series is to provide to the reader, concise, up to date information on one particular topic, by an expert in the subject. The thrust is on presentation of the matter – so that it is easy to read and implement in practice.

Dr Harbansh Lal's CME on "A Guide to Phacoemulsification" covers the topic in a very simplified and lucid manner. We have known Dr. Harbansh Lal for many years and he always has lots of practical and useful surgical tips to share which have been incorporated in this CME series.

We are sure that this is going to be a useful compilation for all practicing as well as aspiring phaco surgeons.

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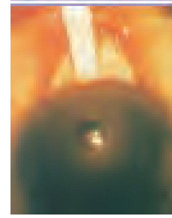

Foreword

Dear Colleagues,

Cataract surgery is the commonest surgery performed by Ophthalmologists and phacoemulsification is the best technique for this. There are many books available on Phacoemulsification, but concise, brief and to the point instructional phaco techniques for the learning surgeon are not available. Even in Conferences and CMEs the discussions revolve around fourth generation phaco machines, advanced IOL materials and techniques. However, it is a thorough knowledge of basic techniques that lays the foundation for graduating to advanced methods and avoiding complications.

In this issue of AIOS CME series titled "Basics of Phacoemulsification", Dr Harbansh Lal, Vice Chairman, Department of Ophthalmology, Sir Ganga Ram Hospital, New Delhi and the co-authors have presented the basic techniques of Phacoemulsification in a very simplified and illustrative manner.

Every step of phacoemulsification from incision to IOL implantation, as well as how to convert and the management of the most dreaded complication – PCR have been very well covered. I am sure this will benefit each and every Ophthalmologist.

I would like to appreciate the efforts of Dr Harbansh Lal, Dr Tinku Bali, Dr Ikeda, Dr Swapna Parekh and Dr Saurabh Sawhney in compiling an excellent practical guide on Phacoemulsification.

Dr S Natarajan
Chairman ARC

All India Ophthalmological Society
(Academic & Research Committee)

A Guide to Phacoemulsification

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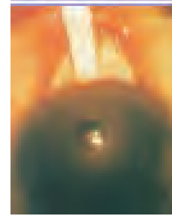

Contents

AC	Anterior Chamber
ACM	Anterior Chamber Maintainer
AP	Aspiration Phaco
AFR	Aspiration Flow Rate
CCC	Continuous Curvilinear Capsulorrhexis
CIM	Continuous Infusion Mode
CSZ	Central Safe Zone
CF	Capsular Fornix
ENP	Epinuclear Plate
FR	Flow Rate
FP	Foot Pedal
IA	Infusion and Aspiration
IAP	Infusion, Aspiration and Phaco
IOL	Intraocular Lens
ILP	Intralenticular Pressure
PC	Posterior Capsule
PCO	Posterior Capsular Opacification
PCT	Posterior Capsular Tear
PA	Phacoaspiration
PUSZ	Peripheral Unsafe Zone
RT	Rise Time
RMT	Rhexis Margin Tear
SPI	Side Port Incision
U/S	Ultrasound
VES	Viscoelastic Substance

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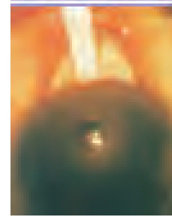


Introduction

The preparation for phaco must be started ***much*** before one has even ventured near a phaco machine if you are to achieve success. Mental preparation needs to be commenced before the actual physical preparation. The first step is to **BELIEVE IN YOURSELF** that ***you too*** can be a successful phaco surgeon.

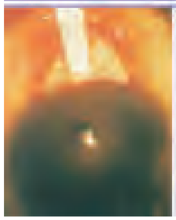
Before attempting phaco, one must be **proficient at extracapsular cataract extraction** and other intraocular surgeries. This surgical experience will stand you in good stead while attempting various maneuvers with the phaco probe or the second instrument. It is important to be **ambidextrous** during phaco and this can be improved by practicing activities with the left hand. Even before actually obtaining a phaco machine, one must initiate a few steps while performing planned ECCE. For example, CCC and Hydroprocedures may be attempted, taking care to release or extend the CCC in 2-3 places before delivering the nucleus.

Understanding the phaco machine is vital to a successful surgery. You should **read the manual** carefully. The movement of the foot pedal is of paramount importance and you should practice the positions of the foot pedal (i.e. moving between irrigation, irrigation-aspiration and phaco) for at least ***10 hours*** before even starting phaco.

If operating under supervision, you can be a little bolder since the senior surgeon will take over in case of a problem. However, if you are on your own, try not to be complacent. **DON'T HURT YOUR EGO BUT CONVERT**.

Phaco surgery is performed in the mind. If you keep thinking about the procedure all the time, your understanding of the machine, mechanisms and instruments will be better and you will be able to master the technique much faster.

CHAPTER 1



Phacomachine and Phacodynamics

PHACOMACHINE

The machine consists of the ***console, foot pedal, handpiece*** and their connections.

CONSOLE

The ***console*** consists of a computer which controls all the functions of the machine. The setting for the various parameters, i.e. power, vacuum and flow rate are fed in here. These settings represent the maximum level of the parameter that will be achievable: the further linear control is with the foot pedal. Newer machines have a multi-mode panel, where multiple settings of all variables, as is required by different surgeons, can be fed in. The same surgeon may like to change all the variables during the surgery and these parameters can also be fed in and can be recovered by touching the memory button only. Settings for different types of cataract can also be fed into the memory. In some machines the memory can be activated by the foot switch so that the surgeon can continue the surgery without having to look at the console.

HANDPIECE

There are two types of handpieces—***phaco handpiece*** and ***irrigation aspiration handpiece.*** The phaco handpiece contains the piezoelectric crystal, which is in contact with the tip. The tip is covered by a silicon sleeve. The infusion fluid flows between the tip and the sleeve cooling the former. There are two openings on the sleeve for the exit of this fluid, which should be kept perpendicular to the tip bevel. The proximal end of hand piece is connected to the console with an electric cord. There are two more connections: one each for the irrigation tubing and for connecting the aspiration system.

There are various types of tips, the utility and functions of which are discussed in the power system.

FOOT PEDAL (Figs. 1.1, 1.2)

Foot pedal control is the most important aspect of phaco. Though the foot pedal of each machine may have a different design, it essentially consists of main **central part** and **side kicks**. The main part of the foot pedal controls infusion, aspiration and phaco power. The entire distance that the foot pedal traverses is divided by 2 dentations into 3 excursions-**I** (**irrigation only**), **IA** (infusion and aspiration) and **IAP** (**infusion, aspiration and phaco**). The excursion before the first dentation is the **I** excursion, the excursion between the 1st and the 2nd dentation is the **IA** excursion and the excursion after the 2nd dentation is the **IAP** excursion. Resistance is felt at the dentations or position where the mode changes and it is to feel these dentations that one has to train oneself both while depressing and while coming back up. Familiarity with the feel of dentations of the pedal (***tactile feedback***) and the sounds that the machine makes (***auditory feedback***) is mandatory before attempting phacoemulsification. Ability to move quickly from one mode to the other at the correct time is the key to successful chopping.

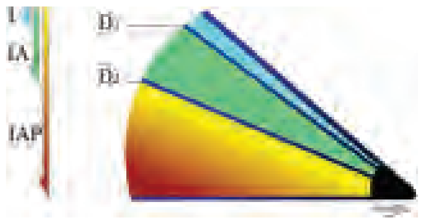


Fig. 1.1. Foot pedal. In phaco mode there are 2 dentations (D_1, D_2) where the resistance is felt. Note the 3 excursions. **I** - Irrigation only, **IA** - irrigation aspiration, and **IAP** or **P** is the phaco mode.

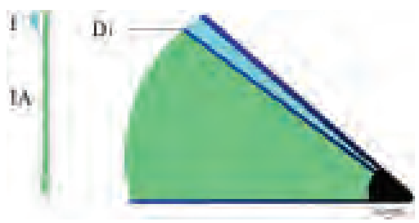


Fig. 1.2. Food pedal in irrigation-aspiration mode. There is only one dentation and 2 excursion. **I** - Irrigation, **IA** - Irrigation-aspiration.

The point to remember is that in the ***I excursion***, irrigation is fully on. In the ***IA excursion*** both irrigation and aspiration are on and in the ***IAP excursion***, irrigation is on, aspiration is at the maximum preset, and phaco power will depend on the amount of depression.

In the ***I excursion***, the pinch valve opens and irrigation is switched on. There is no gradient in this step and the irrigation is either switched fully on or off. In the absence of gradient, the function of this dentation is to dissociate infusion from irrigation-aspiration. As foot is brought back from **IA/IAP** excursion, stopping at this dentation will keep the infusion on preventing the collapse of anterior chamber. Many steps like nuclear rotation, manipulation of nuclear fragments, epinuclear plate etc. require a formed AC without any aspiration.

Dentation 1 to dentation 2 is the aspiration or the **IA excursion**. From dentation 2 to full depression is the phaco or the '**IAP**' excursion. At $\mathbf{IAP_0}$ phaco energy delivered will be zero and at $\mathbf{IAP_{max}}$ the energy will be maximum preset. The delivery of phaco energy is linear both in the surgeon and the pulse mode. However, in panel or burst mode, as soon as foot clears $\mathbf{IAP_0}$, maximum preset energy is delivered.

Foot gradient (Fig. 1.3)

Foot gradient is the excursion of foot pedal in mm to produce unit power of phaco energy. To give an example—If the total foot excursion, from $\mathbf{IAP_0}$ to $\mathbf{IAP_{max}}$ is 10 cm i.e. 100mm and the maximum preset phaco energy is 100%, then the foot gradient (FG) becomes:

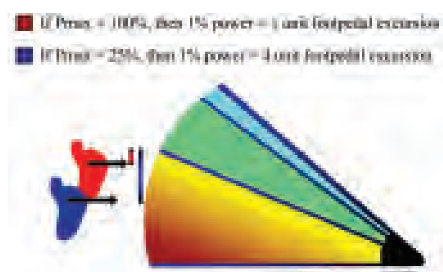


Fig. 1.3. Food gradient. Note that for the same unit change in power, the excursion of the foot pedal is 4 times more when the maximum power is set at 25% (blue pedal) thus giving better control.

$$FG \quad \frac{100\text{ mm}}{100} \quad 1\text{ unit power per } 1\text{ mm of excursion}$$

Now, if maximum preset phaco power is changed to 50%:

$$FG \quad \frac{100\text{ mm}}{50} \quad 1\text{ unit power per } 2\text{ mm of excursion}$$

At phaco power 25% maximum:

$$\text{FG} \quad \frac{100\text{ mm}}{25} \quad 1\text{ unit power per } 4\text{ mm of excursion}$$

Decreasing the maximum preset power on console increases the foot gradient and hence the foot control. Therefore, phaco maximum should be set at the minimum power which is required for a particular step in that grade of cataract.

Side kick functions of foot pedal

The most important sidekick function of foot pedal is ***reflux***. On kicking the side switch, aspiration flow rate is inverted and the material aspirated is expelled into the AC. Since it is not a continuous function, for further reflux, the switch needs to be kicked again. Inadvertent aspiration of wrong tissue (iris, capsule) can be released by this function especially by beginners.

Continuous infusion mode (CIM) can prove to be a boon for an inexperienced surgeon. In this mode, the infusion remains on regardless of the position of the foot pedal (i.e. even if the foot is accidentally lifted ***off*** the pedal the infusion remains on, and the chamber remains formed). It is started by kicking the side switch and remains on, till kicking the same switch again stops it. While changing modes, the backward tactile feel on the foot pedal is less so one may not be able to judge when one is in the **Infusion** mode. With **CIM**, the eye remains pressurized even when the pedal is released. Whenever the probe is in the eye the infusion must remain on and in steps like cracking the nucleus, where the probe is inside, but no phaco or aspiration are being used, this mode is especially useful. In machines, which do not have the CIM mode, the assistant can remove the infusion tubing from the pinch valve as soon as the probe is in the eye.

Few machines also have pulse on-off, bottle height adjustments, multi-mode panel, and dual linear control in the foot pedal. In the latter, linear control is in both directions—downwards and sideways.

PHACODYNAMICS

The various functions of the phaco machine and their inter relationship is called phacodynamics. The basic functions of the machine are two,

which include ***ultrasonic power*** for emulsification and ***irrigation-aspiration*** for safe suction of the emulsified material. Irrigation-aspiration system and the parameters on which it depends together are called ***fluidics***.

POWER (Fig 1.4)

Phaco power is produced by the Ultrasonic vibrations of the Quartz crystal in the hand piece. There may be 2–6 crystals, 6 giving more stroke length and more power. The frequency is variable from 29–60 Hz in different machines. Higher frequency ensures a better cutting action but more heat is generated though, practically this does not significantly affect the surgical outcome. However, in each machine, the frequency remains fixed—power is varied by varying the **stroke length** which is the to and fro movement of the tip and varies from 2/1000–6/1000 of an inch. The actual mechanism of emulsification is a combination of the bombarding action of the tip (***Jack-hammer***) and ***cavitation*** phenomenon caused by the high velocity of the tip moving backwards. The ***Jack-hammer*** action requires that the nucleus should be fixed as during trenching, or the nuclear fragment held by vacuum, during phaco-aspiration, for the bombarding action to be effective. This is the action that is primarily used during trenching. The rapid backward excursion of the tip creates a cavity into the area (as the tip moves faster than fluid) causing the surrounding fluid to fall into this space, virtually generating an '***implosion***' thereby causing disintegration of the nuclear material. The forward movement of the tip also generates an ***acoustic wave*** of fluid that can disintegrate the softer lens material. This shock wave is also responsible for some emulsification. The disadvantage of this wave is that it may push nuclear pieces away if the

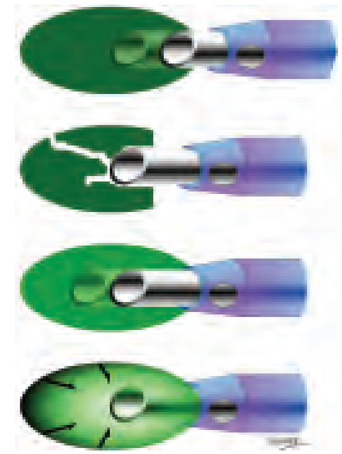


Fig. 1.4. Mechanism of phaco. (A) ***Jack Hammer effect:*** The rapid to and fro movement of the tip bombards the tissue in front and disintegrates it. (B) ***Cavitation phenomenon:*** The frequency of oscillation is 40,000/second. The swift backward movement of the tip results in a cavitation phenomenon causing an implosion of surrounding tissue.

hold is not good and thus decrease the ***Jack-hammer*** effect. If the vacuum hold is good, then this action can be synergistic with the ***Jack-hammer*** effect.

Till now, the power was delivered by to and fro movement of the tip, but now the tip can move transversely (Ozil, Alcon) or elliptically (Eclipse, AMO). This increases the heat generation and increases followability and hold in these newer fourth generation machines.

Tips (Fig. 1.5)

The angulation of the tips may vary from 0–60°. Tips with 60°, 45°, 30°, 15° and 0° angulation are available. More the angulation, the lesser the holding power but the cutting power is more, e.g. 60° tip is a sharper tapered tip making occlusion difficult. Therefore, this tip has a better cutting and less holding power. The **45°** tip has a very good cutting ability and was very popular initially as the emphasis was then on 'Divide and Conquer' in which trenching (thus cutting ability) was more important than occlusion.

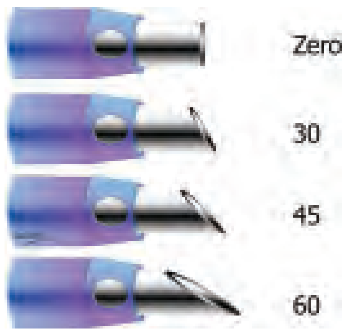


Fig. 1.5. Phaco tips. A = 0°, B = 30°, C = 45°, D = 60°.

With the advent of aspiration phaco the most popular tip today is **30°**. This has adequate holding and cutting power and is useful both for trenching and in chopping. The 15° and 0° angulated tips are better for holding but have a poorer cutting action.

Control and delivery of power

All machines provide 0–100% power and the power required can be chosen from the computer controlled panel. There are various modes—surgeon/linear or panel. In the ***surgeon*** mode, the power delivery varies from 0 to the maximum that one sets on the panel, by varying the foot pedal in phaco mode. At pedal position 2, i.e. at the start of phaco mode (P_0) the power will be 0 and at full depression (P_{max}) power will be the maximum that has been pre-set. Thus the excursion of the foot in phaco mode will determine the amount of power being delivered. In the **panel** mode, as soon as you depress the foot pedal into the phaco

mode (P_0), you will immediately reach the maximum power that you have set on the panel. Here, there is no variation and full power is delivered. As we know the hardness of the nucleus is not uniform, most surgeons prefer the linear mode so that they can control the power according to the hardness of the cataract. The only probable indication for the use of panel mode is in a very hard cataract where the nucleus is uniformly hard requiring more or less uniformly high power for emulsification.

There are a few other modes of power delivery available in certain machines. In **pulse mode** each pulse of energy is followed by a gap of equal duration. For effective power delivery, the nuclear fragment has to be held, so the interval between the pulses of phaco allow the vacuum to build up and thus a good hold is developed. Pulse mode is a variant of linear phaco mode where the frequency of the pulses is fixed and the phaco energy delivered in each pulse will depend on the amount the pedal is pressed. Thus the power is delivered at pre-set intervals, the frequency of which is pre-set and decided by the surgeon. For example, if set at 5 pulses/sec, there will be 5 pulses of energy and each energy burst will be followed by a gap of equal duration- i.e each pulse and each gap will be of 100 msec duration (1 sec = 1000 msec, 1000 sec/5 pulses + 5 gaps = 100 msec). Most machines have from 0–12 pulses. The use of the pulse mode in phaco aspiration almost halves the power use, as the vacuum build up between the pulses ensures efficient emulsification and aspiration.

Now, newer machines have softwares which can have pulses in hundreds and thousands. This is called the **hyperpulse mode**. Not only this, the duration of on and off time can also be decided by the operator, which is called **Duty cycle**, thereby further reducing heat generation and increasing followability.

One other mode that is useful in hard cataract is the **burst mode** where maximum power is delivered at intervals which vary with the amount you depress the foot pedal. Burst mode is a variant of panel mode where the energy is fixed and the frequency of phaco bursts will increase with increasing depression of the foot pedal in phaco mode. At P0 there will be one burst per second and at full depression (P_{max}) the power delivery is continuous. The duration of the burst can be selected and is usually 100 msec. This mode is only available in the higher end (third generation) machines.

FLUIDICS

The fluidics of the machine refers to the integrated functions performed by infusion and aspiration systems by which a stable AC is maintained. One of the major advantages that phaco has over conventional cataract surgery is the fact that it is performed in a closed chamber. Maintaining a stable chamber depth is vitally important for avoiding damage to all the intra-ocular structures especially the cornea, iris and PC.

Infusion system (Fig. 1.6)

The infusion system consists of a bottle, the height of which provides the gradient for flow. The tubing from the bottle is run through a pinch valve which is controlled by the foot pedal. The infusion is gravity fed, 2 feet bottle height conforming to approximately 44 mmHg (2 ft = 60 cm = 600 mm water column, 600/13.6 = 44 mmHg). A bottle height of 3 ± 1 ft maintains a safe IOP with sufficient fluid entering the eye.Raising the bottle height too much can have undesirable effects due to the fact that the AC has a fixed volume and trying to fill excess fluid results in zonular stress leading to patient discomfort. Also, too much fluid can lead to fluctuation of the lens iris diaphragm resulting in irritation to the iris and miosis. Another problem in raising the bottle height maybe repeated iris prolapse, especially if the pupil is small and wound is large and there will be unnecessary lavage of the cornea and iris.

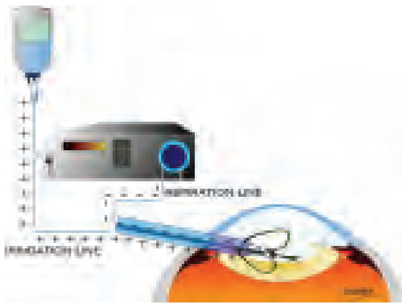


Fig. 1.6. Note the gradient created at the tip by the interplay of the negative pressure due to the aspiration system and the positive pressure of the infusion. This gradient or **followability** is greatest at the tip.

Aspiration System

The present computer-assisted aspiration systems together with improved tubing have made phacoemulsification a swift and safe surgery.

The two functions of the aspiration system are lavage of the anterior chamber and creation of a hold for emulsification/crushing of the nucleus. Lavage is governed by the ***flow rate*** and the hold is a function of the ***vacuum*** generated by the system. The aspiration systems consist of a pump that is either flow based or vacuum based. The common type of flow pump is the **Peristaltic pump**. **Venturi** is the prototype of a vacuum-based machine.

Venturi System

Venturi Effect: The swift movement of a compressed gas creates a negative suction force, i.e. the vacuum, inside a closed chamber. In a Venturi system, this principle is used to create vacuum in the cassette (closed chamber). This vacuum is then directly transmitted to the handpiece. The amount and speed of the gas decides the level of vacuum developed in the cassette. This process is controlled by the foot pedal.

In the venturi system only the level of vacuum can be controlled and not the flow rate, which is the amount of fluid withdrawn from the anterior chamber per second. Here the flow rate is a fixed fraction of the vacuum. However, the change in vacuum level doesn't always lead to a proportionate change in the flow rate since port size and resistance in the passage also modify flow rate. The advantage of this system is that the vacuum is directly transmitted to the tip from the system ensuring a better followability.

Peristaltic System

In a peristaltic pump, the rotation of the rollers by the pump pinches the soft, silicon tubing, creating a negative pressure by squeezing the fluid out of the tube. The faster the rollers rotate, more fluid is withdrawn and therefore there is a higher flow rate. In this system, vacuum will be built up only after the tip is occluded. Flow rate and vacuum can be set independently in a peristaltic system.

Flow Rate (FR)

Flow rate determines how fast things will happen in the eye. The higher the flow rate, the lesser the rise time and the sooner the debris in the AC is cleared. However if the flow rate is too high, the events may occur faster than you are able to control them. At a very low flow rate things are painfully slow. Most peristaltic machines work best at an optimum FR of 20–36 cc/min. At higher speeds, the pump rotates faster but effectiveness of the pinching action decreases due to slippage of the rollers.

Vacuum

Vacuum is generated by the machine and is a measure of the strength of the 'hold' that the handpiece has on the nucleus. Level of vacuum and port size will determine how strong the grip is. The holding power is inversely proportional to the port size. Vacuum is a double-edged sword which must be used/set carefully depending on what needs to be held (nucleus, cortex), for what purpose (chopping, aspiration) and with what instrument (phaco tip, I/A canula). The setting of vacuum also depends on the machine since each machine has its own capabilities. In the first generation machines vacuum may be set upto 120 mmHg in Phaco mode. In the second-generation machines vacuum levels upto 250 mmHg can be used safely whereas in the newer third generation machines vacuum levels upto 650 mmHg can be used comfortably. While checking the machine, one can pinch the aspiration tube and let the vacuum build upto the maximum one plans to use. On release of the tubing, if the test chamber collapses then post-occlusion surge is inevitable at that vacuum setting and flow rate, so the setting should be lowered.

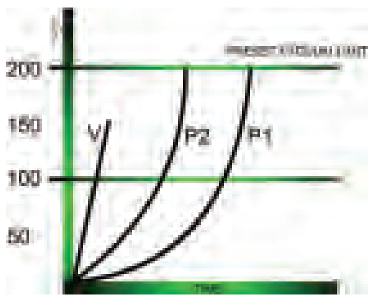


Fig. 1.7. Rise time. Time taken for vacuum to build at the tip. Note that in a Venturi system (V) the rise time is linear and fast. In a peristatic system (P_1, P_2), after initial slow start, vacuum builds up faster. Increasing the flow rate will shorten the rise time, more so for the initial vacuum build up. The curve of P_2 (flow rate 30 cc/min) is steeper than P_1 (flow rate 20 cc/min).

Rise Time (RT) (Fig. 1.7)

The rise time is the time taken by a machine to reach maximum preset vacuum after occlusion has been achieved. In a Venturi system, the RT is fast, linear and dependent upon the highest preset vacuum, while in a peristaltic pump, RT depends on the FR of the machine. The higher the FR, the lesser the RT though the relationship is not absolutely linear. For a given flow rate, the initial rise time is more till a certain level has been achieved after which the vacuum build up is faster.

CENTRAL SAFE ZONE (Fig. 1.8)

Fig. 1.8. Zone of safety. The green shaded area represents the ***Central safe zone***. Phaco aspiration should be done here. The surrounding peripheral anterior chamber and capsular fornices constitute ***Peripheral unsafe zone***.

The ***central safe zone*** is not an anatomical area but a concept that needs to be understood for performing safe aspiration. This is an area within the CCC margin which is bounded vertically by the cornea on the top and the posterior capsule in opposite direction. This is the area with maximum space in the AC. All aspiration—nuclear, epinuclear or cortical—should be done here as there is maximum safety here. Even if there is AC flutter, the probe will not damage any vital structures. The nuclear pieces and cortical matter can be held in the periphery and then brought to the CSZ for aspiration. This is a dynamic area- as more of the nuclear pieces are removed, the space and thus the safety margin keeps on increasing. **In myopes, zonular stress syndromes and vitrectomized eyes the CSZ is further increased whereas in hypermetropes, small pupil and small CCC the CSZ is smaller.**

PERIPHERAL UNSAFE ZONE

Due to the corneal curvature, as one proceeds towards the periphery, one enters an unsafe zone as there is less space for maneuvering. The capsular fornices and the angle region are thus areas where it is dangerous to do phaco-aspiration since the vital structures are extremely close. This constitutes the ***Peripheral unsafe zone*** (***PUSZ***).

FOLLOWABILITY

The positive pressure due to the infusion and the negative pressure created by the aspiration pump are responsible for the creation of a pressure gradient at the tip. This in turn leads to eddy currents from the infusion orifice to the phaco tip. The area encompassed by these eddy currents is known as the zone of followability. **Followability refers to the tendency of the nuclear fragments/cortical matter to come into the tip.**

Another important aspect of followability is the size and location of the pieces. It is seen that the smaller pieces tend to come into the eddy currents easier. This highlights the importance of mechanical crushing of pieces to increase the followability. However, if they are lodged in the angle/capsular fornices (PUSZ), it is tougher to suck them into the CSZ and may require mechanical dislodging.

Zones of followability (Fig. 1.9)

The gradient is maximum at the tip and the eddy currents generated ensure a zone of reasonable followability around the tip. The area just in front of the tip is the **area of highest followability**. All the fragments in this area will be attracted towards the tip. Followability decrease as you go further away (both horizontally and vertically) from the tip.

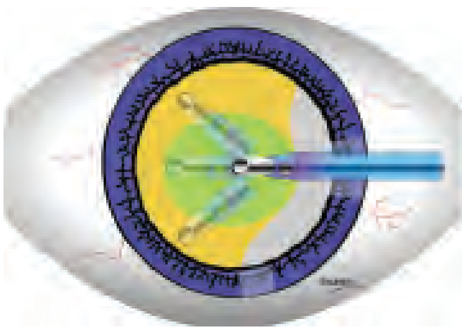


Fig. 1.9. Zones of followability. Area around the tip (shaded green) represents zone of ***good followability***. Area around the incisions (shaded gray) represents zones of ***no followability***. The remaining area (shaded yellow) represents the area of poor followability. Followability in these areas can be increased by moving the probe in the directions as shown by the shaded probes.

The angle of the anterior chamber and the capsular fornices are the areas of poor followability. As there is no infusion pressure here, these pieces do not get aspirated easily. It is possible to aspirate them by either increasing the gradient (increasing vacuum/flow rate) or taking the probe closer to the pieces making them fall into zone of followability. However, now you are in the peripheral unsafe zone, i.e. you are in the periphery of the anterior chamber where the AC depth is less and both the iris and capsule are dangerously close to the tip. If you want to engage the fragments in that position, avoid holding the iris and bring

the piece quickly into the CSZ before aspiration.

There are some **areas of no followability**, i.e. fragments here will not come into the tip. These are the areas of the AC from where the fluid is spontaneously leaking out, i.e. the side port and the main wound behind the infusion ports on the handpiece. Here the positive pressure from the infusion pushes the pieces out of the eye. These pieces will not come into the tip even if vacuum is increased to the maximum as the AC will collapse before these can be aspirated. One needs to mechanically bring these pieces into the followability zone either with a 2nd instrument or using visco-elastic material after removing the phaco probe from the eye. Another area of no followability is the dome of the cornea, the eddy currents do not reach here and due to surface tension the pieces tend to get stuck. These need to dislodged with a VES and then brought into the CSZ. Repeated attempts with the phaco probe can damage the endothelium. Nuclear fragments lying in sub incisional capsular fornices have to be brought mechanically in front for aspiration.

COMPLIANCE (Fig. 1.10)

A Silicon tube connects the aspiration system with the handpiece in both types of pumps. Additionally a thick wide bore tubing is required

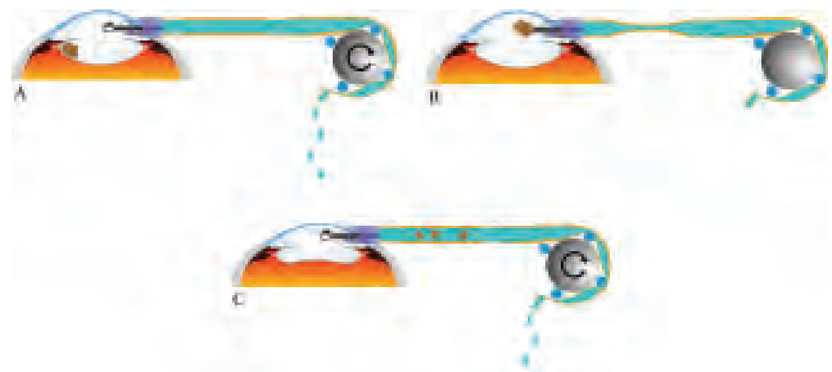


Fig. 1.10. Compliance in a peristatic system. (A) Rollers are rotating, no occlusion, no collapse of tubing. (B) Occlusion occurs, vacuum builds up, rollers stop. Negative pressure generated within the whole system, ***Tubings collapse***. (C) Occlusion breaks, release of negative pressure, tubing re-expands of the original size (this is what causes surge). ***Property of the tubing to collapse (deform under pressure) is the compliance of the tubing***.

for the rollers to be effective in a peristaltic pump. While the rollers are rotating, there is no occlusion and no collapse of tubing. When occlusion occurs, vacuum builds up,the rollers stop and negative pressure is generated within the whole system.This causes the tubings to collapse.

Property of the tubing to collapse (deform under pressure) is the compliance of the tubing.

Once the occlusion breaks, there is a release of negative pressure and the tubing re-expands to the original size. Fluid is drawn from the AC to fill up this extra volume (this is what causes surge). Though this volume is not much, it is this instantaneous withdrawal of fluid over an extremely short period of time which causes the **surge.**

This extent of collapse of the tubings will depend on the lumen size, the level of vacuum generated and the thickness of the tube. The collapse is more at higher vacuum levels and less if the lumen is smaller and the walls are thicker (less compliant tubing). Tubings of these characteristics are known as '***High Vacuum***' tubings.

SURGE

Sudden withdrawal of fluid from AC after occlusion breaks is called surge. Beyond a certain limit it may cause collapse of chamber, jeopardizing the vital structures of eyes and making the surgery filled with complications. In fact modifications introduced over a period of time have taken place to manage this surge and thus make phaco surgery free from complications. If there was no surge, any one could have mastered phacoemulsification. To maintain a constant volume and IOP of the AC, inflow, i.e. infusion has to be equal to outflow, which is the sum of aspiration by pump and the wound leakage. For a given bottle height inflow is constant and so is the leakage. The only variable parameters left in the above equation are the aspiration flow rate and the vacuum, i.e. the outflow by aspiration.

Relationship between vacuum, surge and flow rate

Suppose at 25 cc/min FR and 200 mmHg vacuum setting one is getting the surge beyond acceptable limit. Now he has two options—either reduce the flow rate or the vacuum.

Decreasing the AFR has a direct and linear effect but increases the

rise time and makes the procedure slower, which may not be such a disadvantage to a beginner. On the other hand decreasing the vacuum will decrease the holding power which is not desirable in steps like chopping/phaco-aspiration of a hard cataract. So it is better to lower the FR in such a situation to decrease the surge, while maintaining high vacuum. On the other hand, in situations where a firm hold is not so important like ***divide and conquer*** technique, soft cataracts or epinuclear plate removal, one can lower the vacuum settings to decrease the surge while maintaining the AFR.

CONTROL OF SURGE

There are various methods of controlling the surge. Some are incorporated into the newer machines and there are some measures that the surgeon can apply.

Surge prevention by the machine

In a peristaltic machine, apart from the high vacuum tubings and use of cassettes (to decrease the compliance of the tubings) there are a few more methods of decreasing surge.

1. Venting (Fig. 1.11)

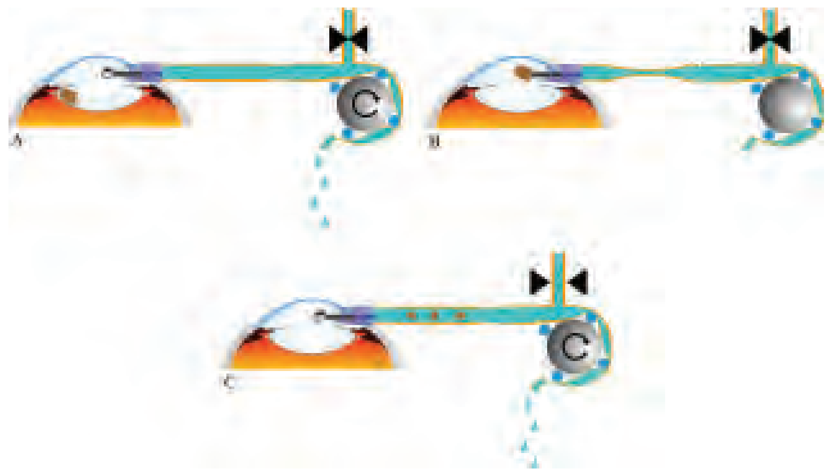


Fig. 1.11. Venting. (A) No occlusion, valve closed, tubing normal, pump rotating. (B) Occlusion, valve closed, vacuum build up, tubings collapsed. (C) Occlusion broken, valve opens momentarily, provides fluid/air to overcome collapse of tubing, thus preventing the withdrawal of fluid from AC and surge.

In this, the machine has a sensor which detects occlusion break and releases fluid/air into the system to fill the volume of the re-expanding tubing. This prevents fluid being drawn out of the AC.

2. Delay in start of the motor following occlusion break

Here, following occlusion break, start of the motor is delayed till the expansion of the tubings is complete.

3. Differential FR/vacuum settings before and after occlusion

Some machines have an option of setting different FR and vacuum settings which the machine can switch to after occlusion break. The vacuum and AFR are decreased for a short period of time as soon as the occlusion breaks, to decrease the surge. Once the piece has been aspirated, the settings then revert to whatever had been previously set.

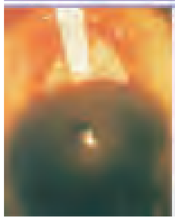
Surgeon's Control of Surge

1. ***Decreasing the effective flow rate:*** Without changing the actual setting on the machine, the surgeon can decrease the effective FR by using a smaller bore aspiration port, e.g. Microflow tip.
2. ***Increasing the infusion*** by raising the bottle height or using a TUR (Transurethral resection) set may be useful in some cases.
3. The use of an ***ACM*** is useful for decreasing surge (especially for beginners).
4. ***Proper wound construction:*** A leaking wound will disturb the equilibrium of the chamber so that even a very small amount of fluid withdrawn can cause it to collapse. This highlights the importance of making a good main wound and side port. The wound construction should be such that it conforms to the tip that you are using, i.e. 2.8 mm is usually good enough and anything larger, i.e. 3.2 mm may cause a leaky wound. Premature entry also results in a leaking wound. Distortion of the wound, i.e. with the IA handpiece may cause a leak too. Too tight a wound or too long a tunnel can also cause a problem by reducing the inflow. Thus both a leaky or too tight a wound can increase the surge.
5. ***Increased viscosity of the AC contents:*** The flow rate settings are for clear fluids like BSS/Ringers. A thicker fluid increases the resistance and does not flow out easily. The use of visco-elastic

substance (VES) can cause a decrease in the effective FR and thus decrease the surge. The commonly used VES, methyl cellulose does not alter the vacuum or the rise time but decreases the post occlusion surge. This is particularly useful in hard cataracts where the settings are usually high and while aspirating the last nuclear fragment. It is wise to inflate the bag with methylcellulose to avoid post-occlusion surge as the last piece goes in.
6. ***Partial occlusion of the tip:*** Partially occluding the tip with another piece before the occlusion breaks and the occluding fragment gets aspirated, ensures that any surge that occurs will be used to draw in the next piece to occlude the tip. This will maintain occlusion and prevent fluid from the AC being aspirated.
7. ***Foot control:*** Above all, good foot pedal control is of paramount importance in controlling surge and utilizing it to your own advantage. If one can anticipate the events then surge control is not a problem. That is why experienced surgeons can operate on any settings and any machine. In a peristaltic system, the surge will depend on the FR and the collapse of tubing at the time of occlusion break. As soon as the occlusion is about to break (i.e. the piece is about to be aspirated into the tip) is the surgeon lifts the FP to IAo (or completely in CIM), the piece will go in on its own momentum and without any of surge as the FR will decrease. Thus fluid withdrawn from the AC will be very little to overcome the compliance of the system. However, if the FP is withdrawn too early and there is not enough momentum then it will take more time to build up vacuum again. This balancing between the AFR, vacuum and the momentum of the pieces needs to be done very carefully, it is ideal to bring the FP to a position where the surge is decreased without breaking the momentum.

However, it must be kept in mind that since there are so many variable affecting surge, it may not always be present to the same extent in every case. It may vary from day to day depending on the type of cataract and settings being used but good FP control will ensure safe surgery in all circumstances.

CHAPTER 2



Incisions and Wound Construction

A small incision as far away from the centre of the cornea as possible, with no gape and no sutures is closest to the ideal incision and will induce least post operative astigmatism.

APPLIED ANATOMY

The surgical limbus is a zone of 1–2 mm, marking the transition between the sclera and the cornea. The anterior limbus is bluish and the posterior limbus is whitish in color.

It is important to keep in mind the curvature of the corneal dome, **both** in the vertical direction (from limbus to the centre of the cornea) **and** in the horizontal direction (from side to side) while advancing the knives, to maintain the correct planes.

Astigmatic Neutral Funnel (Fig 2.1)

The concept of an astigmatic neutral funnel was derived from 2 mathematical equations:

- Corneal surgically-induced astigmatism is directly proportional to the cube of the length of the incision.
- Corneal surgically-induced astigmatism is inversely proportional to the distance of the incision from the centre of the cornea.

Keeping this in mind, the concept of an ***astigmatic neutral funnel*** has evolved. The mouth of the funnel is 3 to 3.5 mm at the limbus and it flares out as we move posteriorly. Making the incision within this funnel will result in least astigmatism. The shape of the incision may be '***Frown***' (convex towards the limbus), '***Smile***' (concave towards the limbus) or '***Straight***'. For the same chord length of incision and at the same distance from the limbus, a convex incision would extend slightly outside the funnel followed in decreasing order by straight and concave. **Wound gape due to sagging** of the wound is also in the same order.

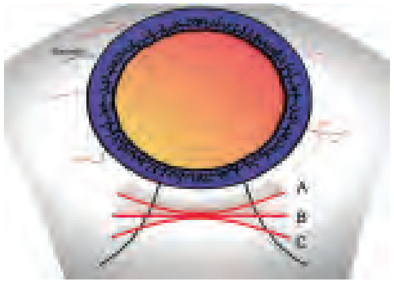


Fig. 2.1. Astigmatic neutral funnel. Note that for the same chord length and at the same distance from the limbus, amount of incision falling out of astigmatic neutral funnel is least in frown and most in concave. A = Concave towards limbus; B = Straight line incision; C = 'Frown' incision convex towards limbus.

Self-sealing incision

(Figs. 2.2A & B)

The advantage of a self-sealing incision, not requiring sutures is obvious. The features of an incision that make it self-sealing are:

- Creation of a corneal valve
- Square incisions are self-sealing

It is the inner corneal lip of the wound that functions as a valve. With the normal IOP of the eye, this lip gets pushed up against the

Fig. 2.2. Corneal valve. (A) Valve open. (B) Soft corneal lip acts as a valve and is closed by the IOP. More the IOP the better is the valve action.

dome of the cornea thus sealing the wound. Usually 1.75 mm is adequate for the formation of a good corneal valve, with an incision of upto 4 mm. The corneal lip needs to be of adequate length ***all along***; a ragged or irregular corneal lip will not function as a good valve. The larger the corneal lip, the better the sealing action. However, you must keep in mind that enlarging the lip more than 2 mm results in encroachment onto the centre of the cornea which can decrease the visibility for the rest of the surgery. When planning for a 5.5 mm optic IOL, a slightly larger corneal valve is required. In these cases, one should start the incision a little more posteriorly.

INSTRUMENTS

15 degree blade/MVR blade, keratome (2.8 mm to 3.2 mm and 5.2 mm) and crescent knife are needed.

PRE-REQUISITES

Sharp instruments and a tense eyeball are the pre-requisites for good incision. Exchange aqueous with Viscoelastic substance (VES) from the side port to obtain adequate IOP of 30 mm Hg before starting the incision.

SIDE PORT INCISION (SPI)

Location of SPI should be 2 to 3 clock hours away from the main incision.The size of the side port should be 1 to 1.5 mm. A clear corneal square tunnel is preferable. A scleral tunnel would not only bleed more, but also increases the incidence of iris prolapse, being closer to the iris root. The sclera also does not swell, rather it retracts increasing the incidence of wound leak.

A 15 degree blade/MVR blade may be used. Enter with the knife pointed towards the ciliary body 150 degree to 180 degree away creating a uniplanar 1.5 mm × 1.5 mm square tunnel. Counter pressure by a toothed forceps/chopper can be applied on the other side to assist this. A larger tunnel would lead to iris prolapse and unstable chamber. A tight tunnel leads to localized corneal whitening or edema.

SCLERAL TUNNEL/SCLERAL POCKET

Scleral tunnel is more forgiving and useful for PMMA IOLs.An ideal tunnel would be square, self-sealing, lying within the astigmatic neutral funnel, which has a minimum width of 3 mm in the center and flares out at the periphery. A 1.75 mm corneal lip is maintained all along the incision, parallel to the limbus. A depth of 1/3 to 1/2 thickness of sclera is ideal (300 μ to 500 μ).

Technique

Make fornix based conjunctival flap. Apply light cautery.

Initial groove

The initial groove is made with a 15 degree blade or 11 No. blade. This groove is 1.5 mm away from the limbus at the centre and at about 1/2 scleral thickness depth (500 to 600 microns).

Making the tunnel (Figs. 2.3 and 2.4)

The tunnel is constructed with a sharp crescent knife. Engage the tip of the crescent knife in the center of the groove at adequate depth (300-400 micron) and advance the knife from **outside in** with slight sideward movements. Once initial central tunnel is made, the knife is moved from **inside out** to extend the tunnel. Corneal dissection is much easier than scleral dissection. The corneal valve must be 1.75 mm long and circumferential to the limbus.

Put VES into the tunnel to assist in visualizing the extent and shape

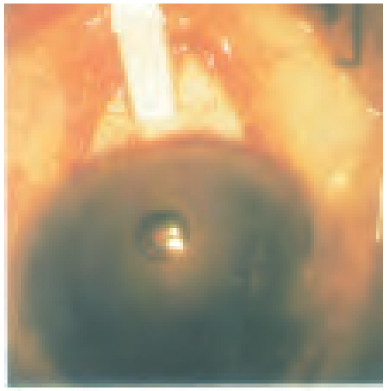


Fig. 2.3. Going 1 mm into sclera with an outside-in motion centrally.

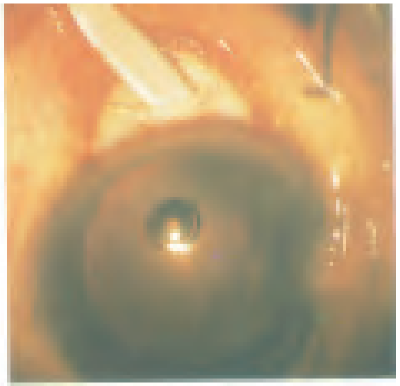


Fig. 2.4. Extending onto one side by inside-out motion.

of the internal end of the tunnel. VES also lubricates the passage and prevents the knife from getting caught in the bed. Lift the scleral lip with the help of a rounded repositor or forceps, and gently introduce the keratome with side to side movement. Change the direction of the keratome by lifting the handle so that the tip now points towards the opposite ciliary body. This will create a dimple in the cornea before perforating. Once the tip perforates the cornea, turn the handle downwards to make the blade parallel to iris plane or even tilt a little upwards and advance further. If the direction of the keratome isn't changed immediately after perforation, the corneal valve assumes a triangular configuration with 1.75 mm length in the centre and much less on the sides.

CLEAR CORNEAL INCISION

Phacoemulsification under topical anaesthesia is more convenient with a corneal incision since cautery, which is quite painful, is not required.

The temporal approach is specially suited for a clear corneal incision since the horizontal diameter of the cornea is usually 1 mm more than the vertical and the tunnel interferes less with the visibility. The other advantage of the temporal incision are ease of surgery, especially in deep set eyes, where the eyebrow and supra-orbital margin can interfere with the movement of the probe. There is less pooling of fluid in fornices, better red reflex and less chance of oar-locking of instruments in the temporal approach. However, *temporal scleral incision* is not recommended since it is cosmetically unacceptable.

Types of Corneal Incision (Figs. 2.5–2.8)

- Triplanar
- Biplanar
- Uniplanar
- Hinged

Sharp instruments and pressurized eye are two essential requirements for any incision, corneal or scleral.

Triplanar incision

The initial vertical cut is made with a No. 11 blade or a 15º knife. The

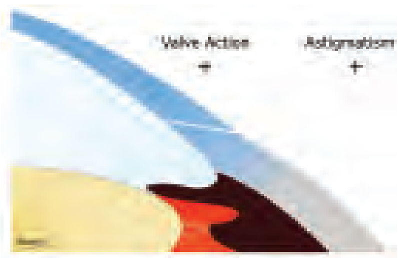


Fig. 2.5. Uniplanar incision.

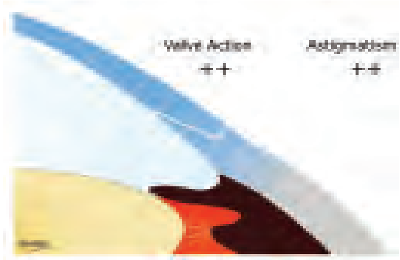


Fig. 2.6. Biplanar incision.

Fig. 2.7. Triplanar incision.

Fig. 2.8. Hinged incision.

cut should be 500 μ deep and 3–3.5 mm in width. The dissection is done with a crescent knife. Inner lip is straight and parallel to the initial incision. Then, viscoelastic is injected into the tunnel and AC entered with 3.2 keratome. Advantages of this incision is that it is a well controlled incision with an excellent valve.

Hinged incision

Initial groove is 600 μ or more and the tunnel is made at 300 μ as in the triplanar incision. The valve action is considered to be better.

Biplanar corneal incision

After the initial groove, the keratome is used directly to make 1.75 mm corneal valve and then the direction is changed to enter the AC (no crescent knife is used).

Unilplanar clear corneal incision

Incision is made in a single plane.The post-operative irritation is reduced. However, the outer flap is very thin and tends to roll into the tunnel with the introduction of phaco probe (this may result in corneal burn). It is also very difficult to control the course of the incision.

I personally feel that the beginners should initially start with ***triplanar*** incision. Once the surgeon is comfortable with the feel of tissue, he can shift to ***biplanar*** incision. ***Uniplanar*** incision is not recommended except in expert hands.

LIMBAL INCISION

Incidence of endophthalmitis is more with clear corneal incision (CCI) than with scleral incisions. A limbal incision, is a good compromise between a clear corneal and a posterior limbal incision. Incision should be made at the limbus with minimal oozing, if at all and minimal disturbance to the conjunctiva. Bleeding usually stops by the end of surgery and chances of corneal burn are less (particularly in hard cataract).As in CCI, the incision may be uniplanar/biplanar/triplanar or hinged.

Modified temporal limbo-scleral incision

This incision is a modification of *temporal limbal triplanar* incision for a PMMA lens.

The site of the initial groove is the same as for ***limbal incision.*** Incision should not cut the conjunctiva in the central 3 mm, to avoid chemosis. Aim for a tunnel approximately 2 mm long. Enlargement of incision is done in the same way as for scleral tunnel for insertion of IOL.

Problems of corneal and limbal incisions

1. Torn edges

They are very common with a corneal tunnel, particularly during the enlargement. This is due to failure to understand the curvature of cornea. While advancing the knife, beginners tend to lift up the flap and concentrate on the tip of the keratome. In such a situation the shoulder of the knife may cut the edges of the external wound. During entry one should press the shoulder of the knife ***downwards*** against the floor of tunnel (to flatten the curvature) and point the knife slightly upwards. Once the shoulder has passed the external wound concentrate on the internal wound enlargement.

2. Premature entry

Much more common in clear corneal incision because of the use of sharper knife. It is most frequently seen in uniplanar incision.

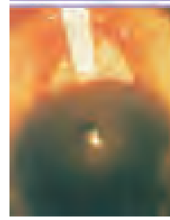
3. Long tunnel

Commoner in soft eyeball like myopes/inadequate viscoelastic and more so if the knife is blunt.This is because it is difficult to penetrate the cornea in a soft eye.

4. Leaky wound

Increased length of the incision and premature entry are major causes of leaky wound. To avoid this, do not put the entire keratome inside, just go upto the shoulder of the knife. If AC is not too unstable, cataract is not too hard and pupil not too small; one can proceed to phaco from the same port. In case of a leaky wound with iris prolapse it is best to close this incision and make a fresh one to continue with the surgery.

CHAPTER 3



Continuous Curvilinear Capsulorrhexis

The single most important development that has made Phaco and Small Incision Cataract Surgery popular is Continuous Curvilinear Capsulorrhexis (CCC). The continuity of CCC gives strength to the capsule to withstand wide fluctuations in IOP as well as bombardment with the phaco probe and nuclear fragments. This facilitates posterior chamber phaco, which helps to safeguard the cornea.

APPLIED ANATOMY

The capsular bag is 10 to 11 mm in diameter. The thickness of the capsule varies in the different parts. Zonular fibers are attached to the lens capsule in a criss-cross pattern at the equator, anterior and posterior surface of the lens, and leave about 6–7 mm of central capsule clear. The anterior capsule is a basement membrane with a lining of proliferating epithelium. The young anterior capsule is very elastic i.e. it stretches a lot before tearing. With advancing age the capsule becomes firmer. Between the age of 40 to 60 years it is usually easiest to handle. On further maturation, it may become atrophic or fibrotic, with or without calcification. Calcification is very common with hypermature, morgagnian absorbed cataract. In the hard nuclear cataract the capsule tends to be atrophic.

PHYSICS OF CAPSULORRHEXIS (Figs. 3.1, 3.2)

Types of force

1. **Ripping:** Using a ripping motion, the tear obtained will be uncontrolled. Since many fibres are pulled, all at different angles and with differing force, the break-point will not be simultaneous and thus the tear will be uncontrolled.
2. **Shearing:** In this, one fibre is broken at a time. Thus the tear is more controlled and requires much less force.

Fig. 3.1. (A) With the application of force (red arrow), the fibre stretches and then breaks. The blue zone denotes the stretch of the fibre. (B) **Ripping force:** When the same force (red arrow) is applied to a sheet of fibres, there is varying force on the different fibres which stretch and break at different sites resulting in an uncontrolled uneven tear. (C) **Shearing force** causes stretch of one fiber at a time, a controlled tear is obtained.

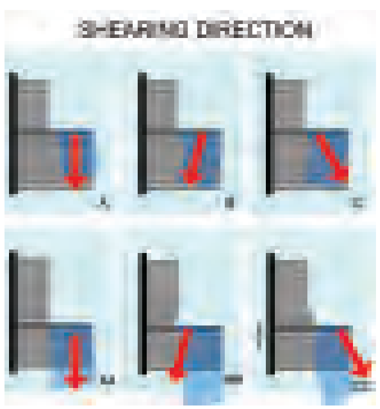


Fig. 3.2. Direction of shearing force – by varying the direction of force (red arrow) the direction of the tear can be controlled.

Tangential force

(Figs. 3.3, 3.4, 3.5, 3.6)

A line perpendicular to the radius at any point on a circle is the tangent at that point. Any force applied in this direction is **Tangential Force**. The direction of tangential force is continuously changing. Movement of the needle should be curvilinear along the proposed margin of CCC (nearly super-imposing).

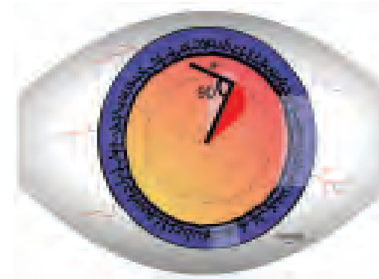


Fig. 3.3. ARrow shows the direction of tangential force 'F' to be applied.

SIZE OF CCC

The CCC should cover the optic of the IOL by 0.25 mm circumferentially

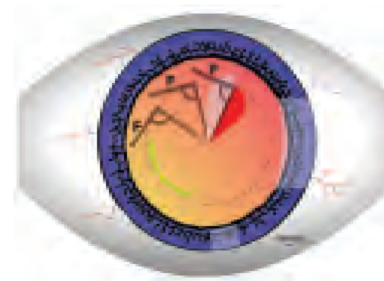


Fig. 3.4. Note the direction of force 'F' is continuously changing as the CCC proceeds.

INSTRUMENTS

Cystitome

The cystitome is usually made out of 26 G needle by turning the tip twice. The first turn is at the bevel which may be turned out (more common) or in by 70º.The second turn of the needle at the junction of the hub and the needle. This may be by 60° or according to the convenience of the surgeon.

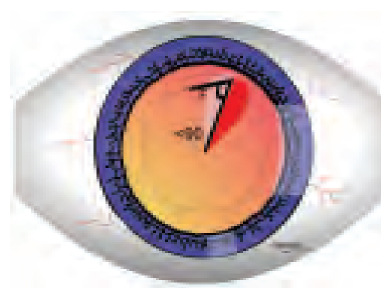


Fig. 3.5. The size of CCC can be reduced by decreasing the angle of the force applies to less than 90 degrees.

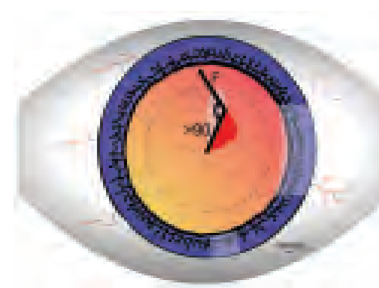


Fig. 3.6. The size of the CCC can be increased by increasing the angle of the force applied to more than 90 degree.

Forceps

A good Utratta forceps is an essential instrument for all phaco surgeons.

PRE-REQUISITES

The pre-requisites for a good CCC are:

1. Good akinesia
2. Moderate hypotony: For phacoemulsification, moderate to minimal hypotony is required. The eye should not be very soft (as required for ECCE) since nucleotomy becomes difficult.
3. Good red reflex: Following measures should be taken for a good red reflex:
   - The lipid layer of the tear film is removed by scrubbing with a betadine-soaked swabstick and washing with BSS simultaneously.
   - Position the eyeball and head in such a way so as to obtain a good red reflex.
   - The pupil should be well dilated with mydriatic. We routinely use intra-cameral adrenaline in a 1 : 10 dilution.

TECHNIQUES OF CCC

CCC can be done either with cystitome or forceps or a combination of the two. The aqueous in AC should be totally replaced with viscoelastic till the lens-iris diaphragm moves backwards and the chamber is flat/ concave in centre. Approximate IOP should be 25-30 mmHg. **Under no circumstances should rhexis be done in a shallow AC with a convex lens-iris diaphragm.**

NEEDLE CCC

Rhexis can be done from the main port or side port. Advantage of side port rhexis is that there is no leakage of viscoelastic, but there is less maneuverability. Rhexis from main port obviously means better maneuverability, but there is more leakage and one needs to keep reforming the chamber

Initiation

The cystitome is mounted on a viscoelastic filled syringe.

Linear cut

The needle is kept vertical at the exact centre of the pupil. Press it gently downwards to perforate the capsule. Move in a linear fashion towards the right creating a cut of approximately 1.5 mm in length. Linear extension can also be done by multiple punctures as in 'can opener technique' from uncut to cut area.

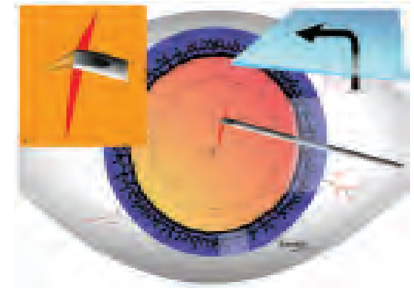


Fig. 3.7. Lift the flap by placing the cystitome at the junction of the central 2/3rd and the outer 1/3rd of the initial cut (inset 1) and lifting up and then pushing the flap down (inset 2 showing direction of force). Correct application of forces will result in a curvilinear extension of 1–1.5 mm as shown by the dotted line.

Raising the flap (Fig. 3.7, 3.8)

The needle is then brought to the junction of medial 2/3rd and lateral 1/3rd of the cut. Put the needle under the cut edge and try to lift the cut edge ***up towards*** the ceiling. Snap open the flap. The initial force will be directed towards the ceiling and as soon as you get the feeling of give-way then turn it down, giving a curvilinear extension of approximately 1 mm. Now the cut end is approximately 2.5 mm from the centre and if the rhexis is continued parallel to the pupillary border, it will be 5 mm in diameter.

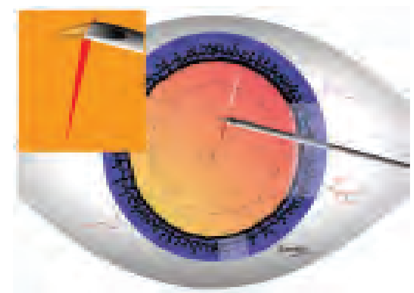


Fig. 3.8. Problems in initiation – if the flap is lifted from the periphery of the initial cut (inset), the tear will go to the periphery instead of making a curvilinear extension.

Problems in Initiation

1. While trying to make the initial cut, the needle must not be pushed too deep into the cataract as this disturbs the cortical fibres, which then interfere with the visibility of the cut edge. While attempting to lift the flap also one has to take care not to disturb the cortex.
2. At times the needle edges are not sharp and instead of a single linear cut, a triangular tear is obtained. A triangular flap will have

an upper and lower edge. If both these tears are equal and not very large, then the tear close to the incision may be extended towards the periphery and turned downwards to create a flap for CCC, so that the other tear will get incorporated into the flap.

Continuation of CCC (Figs. 3.9, 3.10, 3.11, 3.12, 3.13, 3.14, 3.15)

The flap is turned over such that the anterior surface of the flap is touching the intact capsule. This can be achieved by either pushing it over with the cystitome or using VES, or a combination of both. At this point, it is to be emphasized that you need to have a mental picture of your proposed CCC with relation to the pupillary border before progressing.

The needle is kept on the line of proposed CCC approximately 1 mm away from the cut end, for good control. To initiate the movement, the flap is gradually stretched such that there is a tactile feed back before it gives way and tears. If the needle is too close to the cut end, it tears too soon and you are not able to maintain control. If you keep too far away, applying a tangential force is difficult and you loose control of the direction. Normally in one push, you can achieve 1–3 clock hours of CCC. The flap should be flat without any wrinkles. Beginners may need to repeatedly flatten the flap It may need over 6–12 strokes for completion. The needle should be kept lightly on the flap.

As in driving, you watch the road and not the steering wheel, similarly, after positioning the needle, concentrate on the movement of the advancing end of the CCC and do not look at the needle.

Subincisional CCC

When the CCC reaches sub-incisional area there are some problems. Visibility is poor due to the corneal tunnel. The flap is now large and tends to flow out of the section. There is less space to maneuver the instruments. Take the flap well away from the incision and spread it so that it lies towards the centre with the edge lying flat over the uncut capsule.

If one finds it difficult to complete the CCC, one can finish the rhexis with forceps or use the side port for completion of CCC with the cystitome. CCC is completed from outside-in to have a perfect round CCC.

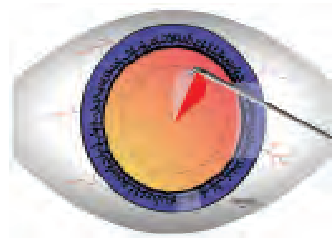


Fig. 3.9. Turning the flap—The flap is turned over so that it lies on the uncut surface of the capsule.

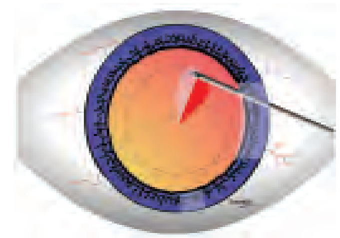


Fig. 3.10. The flap is moved so that the cut edge lies beyond the proposed line of CCC.

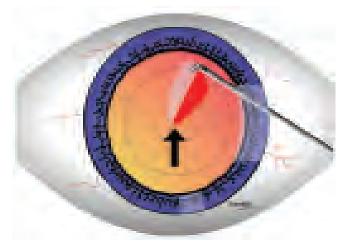


Fig. 3.11. If it is not moving, release at the center so that it can move.

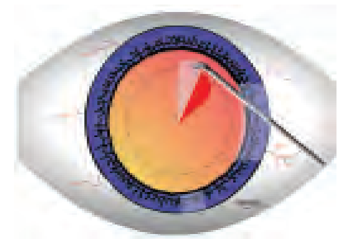


Fig. 3.12. Shearing force is applied such that the flap moves on or parallel to proposed line of CCC.

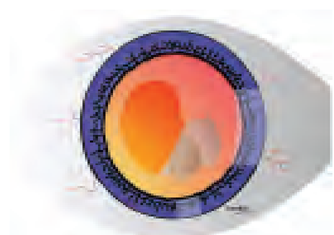


Fig. 3.13a. As the CCC progresses, the flap will enlarge and get crumpled.

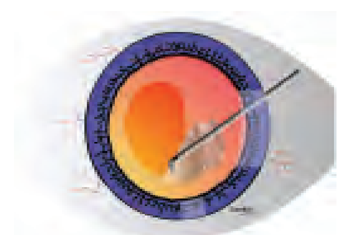


Fig. 3.13b. The flap must be smoothened out before advancing. Note that the corner of the incision is used for correct placement of the cystitome.

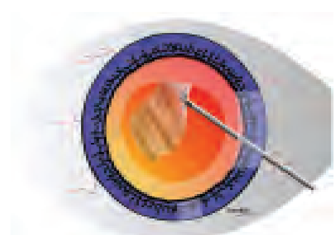


Fig. 3.14. As the CCC nears completion, the large flap tends to flow out of the section obscuring visibility. Reposit the flap towards the center so that the endpoint is clearly seen.

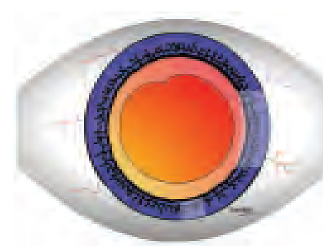


Fig. 3.15. Complete the CCC from outside-in.

FORCEPS CCC

The biggest disadvantage of the forceps is that it causes wound leak and distortion of the cornea. It is particularly difficult to use if you are using low viscosity viscoelastic, e.g. methylcellulose. Also, when initiating the CCC, the puncture may not be as comfortable with the forceps so it is better to initiate with the needle and then continue with forceps. The biggest advantage of the forceps is that the grip on the flap is very good and no counter pressure is required. Also it is easier to change the direction of the flap. Forceps is particularly useful in fibrotic, atrophic and elastic (i.e. pediatric) capsules and in soft cataract with high intra-lenticular pressure (morgagnian and intumescent) where one is not able to get a good counter pressure. Posterior CCC and pediatric cataracts are not possible with cystitome and require use of forceps.

Technique (Figs. 3.16, 3.17)

The ideal grip on the flap is close to the leading edge with one tooth on the undersurface and one tooth on the anterior surface of the flap. After making the initial quadrant one should release the flap in a way that it is in a suitable position for holding again (i.e. the torn edge should always be pointing to the incision site).

Fig. 3.16. Two clock hours of CCC completed. Note the cut end of the CCC parallel to the pupil.

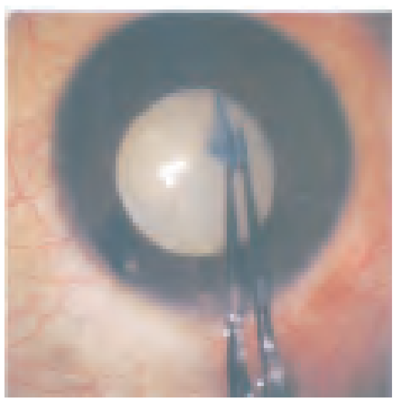


Fig. 3.17. Before leaving the flap, it needs to be positioned for the next grip such that it is lying radial to the pupillary border.

Loss of control of CCC

Why we lose control

As soon as the capsule is opened, there is a tendency for the lens to be propelled out. This happens because of multiple factors, one of the most important factors is intra-lenticular pressure (ILP). ILP depends upon the fluid content of the bag and is therefore high in childhood and intumescent cataracts, whereas it is low in nuclear cataracts. Other factors which tend to push the nucleus out of CCC include vitreous upthrust, scleral rigidity, orbital fat in obese patients, tone of the rectus muscles, micro-retrobulbar haemorrhages, pressure by the lid, wire speculum and bridle sutures. These factors may also cause extension of CCC to the periphery.

Initial large cut, keeping cystitome too peripheral for snap opening of capsule, not positioning and spreading the flap properly, not holding from undersurface of the flap, not regrasping at appropriate time and allowing the shallowing of the anterior chamber may lead to peripheral extension.

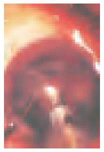
Application of wrong forces (cutting, ripping) or the right force in wrong manner, are major causes of extension of CCC in the hands of beginners.

How to regain control

Identification of the exact location of the cut edge is absolutely essential. **DO NOT PANIC.** Deepen the AC, preferably with Healon GV. Identify the cut end. If need be stain the capsule under healon or under air after complete removal of the viscoelastic by irrigation and aspiration.

Bringing the Rhexis in

If you want to turn the wheels of a standing car it is far more difficult than turning the wheels of a moving car.Wherever the cut end is, you should initiate a large rhexis at the same diameter. Once the rhexis has started then turn and bring it in. (Do not try to pull and bring it in – will cause an uncontrolled ripping force).



At times, zonular fibers which are more stretchable and do not break easily may cause difficulty in bringing the rhexis margin in. In such a situation, one may cut the zonular fibers in front of the cut end by cystitome/sinsky hook by approximately 2 mm to bring rhexis in.

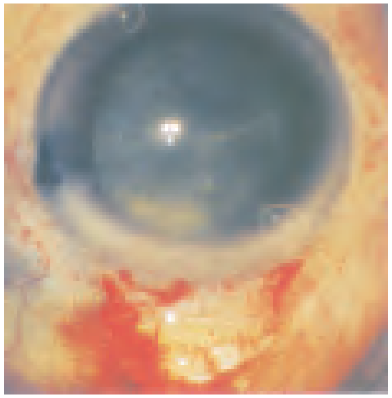


Fig. 3.18. Creation of T making two flaps.

Starting at a new point

Starting at the rhexis margin: If we are not able to bring the rhexis in, then we need to start from the other end. Put a rounded repositor under the intact rhexis for counter pressure and cut with a needle on top of it. Alternatively, coaxial scissors can be used for raising the flap. For this we need to make a second sideport incision for easy accessibility.

Starting afresh at the anterior capsule (Fig. 3.18)**:** Making a T cut – create a horizontal flap and cut with Vannas in the middle. You will get two flaps which you can extend on both the sides.

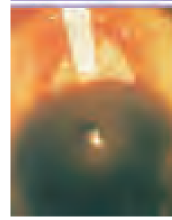
DYES IN CCC

Trypan Blue is commonly used for staining the capsule. Dyes are indicated in cases where the visibility of anterior capsule is poor like in hypermature and morgagnian cataract. Some beginners find it easy to perform CCC under dye even in immature cataract. This could be of use in immature cataract if the operating microscope does not have co-axial light. Dyes are not a substitute to learning to do good CCC.

Technique

To prevent corneal staining, inject air into AC through the side port. Trypan blue is taken in a syringe with 27 G cannula. Go beneath the air bubble to center of the capsule and inject. Keep spreading the dye on the capsule. Make sure that whole of capsule is adequately covered with the dye. Now replace the dye with viscoelastic by starting the injection from the cross-incisional area. This will push both the dye and air out of the side-port incision.

CHAPTER 4



Hydroprocedures

The aim of hydroprocedures is to divide the cataractous lens into 3 distinct zones. Each zone requires to be removed in a specific way and separation facilitates this removal.

The three parts of the lens are:

(a) Capsule with or without cortex

(b) Epinucleus

(c) Nucleus

Separation also ***facilitates rotation***, so that the nucleus and epinucleus can be rotated and brought into the direct line of attack. The Epinuclear plate created acts as a ***cushion, protecting*** the PC during phacoemulsification. Hydrodelineation also decreases the size (horizontal diameter) of the nucleus, thus enabling ***prolapse of nuclear fragments*** out of the rhexis margin, into the Central Safe Zone (CSZ) for phaco aspiration.

INSTRUMENTS

The instruments required for this step consist of a syringe and cannula. The syringe may be glass or plastic and of 1–2 ml capacity. A 2 ml syringe gives a good grip and adequate amount of fluid for injection. Glass syringes are usually smoother and easier to use, though, if it is an ill-fitting piston, there may be fluid leak. It is a good practice to use the same type of syringe and capacity every time, to get accustomed to the feel while injecting. This tactile feedback of the movement of the plunger is particularly important when you cannot see the wave as in cases with poor glow or small pupils. The cannula may vary from 26-30 G. A 27 G cannula (the one with Healon packing) is ideal; it may be straight or bent.

HYDRODISSECTION

Hydrodissection is the separation of the cataractous lens from the capsule by a mechanical fluid wave.

Pre-Requisites

The first step is to partially **remove the viscoelastic** from the chamber, especially if one has used higher viscosity agents like Healon GV and Healon. The fluid injected tends to move the lens forward and if there is already viscoelastic in the AC, the force will be transmitted to the posterior capsule increasing the chance of rupture.

Technique (Figs. 4.1, 4.2, 4.3, 4.4, 4.5)

Hydroprocedures are performed through the main entry.

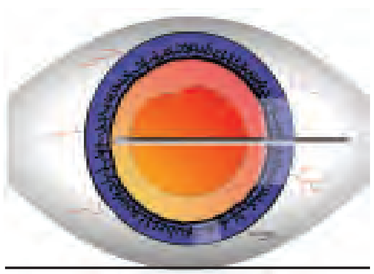


Fig. 4.1. Correct position of cannula for hydrodissection. Note that the tip of the cannula must be at least 1.5 mm under the CCC margin.

The cannula is introduced just under (2–3 mm) the CCC as close to the anterior capsule as possible. After tenting the CCC upward the fluid is injected with a jerk. If it is not injected with a jerk, the fluid tends to come back into the AC and does not form a wave. Therefore being 2–3 mm inside the CCC ensures that there is sufficient resistance to prevent regurgitation and the jerk results in a jet formation that travels as a wave beyond the equator of the lens. As the wave becomes visible along the PC, the speed of injection may be slowed down and when the wave is visible posteriorly, at the end opposite to where injection was initiated, the injection is stopped. If you are watchful you will see that

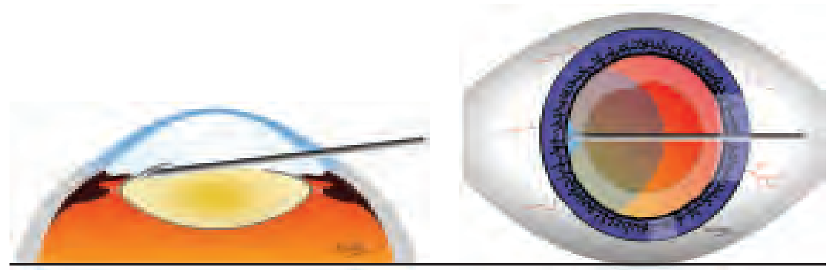


Fig. 4.2. (A) Tenting of the CCC margin before injecting with a jerk. (B) Injected fluid travels as a wave around the lens.

Fig. 4.3. Injection of sufficient fluid. CCC becomes taut, nucleus bulges forward and AC becomes shallow.

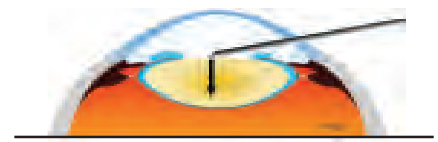


Fig. 4.4. Compression hydro. Gentle pressure in the center allows the fluid to come anteriorly and the wave to be completed on all sides

when sufficient fluid has been injected, the lens comes anteriorly, the CCC gets stretched and the AC becomes shallow. This is the ideal amount and more than this can lead to PCT (Fig. 4.6, 4.7).

Fig. 4.5. Controlled compression hydro. Nucleus is first pushed to one side and then down to allow the fluid to safely come anterior in that quadrant. The procedure can be repeated at different sites.

A gentle pressure on the centre of the nucleus will release the fluid forward and one can actually see the separation taking place from the equator to the CCC margin, this is called **compression hydrodissection**. If this is seen all round then it is fine otherwise one can press on the nucleus on the side where the separation is not seen. Pressing on the centre may increase the risk of PCT particularly in a small CCC and in cases with a fragile posterior capsule. Our preferred method of releasing this trapped fluid is to place the Sinskey hook/chopper close to the CCC margin on one side, move the nucleus to the opposite side and then press slightly downwards for release of the fluid. This sideways movement on one side increases the

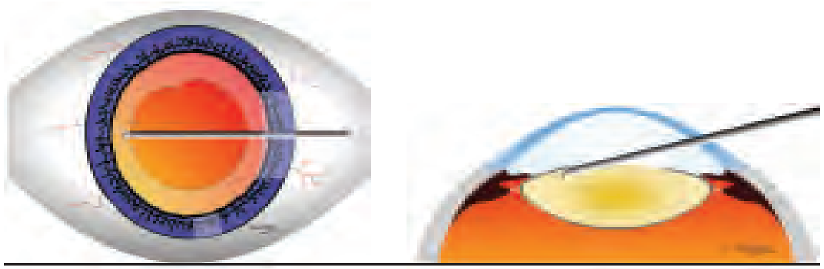


Fig. 4.6. Improper position of cannula. (A) top view, (B) side view.

resistance of outflow of fluid on that side and decreases the resistance on the same side, thus facilitating regurgitation without any pressure on the posterior capsule. This can be called **modified compression hydrodissection.**

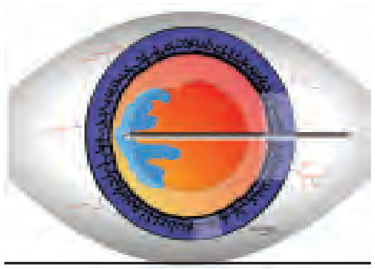


Fig. 4.7. Regurgitation of the injected fluid with no hydrodissection either due to improper placement or gentle injection.

If the hydrodissection does not appear to be complete or one has not been able to visualize the wave, hydro can be repeated at a different site. Alternatively **mini-hydrodissection**, that is injection of fluid upto the anterior and equatorial fibres, can be performed at multiple sites.

Site for Hydrodissection

If using the bent cannula, one can start 90° away from the main port. If using the straight cannula one should start 180° away from the main wound.

Special Situations

1. Small CCC (Fig. 4.8)

In a small CCC the chance of fluid entrapment under the CCC is high. It may be prudent to avoid a complete wave and instead perform mini-hydros at multiple sites. In case of a large CCC, there is a tendency for the nucleus to prolapse into the AC. You will have to reposit the nucleus back into the bag unless supra-capsular phaco is planned.

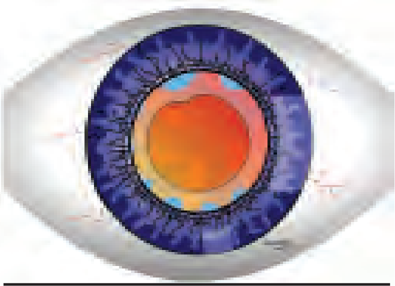


Fig. 4.8. Note small pupil and small CCC. Mini hydro performed by multiple injections note multiple small waves meeting posteriorly.

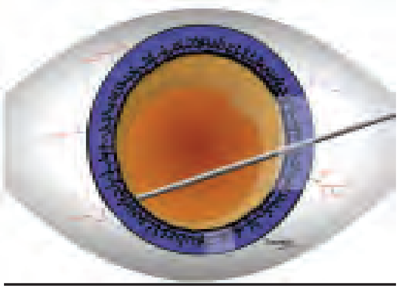


Fig. 4.9. Large eccentric CCC. Inject the fluid from the side of the CCC with the small rim to avoid the nucleus prolapsing into the AC.

2. Eccentric CCC (Fig. 4.9, 4.10)

In case of an eccentric CCC it is better to inject such that fluid can come out of the normal side without entrapment or prolapse.

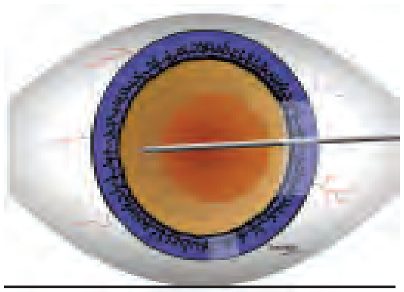


Fig. 4.10. Eccentric CCC. Inject from the side with the larger rim to prevent fluid entrapment which may cause PCT.

3. Hypermature Morgagnian cataract

These case usually require minimal or no hydrodissection.

4. Posterior Polar Cataract

No hydrodissection should be done

HYDRODELINEATION

The aim of this manoeuvre is to create the smallest possible nucleus with the thickest possible epinuclear plate. This would result in minimal use of phaco power with the maximal cushioning effect.

Technique

For hydrodelineation, the cannula is embedded into the centre of the nucleus (without pushing it backwards) and simultaneously advancing towards the CCC margin. Once well under the CCC margin, the cannula is directed slightly obliquely vitreousward and towards the periphery and fluid is injected with a jerk. No wave will be seen, and instead a golden ring reflex or a gray reflex is seen. The posterior separation is usually quicker while the anterior fibres may remain adherent which may get separated by pushing the nucleus down—**compression delineation**.

Note: The fluid must be injected *beneath* the CCC margin, otherwise the fluid injected will just regurgitate into the AC without accomplishing anything. Also, some amount of viscoelastic over the CCC may help in directing the fluid wave into the substance of the lens and delineating the nucleus.

Rotation of the nucleus

Single-handed rotation (Fig. 4.11)

After completing the hydro-procedures, one should see if the nucleus is rotating easily. For this, the eye should be well pressurised with viscoelastic. The nucleus is then rotated with a Sinskey hook or with a chopper. The instrument should be placed close to the CCC, even inside the CCC if possible, and the nucleus is pushed towards the periphery of the lens and then rotated. The common mistake is to rotate trying to bring the instrument to the centre whereas the aim should be to take the counter-pressure from the periphery. Let the whole of the nucleus and the epi-nuclear plate rotate. Rotation of 2–3 clock hours is usually sufficient to confirm the mobility. Once you see that it is moving you can rotate it back to decrease the stress on the zonules. Unnecessary rotation can cause zonular dehiscence particularly in susceptible cases such as high myopes, pseudoexfoliative syndrome and traumatic cases.

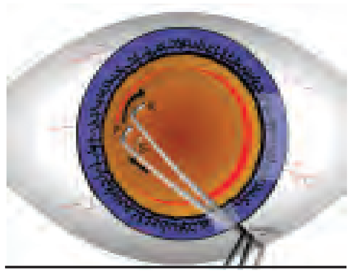


Fig. 4.11. Rotation of the nucleus: Single handed technique. The nucleus is pushed from the central position ‘S’ towards the periphery ‘P’ and then rotated ‘R’. Note the decrease in the delineation ring on the side that is being pushed.

Bimanual rotation (Fig. 4.12)

Bimanual rotation may be done with 2 Sinskey hooks or with one Sinskey hook and a chopper. Once again the eye must be fully pressurized. The 2 instruments are positioned 180° apart and should be pushed towards each other to get a grip on the nucleus. They are then moved in opposite directions to rotate the nucleus, taking counter-pressure from each other.

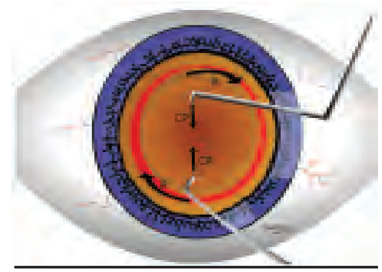


Fig. 4.12. Rotation of the nucleus: Bimanual technique – both instruments are pushed towards each other for counter-pressure ‘CP’ and then rotated ‘R’.

Non-rotation of nucleus

The nucleus will not rotate if the hydro-dissection is incom-plete. If after successfully completing the hydrodis-section the nucleus still does not rotate, especially in a hard cataract, there may be fibrous adhesions and it will be prudent not to do phaco in these cases as there is a high chance of PCT. The nucleus will not rotate easily if there is a dialysis so the surgeon should be cautious. In a soft cataract it is difficult to get a grip on the nucleus and rotation is difficult. However, in soft cataracts rotation is not always essential.

DOS AND DON’TS OF HYDROPROCEDURES

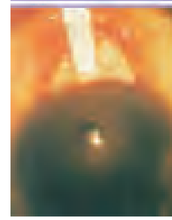
Dos

1. Remove all the visco-elastic before starting hydrodissection.
2. Inject from the main port only.
3. Focus below the CCC (between the CCC and PC) so that the wave is visible.
4. Use the same type of syringe and cannula (same brand) in each case.
5. Tent up the CCC margin before injecting.
6. Make sure the cannula is radial to the CCC and well inside the CCC (3 mm).
7. Start injecting with a jerk and slow down once you see the wave.
8. Inject an adequate amount of fluid.

Don’ts

1. Use the side port for hydroprocedures.
2. Use a very large syringe/sticky syringe.

CHAPTER 5



Nucleotomy

The purpose of this step is to remove the central core of the nucleus, piece by piece, using minimum phaco energy and without damaging the surrounding structures especially the cornea and the posterior capsule.

APPLIED ANATOMY

The increasing density of the nucleus in old age also results in a downward (more posterior) placement of the densest part of nucleus. Thus the trench has to be almost 90% of the thickness of the lens if a complete crack is to be obtained.

The greater curvature of the lens posteriorly is of special relevance to the phaco surgeon. It is important to note that this curvature varies, achieving almost a conical shape, as the age of the patients increases and the lens gets harder. The movement of the phaco probe while trenching ***must*** follow this curvature if adequate depth is to be achieved and capsular injury is to be avoided. The red reflex may be visible from the periphery even in a shallow trench so one should change the direction of the probe accordingly.

INSTRUMENTS

1. Phaco Tip

The phaco tip is a vital instrument for nucleotomy. Various types of tips are available. Most tips are made of titanium. All the tips must have a tapered hub. This reduces air bubble formation in the anterior chamber. Teflon coated tips have an advantage of preventing corneal burn.

The **Standard** or regular tip is most commonly used. It has a 0.9 mm inner diameter and 1.1 mm outer diameter.

The **Microflow** tip is useful in soft cataracts especially those less than grade 3. The internal diameter ranges from 0.45 to 0.6 mm, depending upon the manufacturer. As the fluid drawn out by the small bore is less, the amount of surge is decreased allowing one to work safely at higher vacuum levels. The smaller surface area, however, results in a decreased holding power for the same vacuum as compared to a regular tip. This tip is therefore not recommended for hard and hypermature cataracts.

The **Kelman** tip has a downward angulation. This is ideal for sculpting in hard cataracts and eyes with deep AC. In a shallow AC this downward angulation increases the chances of PC damage. Beginners are advised to avoid this tip or else switch to a regular tip after the trench has been made. A modification of Kelman tip is the bell shaped **Kelman flared** tip. The wider area of this tip allows more power transmission and is, therefore, ideal for hard cataract.

The **Cobra** tip has the base of micro flow tip proximally and that of regular tip distally. This configuration enables it to aspirate a big piece and emulsify it within its walls.

2. Choppers (Fig. 5.1)

The chopper apart from actually chopping or splitting the nucleus can also be used for stabilizing the globe, rotating the nucleus, feeding the tip and even protecting the PC. The length of the vertical part of the chopper is 1.25mm+/- 0.50mm.It may be flat or rounded. Longer choppers are better for big nucleus.The tip may be blunt (good for peripheral chop), sharp (good for central chop) or hybrid (tapered-good for both).

PRE-REQUISITES

Entering the eye

Always enter after partially filling the chamber with visco-elastic.

Fig. 5.1. Various tips of choppers available.

Depress the lower lip of the wound and then introduce the metallic part of the tip. Now lift the upper lip of the wound and guide the sleeve in.

Removal of the anterior epinuclear plate

Removal of the anterior epinuclear plate helps in baring the nucleus for trenching. Use minimum phaco and a vacuum setting of 60-70 mmHg to remove the epinucleus and cortex from the central area within the CCC margins. Here, first only vacuum is tried. Any area not getting aspirated is then given a short burst of phaco energy by bringing the probe close but still keeping a safe distance from the CCC margins (0.5 mm).

NUCLEOTOMY

The most popular methods of nucleotomy are “***Divide and Conquer***”, “***Chopping***” or a combination of the two i.e. “***Stop and Chop***”. In ***Stop and Chop*** we start with a trench as in ***Divide and Conquer***, stop after the first trench and then proceed with chopping techniques.

STOP AND CHOP NUCLEOTOMY

This involves trenching, splitting, chopping and phaco aspiration.

TRENCHING

This step is of vital importance for the ***Stop & Chop*** and ***Divide & Conquer*** techniques.

Dimensions of the Nucleus

Pre-operative assessment of the hardness of the cataract by slit lamp examination, keeping the age of the patient in mind is must. The intra-operative size and reflex of the delineation ring is important indicator: larger delineation ring indicates a larger nucleus. A grey ring, barely visible or not becoming wider on side to side movement of the nucleus is suggestive of a hard nucleus. The presence of a bright golden ring reflex usually indicates a soft cataract and a smaller nucleus. The other clue to the hardness of the cataract is the ease at which the probe is moving through the cataract.

Settings for Trenching

Trenching should be performed at low vacuum settings (i.e. 20 ± 10 mmHg) since we are trying to sculpt the nucleus and don't want to hold it. The power setting will depend on the hardness of the nucleus. **A practical formula that may be applied is Power = Grade of nucleus × 15 + 25**. It is better to keep the setting at the highest required and control the actual energy delivered by the foot pedal. The phaco is kept in linear mode for better control. The ideal power is that at which there is no wasting of energy and no movement of the nucleus. Bubbles in the AC are indicative of wasted energy i.e. giving phaco energy when there is no tissue in front to emulsify. Too little power or moving the probe too fast results in pushing the nucleus without cutting it leading to zonular stress. The speed of the probe should match the rate of emulsification such that no power is wasted and the nucleus is not pushed.

Length of the Trench

The length of the trench should be just short of the CCC. Once the superficial trench has been made at least a tip deep, one can go under the CCC and increase the length. If you reach the delineation margin it is called a ***relaxing nucleotomy***. There is no need to go under the CCC except in hard cataracts, very soft cataracts and in small CCC.

Width

The trench should be '2 tip diameters' wide in order to comfortably accommodate the sleeve. One may make a central groove and then widen both the sides by tilting the probe with the bevel facing the centre. It is better to widen the trench layer by layer before deepening it otherwise the sleeve may get stuck in a narrow trench.

Starting the Trench (Fig. 5.2, 5.3, 5.4, 5.5A, B, C)

It is best to start at the center of the nucleus or just proximal to the centre and move towards the CCC in the cross-incisional axis. ***There should be no occlusion of the tip at any stage during trenching***. The forward stroke consists of a shaving action with an attempt to move into the nucleus by a depth less than half the diameter of the tip. If one goes in too deep there may be occlusion of the tip. On the return stroke, care should be taken that no phaco or aspiration is used. In systems with Continuous Irrigation Mode (CIM), one can take the foot off the pedal as the AC is maintained by the CIM.

Fig. 5.2. Shaving action while trenching. To maintain the shaving action, the angulation of the tip is such that the tip is lifted up and the handle depressed using the incision as the fulcrum while moving forward.

The trench is widened and deepened uniformly with multiple strokes. The nucleus needs to be rotated to bring the sub-incisional nucleus into the cross-incisional area for better access. The eye must first be pressurized by filling the chamber with visco-elastic. The instrument (chopper or dialer) is introduced into the periphery of the trench and rotated clockwise. After gaining proficiency, the phaco probe need not be removed and the second instrument in the left hand can be used for rotating.

Fig. 5.3. Movement of tip such that less than half tip diameter is occluded.

Fig. 5.4. Complete occlusion of the tip.

Fig. 5.5. (a) 'Khurpi' action instead of 'shaving' action. (b) Repeated 'Khurpi' action leads to uneven blumps.

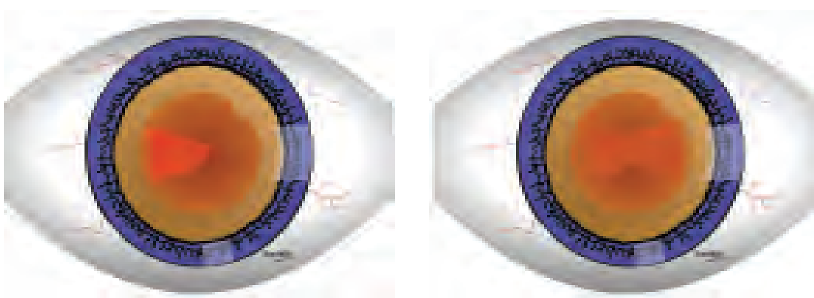
Assessment of Depth

The most important aspect of trenching is achieving adequate depth. In a moderate grade nucleus, the red reflex is usually visible in the periphery first. In order to get the same reflex in the centre one may need to rotate the nucleus once or twice. Once you are deep enough there may be a sudden '***give way***' feeling as the emulsification of the last bit of the harder nucleus gives way to the relatively softer outer nucleus.

Though most authors describe that one should be 2–3 tips deep, the visibility of the red reflex is a better guide. If the depth seems adequate, try to crack the nucleus. If it doesn't break easily then don't try to crack it as you may end up cracking the outer nucleus (exonucleus) with an intact inner hard nucleus (endonucleus). You should carefully try to deepen the trench by continuing the shaving action before attempting the splitting again.

V-SHAPED OR VICTORY TRENCH (Figs. 5.6a, 5.6b, 5.7, 5.8)

A useful modification of the trench is a '**V**' trench. In this, the initial



(a) (b)

Fig. 5.6. V-trench or victory trench.

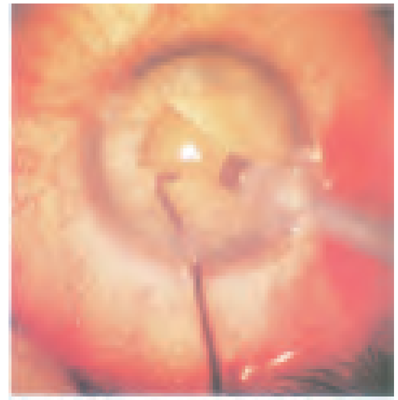


Fig. 5.7. "V" is further deepened.

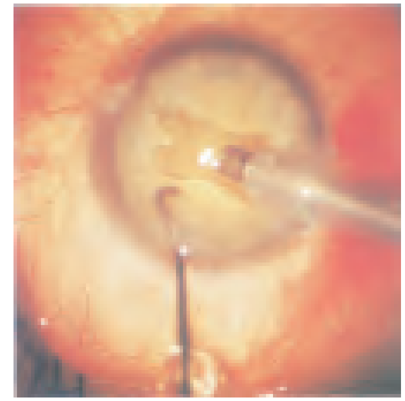


Fig. 5.8. Formation of an "X".

stroke is made slightly radially instead of in the straight axis. The second stroke is also made radially to complete a '**V**'. The trench is gradually deepened in the same shape. The nucleus is rotated and then similar strokes are made on the other side to make an '**X**' pattern. This is our preferred mode of trenching particularly in hard and mature cataracts.

SPLITTING

Before breaking, any object stretches till break-point and then breaks. How much the tissue will stretch depends on length of the tissue between the forces. If the forces are far away from each other more space will be needed. While splitting the nucleus, we need opposing forces to be closer to each other.

Fig. 5.9. Splitting the nucleus. Note the vertical placement of instruments in the depth and the direction of forces.

One should put two instruments (either the phaco probe and chopper or two choppers) as deep as possible in the trench. The instruments must be **close** together both vertically (Fig. 5.9) and horizontally (Figs. 5.10, 5.11). The force is applied in opposite directions such that the centre tends to depress slightly and periphery of the nucleus tends to lift upwards. If the centre comes forward and the periphery is depressed then the nucleus will not crack. In this case, it means that either the trench is not deep enough or the instruments are too superficially placed. It is essential that the split should be through & through and the two halves should be totally separated without any bridging fibers.

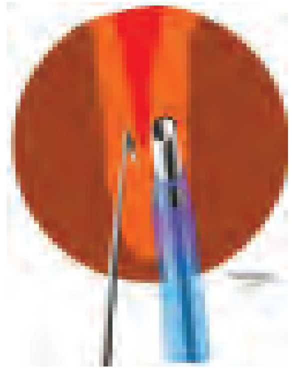


Fig. 5.10. Correct horizontal placement of the instruments.

Another method of cracking the nucleus is to position the nucleus horizontally, embed the probe into the center of the hemi-nucleus and pull with the second instrument to achieve the crack. The settings should be those of chopping and this is only applicable for cataracts harder than grade 2.

Fig. 5.11. Split extended upto the center. Splitting forces applied at the periphery will not cause any extension of the split due to wrong placement of the instruments horizontally.

CHOPPING

Chopping is a term used to denote the splitting of the nucleus into smaller pieces by a chopper. Chopping may be peripheral, central or combination of the two but most essential part of all of this is stabilization of nucleus by vacuum seal and vacuum hold.

Complete trench

In '***Stop and Chop***' technique, we split the nucleus into two halves as already described in 'Trenching'. The complete surface of the hemi-nucleus now provides a good platform for holding. Also there is sufficient space for further maneuvers. The probe can be easily embedded into the hard body of the nucleus and a vacuum seal created for chopping. Since the platform is wide, one can try an alternate site if initially a good hold is not obtained. Each hemi-nucleus can be divided

into three pieces in a safe and controlled manner.

Creation of vacuum seal and vacuum hold (Figs. 5.12a, 5.12b)

Before embarking on this step, a phaco surgeon must have good understanding of the audible and tactile feedback of the foot pedal. One should be able to maneuver the pedal between the positions of aspiration, phaco and back to aspiration and should be able to hold on

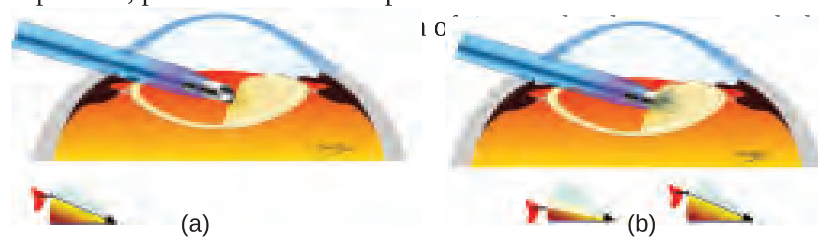


Fig. 5.12. Creation of a vacuum seal. The probe is introduced into the eye in CIM. (A) The nucleus is nudged and foot pedal brought to position 2 (IA). (B) A short burst of phaco (position 3) is given to position 2 (IA) to let the vacuum build up and create a hold.

As the tactile feedback of the dentation of the footpedal is less on upward excursion, while moving from position 3 to 2, overshoot to position 1 or 0 is common. If you have an overshoot, press the foot to pedal back position 2 and remain stable at the dentation.

The surgeon must also be familiar with the high pitched, fixed frequency sound that is emitted by the machine once the maximum preset vacuum is achieved. This indicates full vacuum and thus a good hold. Beginners can practice by pinching the tubing to occlude it with the probe outside the eye and listening for the sound.

Steps in vacuum hold

Foot Movement	Rt. Hand Movement
FP Pos. 1/Pos. 0 in CIM	Tip inside eye.
	Tip close to the nucleus.
FP Pos. 2	Nudge the nucleus.

FP Pos. 3 Bury the tip.

FP Pos. 2 Vacuum hold created.

If the impalement is adequate then on slight to and fro movement of the tip, both the tip and the nucleus piece will move as one unit. If, however, the grip is not sufficient i.e. adequate vacuum seal is not achieved, the nucleus piece will be set free. If impalement is not achieved in one area, move to another site and attempt again. One should carefully select the area to be impaled, trying to remain within the body of the nucleus.

Fig. 5.13. Maintaining the foot in position 3 leads to loosening of the grip.

Causes of poor hold include keeping the foot pedal in position 3 for too long as this leads to emulsification of the nucleus material around the tip (Fig. 5.13). This loosens the grip in addition to causing milking/clouding of the AC. If the site is too superficial, complete occlusion is not achieved and therefore vacuum seal is not effective. In low or inadequate vacuum settings, the probe keeps slipping and a good hold is not obtained. In very soft cataracts, creating a vacuum seal and vacuum hold is more difficult. The cataract gets sucked even without use of phaco energy and danger of going through and through is high. In such a situation vacuum and power settings should be lowered.

Settings for vacuum seal

The recommended settings are**:** Depending on machine and experience of the surgeon.

Bottle height 80 +/- 20 cms

Vacuum 350 +/- 100 mm Hg

Flow rate 30+/- 6

PHACO CHOP

There are two basic techniques of chopping namely **peripheral** and

central. Peripheral chopping begins from the periphery of the nucleus and proceeds towards the center. Central chop (Karate chop) involves splitting of nucleus from mid-periphery by embedding the chopper on the anterior surface of the nucleus.

Peripheral chop (Figs. 5.14a, b, c, d)

Chamber is moderately filled with viscoelastic and continuous infusion is set. Chopper is placed on the anterior nucleus surface, close to the rhexis margin in a horizontal position. It is slipped underneath the CCC margin and positioned at the delineation line. Now with the other hand, phaco probe is impaled into the nucleus. The chopper is turned vertical and pulled towards the U/S tip. Just before reaching the probe, the nucleus is split sideways.

Problems with peripheral chop

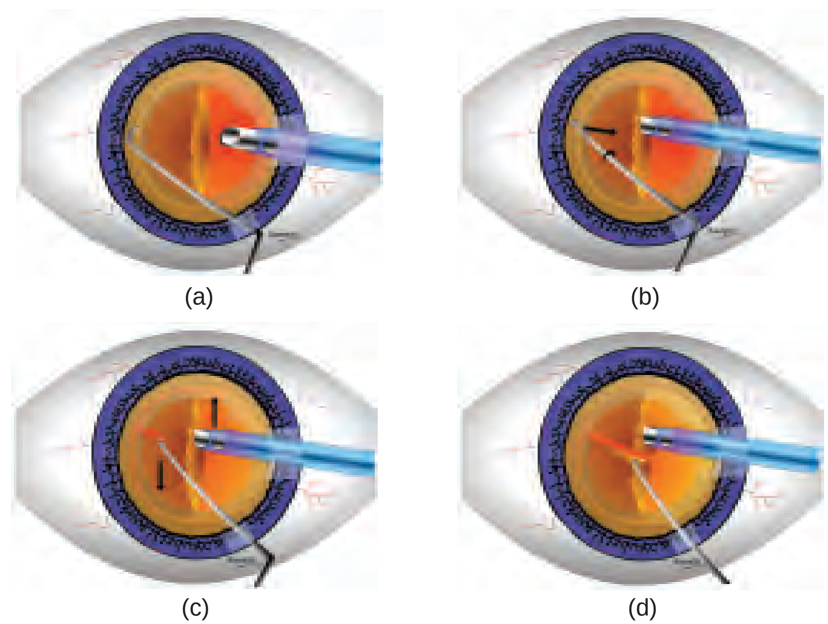


Fig. 5.14. Peripheral chop. (A) Place the chopper underneath CCC at the delineation line. (B) Embed the tip to create the vacuum seal. Now turn chopper vertical and pull it towards the phaco tip. (C) Once the chopper reaches the tip move it sideways to complete the crack. (D) Crack will proceed from periphery to centre.

1. Complex maneuverability needed for this technique. The chopper must be negotiated under the CCC margin while ***simultaneously*** the hold on nucleus has to be maintained.
2. Use of a long chopper on a soft nucleus in an unstable AC can lead to PCT.
3. If the chopper is accidentally placed over the anterior capsule instead of underneath it and the chop is initiated, it may lead to Rhexis Margin Tear (RMT) or zonulolysis.

Central chop (Figs. 5.15a, b, c, d)

Central chop entails chopping without going underneath the CCC.

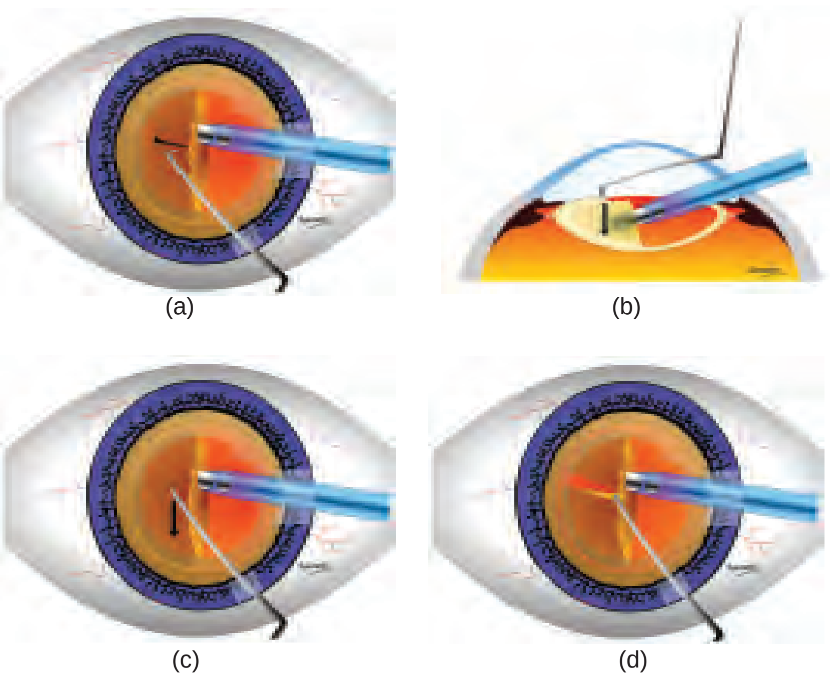


Fig. 5.15. Central chop. (A) Embed the probe into the nucleus and create a vacuum seal. Black line denotes the ideal area to embed the chopper close to and to the left of the probe. (B) The chopper is embedded close to the probe tip. Note the direction of force towards the vitreous cavity. (C) Note the direction of movement of the chopper. (D) The split starts superficially and goes deeper. One may have to move the chopper deeper to complete the crack.

Instead of a blunt chopper, a sharp or thin rounded chopper or even a Sinsky hook may be used. Emphasis is essentially on ***splitting*** of fibres rather than on ***cutting*** them.

In this technique, the positioning of the chopper is all important to achieve a correct interplay of forces. The points to be kept in mind are:

- the chopper has to be very close to the phaco tip otherwise there will be rocking of the nucleus
- at the time of actual splitting, the chopper **has** to be on the left of the tip, it **cannot** be on the right otherwise it will break the vacuum seal.

A vacuum hold is created by impaling the phaco probe with a burst of energy and withdrawing the pedal to position 2. The chopper is kept just left to or in front of the phaco tip within the CCC margin. The vertical portion of the chopper is buried deep in the nucleus in the direction of optic nerve. The chop is initiated by pulling it sideways (i.e. to your left). This can be accomplished by two methods:

1. Just pull chopper sideways while nucleus is stabilized with the phaco probe. This is easier to accomplish by beginners since concentration is only on movements of one hand.
2. Pull both the chopper and the probe in opposite directions. If the fibres do not entirely separate by the first method, the other hand can be moved to complete separation.

The break can be made full thickness by moving the chopper more central and deeper and continuing splitting if need be.

Modification

Instead of keeping the chopper centrally and embedding it vertically in the hardest part of the nucleus, chopper is kept slightly in the periphery and as you move it towards the centre, it is pushed deeper.

Problems with central chop

1. Since chopping is not started at full depth, sometimes a partial thickness chop may occur. To complete it, chopping has to be repeated twice or even thrice. In a peripheral chop, once the chop is initiated, it is usually full thickness.

2. Peripheral chop is stronger than central chop. In a hard nucleus, the chopper may not embed to the required depth. Also leathery fibers which do not split can be easily cut in the peripheral chop.
3. Central chop needs more space due to the rotational component in it.

Modified Peripheral Chop (Fig. 5.16)

Negotiating the rhexis margin is the most difficult part of the peripheral chop. Benefits of both kinds of chopping are obtained using a modified

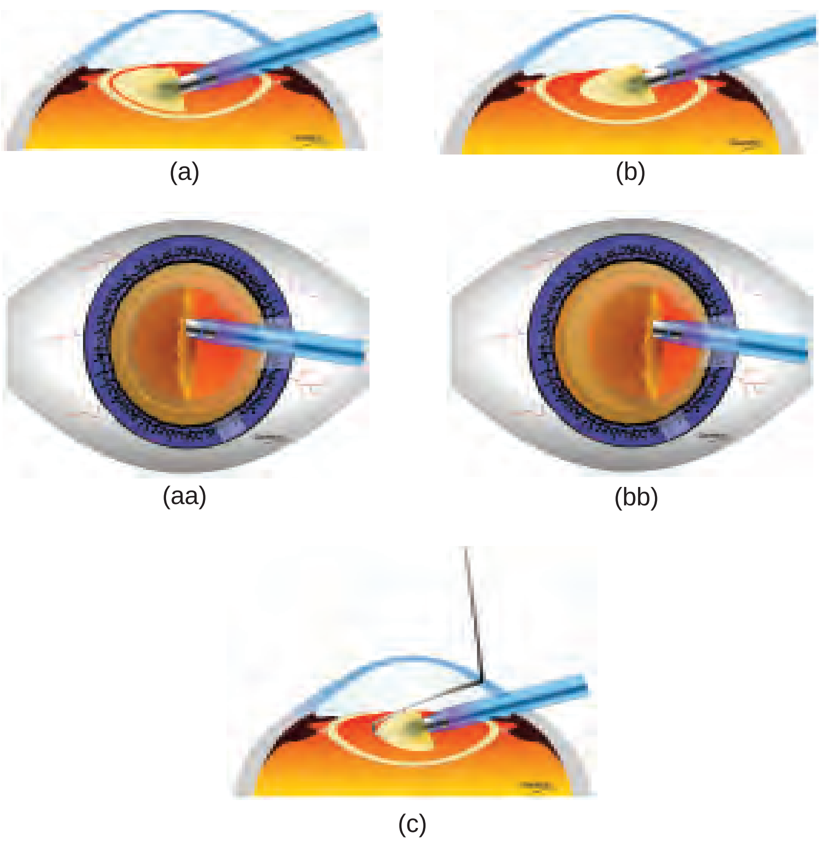


Fig. 5.16. Modified peripheral chop. A vacuum seal is created. (a) Side view. (aa) Top view. (b) Side view. (bb) Front view. (c) Chopper is brought from the periphery to centre to create a split as in a peripheral chop.

peripheral chop. In this, after a vacuum seal has been created the periphery of the nucleus is brought out of the rhexis margin thus avoiding negotiating under the CCC. Following this, the method is same as in peripheral chop. However, this is only possible if:

1. The capsulorrhexis is large
2. The nucleus is small
3. One half of nucleus has been removed by central chopping leaving the other half for modified peripheral chop.

This is an extremely useful procedure for hard nuclei with leathery fibres.

ASPIRATION PHACO

The removal of divided nucleus segments from the capsular fornices and their aspiration in the central safe zone (CSZ) is called aspiration phaco. In earlier days more amount of phaco power and less of aspiration was used to achieve this. This procedure was known as phaco aspiration (PA). With improvement in the fluidics of the machine, more of aspiration and less of phaco power is used. Hence, aspiration phaco (AP) would perhaps be a more appropriate term.

The aim is to perform the surgery in such a way that there is minimal keratitis or complications, irrespective of the hardness of the cataract, the pupil size, anterior chamber depth and corneal health.

Settings

Power settings depend upon the grade of nucleus and can be further controlled by the foot pedal. A 30% reduction in power setting from that kept during trenching, helps in increasing the foot gradient and therefore control.

Pulse mode reduces the consumption of phaco energy by half and allows adequate time for vacuum build up during the interval when the phaco is off. Pulse settings between 2 to 6 is ideal for this procedure.

Vacuum settings depend upon the type of cataract and the space in the anterior chamber. For example, in hypermetropic eye the space in

AC is less. Slight collapse of chamber can cause corneal probe touch and increase the possibility of keratitis. Therefore low vacuum settings are required for such a case. While in myopic eyes there is enough space and high vacuum settings are possible. Small pupil and small CCC require stronger grip and higher vacuum settings to pull the pieces out of capsular fornices into CSZ in the first attempt, to avoid eating the tip away.

Technique

Removal of the first piece from the capsular fornices (CF) is the toughest as it may be entangled with other chopped pieces, or the fibers may not be divided completely. The ideal piece to remove first is the smallest piece which has been completely separated from the rest of the nucleus.

As in chopping take the probe close to the body of the nucleus piece and embed in it with a small burst of energy. Allow time for vacuum hold to build up and then pull the piece out of CF to CSZ. Attempt to keep the piece away from cornea by angulating the probe a little downwards. Then crush or divide the piece with the help of the chopper. Phaco should be **off** while crushing i.e. FP position 2. Care should be taken throughout the procedure to avoid contact of the chopper with probe when the foot pedal is in phaco mode. Mechanical crushing may be added on, as and when needed and minimal phaco must be used. Phaco should only be used when pieces are gripped by phaco probe and are not getting sucked in, i.e. the probe is fully or partially occluded.

If after removal of first piece surge is noticed, vacuum settings can be reduced as the rest of the pieces are easier to maneuver and remove. During removal of last piece vacuum settings can be further lowered, as at this stage there is no other piece in CF to prevent forward movement of PC. Even a small surge can cause a PCT particularly in a mature and hard cataract where the PC is not protected by the epinuclear plate.

Problems

1. Inability to remove the nucleus piece

One very common difficulty that arises in phaco aspiration is the inability to remove the nuclear piece from capsular fornices. The tip of the nuclear piece is eaten away, leaving the body of the piece in the capsular rhexis. If similar treatment is meted out to rest of the pieces, a

nuclear bowl is formed. The situation arises if any of the following is present:

- *Small CCC:* The widest part of the nucleus is in the periphery and the CCC can stretch to a certain limit. If the peripheral part is too big, then either the CCC breaks or the grip loosens, the latter being more common.
- *Too soft a cataract with high vacuum settings:* Here, as soon as the aspiration is switched on, the piece gets sucked in. Therefore a good hold is not obtained.
- *Pieces entangled with each other:* The resistance offered by the entanglement causes the grip to loosen.
- *Hard cataract with low vacuum settings:* This results in poor hold, the nuclear fragments in such cases are bigger and are more prone to entanglement.
- *Unnecessary phaco:* The grip loosens due to emulsification of nuclear tissues surrounding the tip.
- *Very superficial grip:* A partial vacuum seal is created at the first place.

Management of a nuclear bowl requires phaco aspiration in the unsafe zone, i.e. the capsular fornices where the visibility is poor and the capsular bag is the shallowest.

Management of piece if tip is eaten away

Preventing the situations listed above is preferable. However if a nuclear bowl is created, the following method may be used: Phaco probe is introduced with CIM on. Chopper is horizontally placed under the rhexis margin. After taking it to the delineation line, it is turned vertically and the piece is pulled towards the CSZ for phaco aspiration. However, for beginners, it is safer to remove the probe from AC. Chamber is then filled with viscoelastic. Now the chopper is used to pull the piece into CSZ.

2. Burrowing of fragment

Continuous use of phaco energy leads to through & through emulsification of the nuclear fragment. The piece forms a ring around the U/S tip and needs to be mechanically dislodged. This is more commonly seen with large pieces. Before complete burrowing of a large fragment, it may either be cracked and crushed with a chopper and brought in front for aspiration phaco.

3. Milking

This occurs due to partial or complete clogging of the aspiration system. Therefore, there is low vacuum delivery. The nucleus gets emulsified but not aspirated leading to clouding of the chamber. The blockage is usually at the junctional points. To check the system, take the phaco probe out of the eye and put on the test chamber. Now in I/A mode with highest vacuum settings, depress the foot pedal fully. Pinch the aspiration tube till maximum vacuum sound is heard and then release the tubing creating maximum surge possible. This sudden vacuum may suck the blocking piece in. This maneuver can be done repeatedly. Another method which can be applied is the use of reflux though it is not so effective. If these do not work then the only alternative is to detach the tubing from the handpiece and forcefully inject BSS (with a 10 cc syringe) into the tubing as well as the handpiece. One can use connecting rubber piece from IV sets as an attachment for injecting into the handpiece. At times one may have to unscrew the tip and look for clogging. After reassembling check for the surge again to ensure that the clogging has now been cleared before you enter the eye.

4. Chattering

Chattering is more common with small hard cataract pieces. This is seen when too much power is used with a poor hold on the fragments. The hold may be poor because adequate vacuum has not built up or the vacuum settings are too low. The excursion of the tip then tends to push the pieces away, which is very damaging to the cornea.

5. Pieces lodged in no/low followability zone

Pieces lying in these zones cannot be phaco aspirated and have to be positioned in the zone of followability. In the zone of low followability, the phaco probe is taken near the piece and aspiration is attempted. If unsuccessful, this procedure should be abandoned after the first attempt. If the fragment still remains elusive and in the zones of no followability,

the probe is removed. Chamber is filled with viscoelastic. The piece is brought to CSZ mechanically with the help of one or two instruments. It is then pushed below the iris plane, for phacoaspiration.

Fig. 5.17. Four separate pieces of nucleus.

DIVIDE AND CONQUER (Fig. 5.17)

In this, the first trench is made from the centre of the nucleus, towards the cross-incisional area till the capsulorrhexis margin. Rotate the nucleus with the help of a chopper/spatula about 90 degree in a clockwise direction. Now, a second trench is made. Again, the nucleus is rotated through 90 degree and the process is repeated similarly till the third and the fourth trenches are made. It is important that each trench should be of adequate depth and width and should be in the form of '+' sign, which ensures an easy cracking of the nucleus.

The phaco probe and the second instrument (chopper/spatula) are now placed in the depth of the trench and with either a pull-push action or a cross push action, the two halves are separated till a split appears in the bottom of the trench with a bright glow shining through. No interdigitating fibers should be left which will cause difficulty during emulsification of individual quadrants.

Then turn the nucleus again through 90 degree and another split is created. These two splits leads to four quadrants similar to the shape of pie. Now phaco aspirate the pieces as described above.

DIRECT CHOP (Figs. 5.18)

Phaco probe with **bevel down** is kept flat on the anterior surface of the nucleus. With a short burst of energy, the nucleus is entered. The vacuum is allowed to build up and the nucleus is chopped. The grip is usually superficial and a complete split is not always obtained. If a good grip is not obtained in one attempt, rotate the nucleus and try again at a different

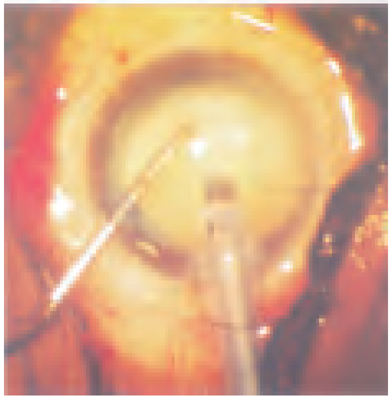


Fig. 5.18. Note the bevel down position of the phaco probe. Bury the tip and create a vacuum seal. Chopper is buried close to the tip.

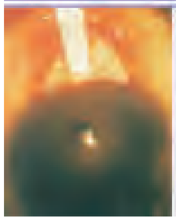
site. However, the hold can be improved by making partial trench.

Partial trenching

Begin the sculpting just proximal to the centre and create a pit at least a tip diameter deep, the deeper the pit, the better the platform for holding. A very long and wide trench is not required. The aim is to get a good grip in the body of the nucleus.

The presumed advantage of this technique is use of less phaco energy and speed of surgery. It is only recommended for surgeons with a third generation machine and huge volumes.

CHAPTER 6



Epinuclear Plate Removal

Somehow the step of epinuclear plate (ENP) removal has not been given due importance with the result that many good surgeons struggle at this stage after successfully completing nucleotomy.

APPLIED ANATOMY

Two important aspects of the epinuclear plate need to be discussed. One is that the size of epinuclear plate is very large vis a vis the CCC. Therefore any attempt to prolapse it intact into the AC will invariably fail. For practical purposes the plate consists of 3 parts, i.e. anterior (beneath the anterior capsule), equatorial (at the capsular fornices) and posterior (along the posterior capsule). The central part of the anterior epinuclear plate is already partially removed before nucleotomy.

INSTRUMENTS

Rounded Iris Repositor/Rod-shaped Iris Repositor

This instrument is very important for the rotation of epinuclear plate. It can be manipulated through the side port and is atraumatic.

Phaco Settings

The settings depend upon the hardness of the epinuclear plate. Flow rate need not be low as the Central Safe Zone (CSZ) has been increased in size due to nucleus removal and there is adequate space in the eye. Vacuum, however, can be lowered, as bombardment of the ENP with phaco will not be needed and so a very firm grip is not required. In fact, higher vacuum may result in biting of the ENP and loosening of the grip especially in a soft cataract. The recommended settings are power of 20+/-10 %, Flow rate 30+/-6 and Vacuum of 250+/-100 mmHg.

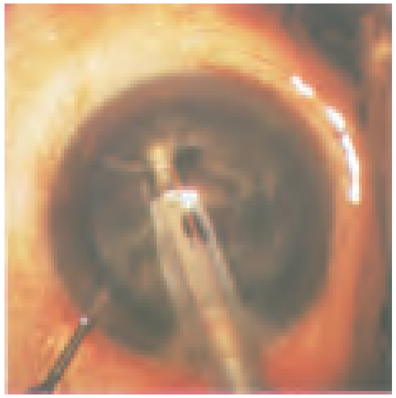


Fig. 6.1. Go under CCC and create vacuum seal on anterior ENP.

TECHNIQUE: FLIP & CHIP METHOD (Figs. 6.1, 6.2, 6.3, 6.4)

The objective of **chipping** is to reduce the size of the ENP by removing most of the anterior and equatorial ENP and some of peripheral posterior ENP. For this purpose, the phaco probe is placed under the anterior ENP with bevel up to occlude the port with the ENP. The foot pedal is depressed between position 1 and 2 and a vacuum seal is created. Once a firm grip is obtained, you should try to pull it into the CSZ. If the grip appears to loosen, one can allow the vacuum to build up further. Note that no phaco is used to create vacuum seal in this step. Once the ENP is in the CSZ give a burst of energy to aspirate the part which is occluding the port. Before the plate falls back, you should simultaneously move the probe forwards and then sideways in a 'L' shaped manner.

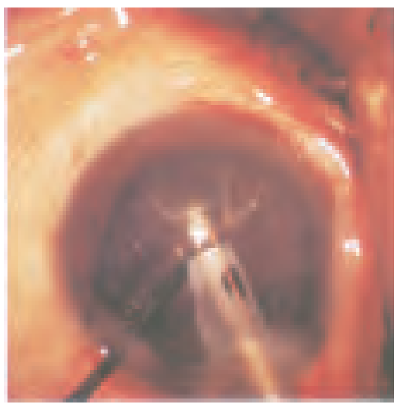


Fig. 6.2. Keep on emulsifying till 1–2 clock hours of tongue-shaped anterior ENP remains attached to the posterior epinuclear plate. Take the tip under anterior ENP and create a vacuum seal. Note position of rounded repositor on posterior EN plate.

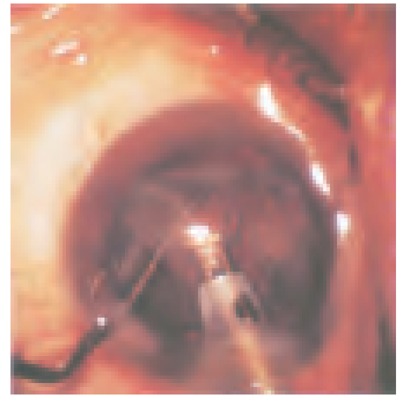


Fig. 6.3. Note the position of rounded repositor, it has pushed the central part of ENP towards periphery for flipping.

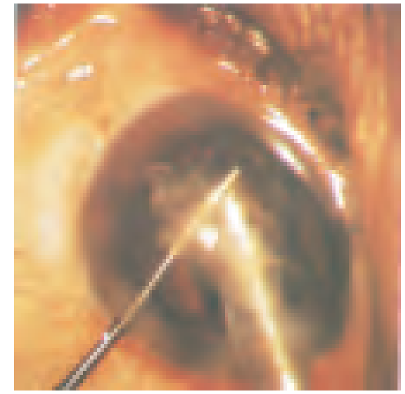


Fig. 6.4. Emulsification of the flipped ENP in the AC keeping the RR below (as AC cannot be visualized) the tip to prevent PCT.

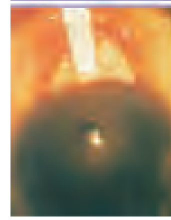
This maneuver allows for wider removal of the equatorial ENP which has a larger circumference. This sideways movement also helps you to grip the adjacent part of the ENP. Now the tip is disengaged by bringing the foot pedal to position I (or position 0 if in Continuous Irrigation Mode). The ENP is then rotated with the help of a rounded repositor to bring the adjacent site into the line of attack and the procedure is repeated. This is continued (may be upto 6 to 8 times) till the last 2 to 3 clock hours of anterior ENP are left.

At this point, you are left with most of the posterior ENP attached to a tongue shaped extension of equatorial and anterior ENP. This now has to be flipped. The tongue shaped area should be sufficient to allow for two attempts of flipping. Vacuum seal is created as described earlier at the tongue shaped area, and the rounded repositor is placed at the centre of posterior ENP. The anterior plate is pulled towards the CSZ with the probe and simultaneously, the rounded repositor is used to slide the posterior plate towards the capsular fornix facilitating the flipping. In case the grip loosens or the ENP breaks, repeat the procedure from another site. Once half of the posterior ENP is pulled out of CCC or flipped over, it does not go back easily and now phaco can be used to aspirate the plate. Most of the times ENP gets sucked without use of phaco energy. It should be noted in this step the PC cannot be visualized as the entire ENP lies in the AC in a zig-zag manner. Therefore, the rounded repositor should be kept below the tip to prevent PCT in case of inadvertent surge. The soft ENP is less damaging to the cornea so this aspiration can safely be performed a little more anteriorly to safeguard the posterior capsule.

PROBLEMS

1. **Posterior ENP without anterior extension:** The commonest problem encountered in ENP removal is when only the posterior plate is left without any anterior extension. This problem is so common that the surgeon must prepare himself from the beginning to manage it. For this, an attempt should be made to create a wedge in the posterior plate during chipping. Along with the anterior and equatorial parts remove a small piece of the posterior ENP as well. If there is no wedge in posterior ENP then rounded repositor pushes the EPN till one end of ENP plate appears close to CCC. Now second instrument is introduced underneath it for lifting it up.
2. If these methods fail to mobilize the plate, you can remove the probe and start irrigation aspiration. Aspiration of the cortical fibres situated posterior to the plate usually result in its prolapsing into the AC.
3. A method followed by some surgeons is to decompress the AC by sudden depression of the posterior wound lip. This results in forward movement of the EPN and injection of Visco-elastic below it can further elevate it. Some surgeons also hold the EPN plate directly with the bevel down—this is **not** recommended especially for beginners.

CHAPTER 7



Cortical Aspiration

A complete cortical clean up is essential to decrease the incidence of early and late uveitis and posterior capsular opacification (PCO).

INSTRUMENTS

1. Co-axial irrigation aspiration system

This has an aspiration orifice in front and the tip may be straight or angulated. The angulation may vary from 45° and 90°. The size of the orifice varies from 0.2–0.7 mm, 0.3 mm being the one commonly used. The tip is covered by irrigation sleeve which may be detachable (silicon) or fixed (metallic), with two openings 180° away from each other.

2. Bimanual irrigation-aspiration (IA) system

There are two handles one with aspiration cannula and second one with irrigation cannula with two orifices on either side.

TECHNIQUES OF IRRIGATION AND ASPIRATION

CO-AXIAL IRRIGATION AND ASPIRATION (Fig. 7.1)

Entering a partially filled or fully formed chamber prevents a Descemet's tear. Aspirate any air bubbles or fluffy material that is lying loose in the AC. Keeping the aspiration orifice facing forward, go close to and underneath the anterior capsule and create a **vacuum seal** by occluding the port with the cortical fibres, pressing the FP between position 1 & 2 (Note: in IA Mode, there is no position 3). Once a firm grip is formed, try to pull the fibres into the CSZ. If successful, a triangular piece of anterior and posterior cortical fibres will be visible. If the fibres are not peeling, the vacuum seal may be only partial. You may need to get a better grip by occluding the tip more (by either moving it deeper or sideways). You may go up to the capsular fornix to get a better grip, even if you can not see what you are holding. Striae on the capsule is an indication of inadvertent holding of the capsule and the foot pedal should be released immediately. **DON'T** try to hold the posterior cortical fibres or turn the aspiration orifice posteriorly.

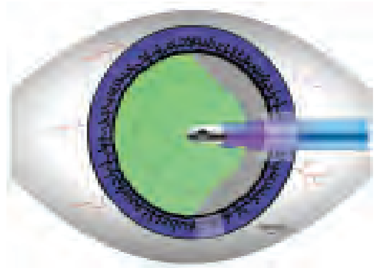


Fig. 7.1. Area of reach with coaxial handpiece. Green area denotes accessible area and gray denotes inaccessible area.

After creating the first triangle, peel off the fibres in an area just adjacent to the one aspirated. It is better to completely clean up one area before moving onto the next. For the cross-incisional area, the orifice is on top, but as you come to the sides you will have to turn the aspiration port sideways. The straight IA cannula is excellent for the cross-incisional area but worst for the sub-incisional area. The 90 degree tip is more suitable for the sub-incisional area but not so for the cross-incisional (Fig. 7.2). The 45 degree tip is a good compromise for all areas.

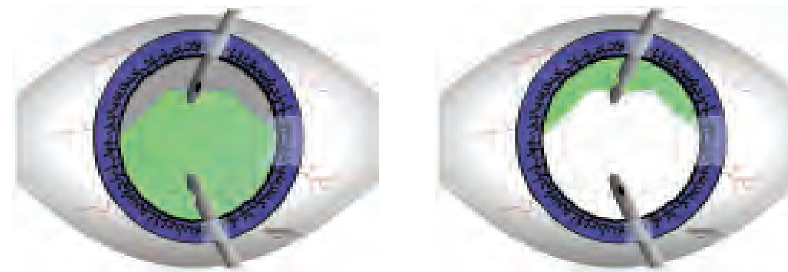
Fig. 7.2. Note the 90^{o} tip is safer for sub-incisional cortex as the orifice is further away from the posterior capsule.

BIMANUAL IRRIGATION AND ASPIRATION (Fig. 7.3a, 7.3b)

For this 2 side port incisions are made approximately **150** degrees from each other; one for infusion and the other for aspiration. By interchanging the irrigation and aspiration cannulas one can ensure that all areas are cleaned up especially the sub-incisional area.

BIMANUAL MODIFIED TECHNIQUE OF IRRIGATION AND ASPIRATION (Fig. 7.4a, b).

In this, we use the main wound for inserting the irrigation cannula



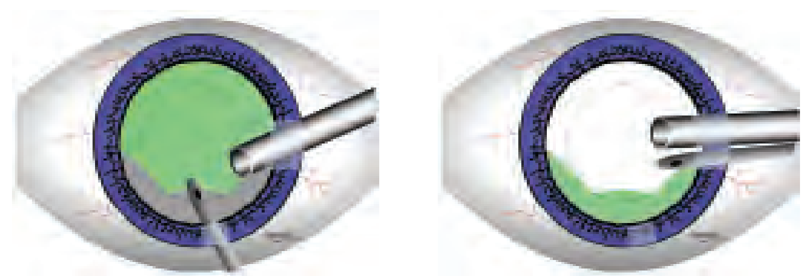
(a) (b)

Fig. 7.3. Bimanual irrigation aspiration. Note: 2 orifices on either side of infusion cannula and one orifice on top in aspiration cannula. (a) Green area denotes accessible area and gray denotes inaccessible area. (b) By interchanging the cannulas now no area is inaccessible.

using a thick cannula which may be rounded or flat. This cannula is placed obliquely into the section to prevent wound leak. The only area difficult to access in this method is the side port sub-incisional area. For this one can introduce both cannulas from the main port. One can also make another side port if the cortical matter is still not getting aspirated. It provides a large quantity of fluid and the creation of another side port is avoided. This is our preferred method of cortical aspiration, though we have nothing against creating another side port.

SUB-INCISIONAL CORTEX REMOVAL

One must keep in mind that leaving some cortex behind is less problematic than creating a PCT. The sub-incisional area is difficult to aspirate with all types of co-axial handpieces due to disturbed visibility.



(a) (b)

Fig. 7.4. Bimanual modified technique – Area of reach. (a) Green area denotes accessible area and gray denotes inaccessible area. (b) By placing both instruments through main port all areas can be reached.

While using the ***co-axial handpiece*** it is best to inflate the bag with visco-elastic and switch over to a 45 degree/90 degree handpiece. ***Bimanual aspiration*** is better for this area since no area remains underneath the incision. Another method that can be tried is the "***suck and spit method***". In this the bag is inflated with visco-elastic. The aspiration cannula (26/27 G) on VES syringe is introduced under the CCC through the side port. A vacuum seal is created and the fibers dragged to the center and spit out there. This is repeated till all the fibers are in the CSZ and then are aspirated with the aspiration cannula.

Move to Bimanual IA; it will be smooth, safe and make your life comfortable.

CAPSULAR POLISHING

Beginners can avoid this step especially if central 5 mm (sub-optic) area is clear.

Technique

Central PC polishing

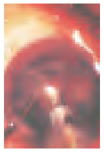
A rounded repositor, sand blasted or ring capsular polisher may be used. The bag is inflated with VES to make the PC stretched and concave. The IOP should be about 30 mmHg. The magnification is increased and one should focus on the PC while gently scrubbing. Folds on the PC imply that the eyeball is not well pressurized. Sometimes the capsule is so loose that despite inflating the eye with viscoelastic, the folds remain. In such a situation it is better to leave it alone.

'Cap vac' mode

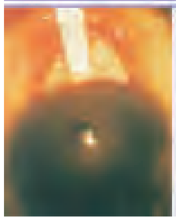
In this, a variable amount of vacuum is used by different surgeons, ranging from 0 to 40 mmHg.

While keeping the aspiration orifice down, capsule is gently held with the cannula with a force sufficient to bring it to the orifice for scrubbing but not enough to tear it. This is not recommended for beginners because of the unstable chamber and decreased visibility and danger of rupturing the capsule.

Capsular polishing is a step that needs to be performed with great care. We feel that the use of a rounded repositor in a visco-presssurized eye is the safest method for capsular polishing.



CHAPTER 8



Insertion of IOLn

The insertion of the intraocular lens (IOL) is a step that if well done, will hardly take any time. The two pre- requisites for that are visco pressurized eye and adequate wound size.

TECHNIQUE FOR SINGLE PIECE PMMA LENSES (Figs. 8.1, 8.2a, 8.2b)

Before inserting the lens one can wash it with BSS in the container itself. A drop of methylcellulose can be put on the leading haptic and optic. Lens is gripped with the McPherson forceps either transversely (10-2 O'clock) or longitudinally. The transverse grip is stronger but you need to release the lens once the optic is in the AC. Holding the IOL in the transverse grip, it is introduced into the section. When the

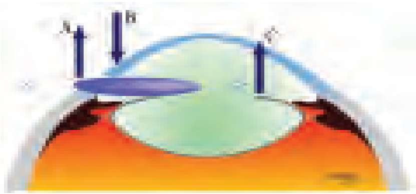
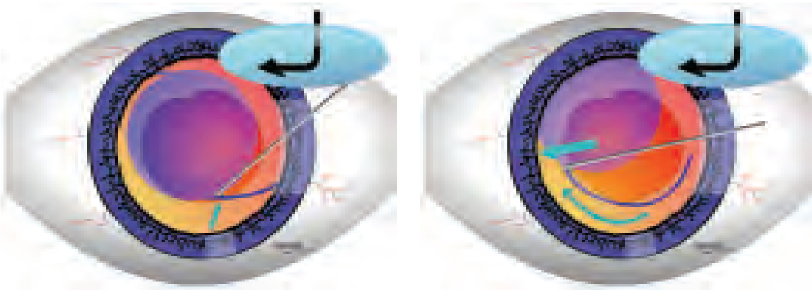


Fig. 8.1. Insertion of leading haptic under CCC. Lift the IOL by trailing haptic or optic in direction 'A'. 'B' denotes the fulcrum for increasing the tilt of the IOL. 'C' – the CCC margin can be lifted by a rounded repositor to facilitate the loop going into the bag.



(a) (b)

Fig. 8.2. Dialing the trailing hepatic. (a) Dumbbell dialer is placed at optic-haptic junction. Note the direction of force denoted by arrows – the dialer is pushing both into the periphery and downwards. (b) The haptic is pushed against the CCC margin. Note the deformation of the CCC margin denoting adequate resistance. Now on rotating the IOL further, the hepatic will slip in.

center of the optic crosses the internal lip, release the grip (1 mm of the optic will still be outside the wound). The loop of the leading haptic will be close to the CCC margin but because of the direction of the tunnel, it will not be pointing down. With the McPherson forceps, hold the lens at the section and lift it up using the internal lip as a fulcrum, so that the leading haptic goes into the CCC. If it does not go in, use a rounded repositor to press on the external surface of the cornea at the site of the internal lip, to increase the tilt of the IOL. You should be able to see the haptic slipping under the CCC. You can also introduce a rounded repositor from the side port to lift the CCC margin and guide the haptic in. This is useful in cases of corneal edema/small rhexis. After the leading haptic has gone under the rhexis, push the IOL in such that part of the optic also slips in behind the CCC. The trailing haptic will now be in the section, but optic haptic junction will be in the AC. This optic-haptic junction is engaged with a dumb-bell dialer or a 'Y' shaped dialer. The instrument should be perpendicular to the haptic (the dialer slips if it is kept oblique). Now push this junction downwards (i.e. towards the vitreous) and towards the periphery. The trailing haptic should come and touch the CCC margin 90° away from the incision. Maintaining the same force, now slightly rotate the optic clockwise (stretch on the CCC will be visible). The haptic will slip in by the time you rotate by 30-40°.

The dialing force has to be applied such that the maximum resistance is felt from the CCC margin, i.e. try to tear the CCC margin with the

trailing haptic—it will slip in automatically. Once you see the peaking of CCC margin it means that enough force has been generated and now, on rotation, the haptic will slip into the bag.

Alternatively, the IOL can be inserted by holding it longitudinally. Though this grip is not so strong, the forceps and the IOL are introduced into the section so that the leading haptic can be directly placed under the CCC margin. The rest of the insertion is as described above.

Putting the trailing haptic by forceps

After inserting the leading haptic and the optic, hold the free end of the trailing haptic with a McPherson forceps. Push it towards the cross-incisional area till the peripheral most part of the loop is at the CCC margin. Now pronate your hand so that the loop of the trailing haptic points posteriorly, and leave it. It will slip under the CCC. Since sometimes the visibility in the sub-incisional area is poor, to overcome this, while releasing the loop, one can rotate the IOL by 30-40° to enhance visualization.

FOLDABLE IOLs

Foldable IOLs are inserted by a Holder-Folder method or an injector system method.

Holder-Folder method

Various types of holders and folders are available, the description of which is beyond the scope of this book. The IOL may be folded ***longitudinally*** (along the long axis) or ***transversally*** (perpendicular to the long axis). Transverse technique is nowadays no longer popular as it requires a larger incision and is more cumbersome.

Fig. 8.3. Placement of folder. Note that the 2 arms are parallel to the long axis and placed in the centre of the optic.

Technique (Figs. 8.3, 8.4, 8.5)

The folder is held in the left hand. For a longitudinal fold of the IOL the folding forceps should be placed such that its two limbs are parallel to the haptics and in the middle of the periphery of the optic. Now start closing the arms such that the ledges slip under the edge of the optic.

Press the 2 arms together and the IOL will start folding. Don't compress fully otherwise the lens may jump out. Now drop the IOL container and take the holder in the right hand and use the holder to complete the fold.

Fig. 8.4. Folder is placed such that the ledges slip under the IOL. The arms are pushed together so that the IOL folds centrally.

Fig. 8.5. Horizontal placement of holder. The correct position is such that the tips meet just beyond the folded optic.

Position the leading haptic close to the external incision and push it inside the AC with a dumb bell dialer, simultaneously pushing the IOL into the section. Once the leading haptic is near the CCC, guide it under the rhexis margin and then push the optic into the AC. Now pronate the hand to make the optic vertical. Place a second instrument between the lens and the cornea and then open the holding forceps. Usually the lens slips out easily. In case of Acrylic IOLs you may have to push it down. The holder and second instrument are withdrawn and the trailing haptic is inserted as for the PMMA lenses.

For ***Silicon IOLs*** the basic technique is the same. Keep in mind that Silicon IOLs cannot be folded if they are wet.

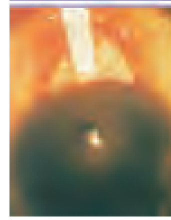
Injecting systems

Injector systems are designed for particular IOLs and are supplied by the manufacturer. One should familiarize oneself with the particular system by reading the literature provided by the company. Irrespective of the injector system, the leading haptic should always be released under the CCC margin and while lens is coming out, the haptic should be kept horizontal.

The presumed advantages of an injector system are:

- Smaller incision
- Disposable cartridge
- Trailing haptic may be inserted without coming in contact with the external ocular tissues.

CHAPTER 9



Complications of Phacoemulsification

CONVERSION TO ECCE

Many times during course of phacoemulsification, the beginner surgeon may find it difficult to continue and may have to convert to ECCE. Under no circumstances, should the surgical outcome of conversion be poorer than that of planned ECCE.

REASONS TO CONVERT

Most common reason for conversion is PCT. However, beginners may need to convert for other reasons.As you become more proficient, the indications for conversion will keep on shrinking.

1. CCC related problems

1. Small CCC (< 4.5 mm) and large nucleus—All steps will be difficult to do so it is better to convert.
2. Too large CCC—Nucleus will prolapse in to the AC and phaco will be difficult.
3. Discontinuous CCC—A discontinuous CCC may be due to inability to make a CCC or Rehxis margin tear (RMT) during any step.

2. Excessive use of phaco and fluids (Prolonged surgical time)

An effective phaco time (EPT) of more than 1-1/2 minutes usually causes sufficient intraocular damage to merit conversion. Under no circumstances should EPT be **greater than 3 minutes**. Surgeon should convert at this stage, even if there are no other complications. Use of more than one bottle of infusion fluid or more than one hour of surgical time may also necessitate conversion.

3. Wound related problems

Leaking wound, with repeated iris prolapse or corneo-scleral burn if excessive may also be a cause for conversion.

4. Corneal edema

Due to any cause, disturbing visibility.

5. Intraoperative meosis

6. Improper case selection

In some cases like deep AC syndrome/cramped AC after starting the case you may realize that it is a tough case. If the surgeon is feeling nervous during a particular case, it is better to convert.

HOW TO CONVERT?

Conversion entails management of the capsule and management of the incision site.

1. Conversion of intact CCC to perform planned ECCE/small incision (non-phaco) cataract extraction

(a) ***Incomplete CCC:*** In the area where you are not able to complete the CCC convert to either can-opener or envelope technique, whatever you are comfortable with.

(b) ***Complete Large CCC:*** If the CCC is large enough (i.e. 1-3 mm less than delineation ring) then because of the stretchability of CCC margin it is possible to prolapse the nucleus into the AC without breaking the CCC. This can be done by nudging the nucleus down with a Sinskey hook (in a well-inflated eyeball) and trying to lift it up with a 2nd instrument inserted below the nucleus. Prolapse the superior pole out of the CCC first. Injecting VES beneath the nucleus will further facilitate the nucleus delivery.

The nucleus can now be totally prolapsed out of CCC. Once the nucleus is completely out of CCC, one can either do an ECCE or perform SICS.

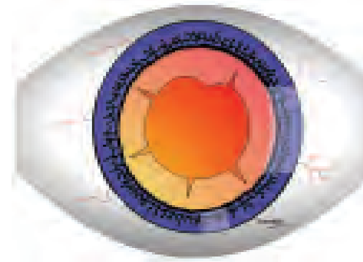


Fig. 9.1. Conversion of intact CCC. Multiple snips made in CCC to release it.

(c) ***Complete Small CCC*** : If the CCC is very small (3 mm)—disregard this rhexis and continue as if the capsule is intact, i.e. one can perform can-opener/envelope capsulotomy. Alternatively you can make relaxing capsulotomies (Fig. 9.1). Only one relaxing capsulotomy will cause loss of elasticity and extension into the posterior capsule at the time of nucleus delivery. It is better to make at least two to four relaxing incisions .While delivering the nucleus, you should try to prolapse the superior pole of the lens out of the CCC. If the CCC is not released properly the superior pole may get trapped under the CCC margin inferior pole will then try to tumble out as in ICCE leading to zonular stress and dialysis.

2. Conversion of superior scleral tunnel (Figs. 9.2, 9.3, 9.4, 9.5)

Extend the conjunctival flap. Now release the side walls of the pocket by cutting with a scissors upto the limbal incision. Lift the scleral flap

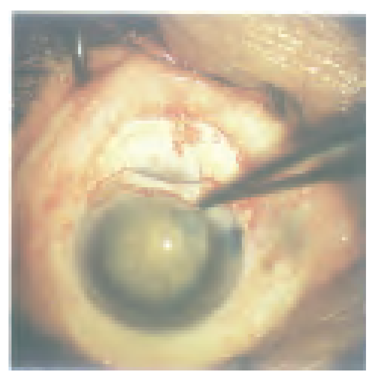


Fig. 9.2. Releasing the scleral pocket.

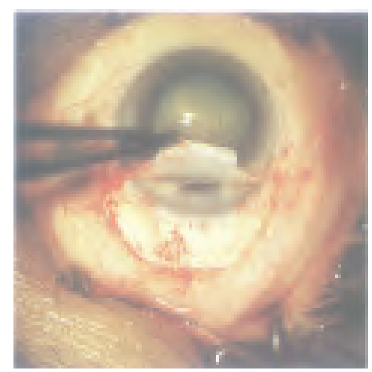


Fig. 9.3. Dissection of limbal groove upon the internal wound on both sides.

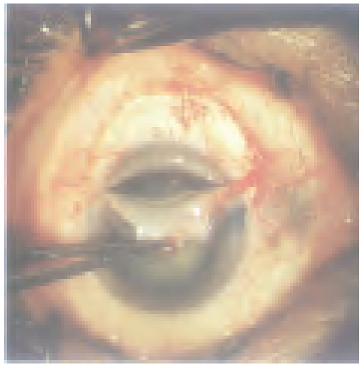


Fig. 9.4. Enlarging the internal incision on both sides. Note that the corneal shelf keeps on decreasing as we go to the periphery.

Fig. 9.5. Closure of wound with shoe-lace suture. Two interrupted sutures at the corners of scleral flap (as in trabeculectomy). Limbal section closed by shoelace stitch.

and dissect into the corneal valve upto the internal lip. Dissect onto the sides , decreasing the length of the corneal valve as you move away from the centre. At the extreme ends you should be 0-0.5 mm into the cornea. Now cut with the scissors from the centre to both the sides to complete the internal wound. For closing the wound after removal of the lenticular matter (i.e. completion of the ECCE) put two sutures on the extremes of the scleral flap (like a trabeculectomy flap). Close both sides of the limbal wound with shoe lace/interrupted sutures.

3. Conversion in a superior clear corneal/limbal incision

The principle is to maintain the same plane all along the incision. The margin of the external wound is extended on either side upto the extent required. Dissection of the wound and formation of the internal lip is as described above for extension of scleral pocket.

4. Conversion in a temporal incision

Temporal incision/modified temporal incision are usually corneal or anterior limbal. A large ECCE incision is not acceptable temporarally mainly because of the exposed sutures and sub-conjunctival haemorrhage being cosmetically unpleasant. It is best to disregard the temporal incision, move to the superior side and make a fresh limbal incision ensuring that it is sufficiently far away from the temporal tunnel.

POSTERIOR CAPSULAR TEAR

CAUSES OF POSTERIOR CAPSULAR TEAR

In phacoemulsification, PCT can be created either by the ***extension of rhexis margin tear*** (RMT) or by ***direct injury*** to the PC during the surgery and during **hydrodissection.**

Extension of rhexis margin tear

If the rhexis margin is continuous, irrespective of shape and size, it will not get torn easily. However, if CCC is not complete (i.e. there are cones in the CCC), it has a high potential to get extended posteriorly. RMT will not get extended if the pressure from above is maintained. The bottle height should not be lowered. Decrease in the pressure from above coupled with the vitreous pressure from below is what causes the margin tears to extend posteriorly.***Beginners should not attempt phaco if the CCC is not complete.***

PCT due to direct injury

The PC can come forward suddenly because of chamber collapse (surge), striking the phaco tip. The instruments, e.g. chopper, rounded repositor or dumb bell dialer etc. may go too deep or towards the periphery and tear the capsule. Manipulation in the bag without **pressurizing** the chamber is also dangerous since a **lax capsule** tends to get entangled in the instruments whereas the fragments and instruments slide easily over a taut capsule. This can happen especially during nuclear fragment rotation or epinuclear plate flipping. To prevent this, either pressurize the eye with VES or keep the continuous infusion mode on. **PCT does not occur if the PC is only caught in the probe; sudden movement after holding with the probe/cannula is what causes it to tear.**

PCT during hydrodissection (Fig. 9.6)

There are three factors for posterior capsular tear during the hydro-procedures:

1. ***Block to outflow:*** The outflow may be blocked due to increased resistance offered by visco-elastic in the chamber or a small CCC/ small pupil. Also injecting from the side port, when the main wound is well sealed can lead to a PCT.

2. ***Injection of too much fluid:*** Injection of too much fluid with too much pres-sure.
3. ***Inherent weakness:*** Weak capsule may be seen in case of posterior polar cataract, high myopes, post-vitrectomy, trau-matic cataracts, pseudo-exfolia-tive syndro-mes and some cases of posterior subcapsular cataract.

Fig. 9.6. Causes of PCT during hydro-procedures. Note that bolus of VE in AC, small CCC, large quantity of injected fluid and inherent weakness of PC in posterior polar cataract.

MANAGEMENT OF POSTERIOR CAPSULE TEAR DURING PHACOEMULSIFICATION

First step to do once a PCT is noted

The most important step on noting a PCT is ***not to withdraw the phaco probe immediately***. With the infusion on, one should take visoelastic in the non dominant hand and inject it through the sideport to *inflate the bag* and then only withdraw the phaco probe. If one withdraws the phaco probe in haste, the anterior chamber will collapse, the PCT may enlarge and the hyaloid phase which may not yet be disrupted will break leading to prolapse of the vitreous in the anterior chamber and/ or prolapse of the nuclear fragments in to the vitreous cavity.

Confirmation of integrity of hyaloid phase

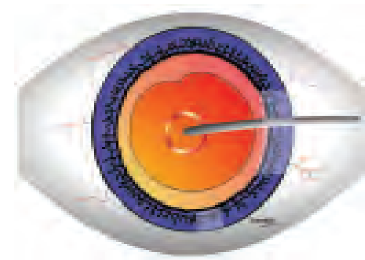
If one observes the borders of the PCT and if they appear to be shiny/ golden, or if they appear to be under stretch or rolled up in the presence of irregular chamber depth, then the chances are that the hyaloid phase has been disrupted. Also, restricted movements of the nuclear fragments and/or entanglement of the nuclear pieces with vitreous will point towards a broken hyaloid phase. One can do the following tests:

Swab test: One can sweep a sponge/swab stick along the incision to detect the presence of vitreous.

***Sweep test*:** One may also try to sweep the spatula from the anterior chamber angle under the incision towards the PCT, vitreous, if present, will be seen dragging in (due to tendency of the vitreous to come towards the wound).

Halo test (Figs. 9.7a, b, 9.8)**:** Put viscoelastic in the bag, to flatten it or keep it slightly convex but not concave to elicit the halo test. Try to look for the ring reflex by applying the pressure in the center of the capsule with the help of a rounded repository. If the PC is intact, a halo will be seen which will vary in size depending upon the amount of pressure applied. This ring reflex will be broken at the site of PCT.

(a)



(b)

Fig. 9.7. Halo test in uninflated capsular bag. (a) Side view—Halo sign in an intact PC is due to total internal reflection taking place at the angle where contour is chang-ing and hence a halo reflex is obtained. (b) Top view of the same.

***Stain test*:** One can also inject Triamcinolone into the anterior chamber just adjacent to the PCT (not above it as it will fall back into the vitreous cavity), vitreous will stain. However, when one is in doubt one should consider the hyaloid phase as disrupted.

Conversion of PCT into PCC

Converting a PCT into a PCC is ideal, but most of the times im-practical. ***One should attempt conversion to PCC only when one has a small central/paracentral PCT (not more than 3 mm), good viscoelastic, excellent capsulor-rhexis forceps and a good operating microscope.*** *However the failure rate is still very high.*

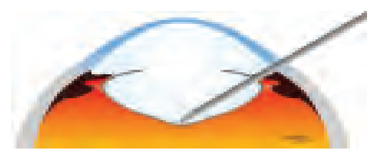


Fig. 9.8. Halo test in capsular bag filled with viscoelastic. In a pres-surized eye, if the PC is already concave the change in curvature is not sufficient to cause total internal reflection and hence there is no change in reflex. Halo reflex will not be so well appreciated.

Management of full nucleus or nucleus fragments

Safety of the hyaloid phase and the cornea is the key. This depends upon the hardness of the cataract and the chamber stability. In the presence of nonleaky wound good bottle height (don’t lower the bottle height), adequate to high power settings with lower fluidics parameters (to avoid surge) are essential.

After inflating the bag with visco, I use the chopstick technique, using two instruments, one sinsky and one chopper. Both instruments can be put through the main port or one through the main port and the other through the sideport, then I hold the nuclear fragments between the two instruments and bring them out of the capsular fornices and place them near the anterior chamber angle. Once the nucleus has been stabilized, one can proceed with vitrectomy. One must coat hyaloid phase with dispersive viscoelastic like methyl cellulose or chondroitin sulphate. If the nuclear fragment is small and soft, one can do anterior chamber phaco. As phacoemulsification is done closer to the corneal endothelium the hard cataract may damage it.

Management of epinucleus

Epinucleus is toughest to manage in cases of PCT & most often, I have seen epinuclear plate falling into the vitreous cavity. Nucleus being firm can be held mechanically by the instruments, or by the phaco probe. Epinucleus, being soft, cannot be held by any instruments. It cannot be held even with the phaco probe because it bites through.

If the hyaloid phase is intact then the epinuclear plate can be removed easily either by phaco or irrigation and aspiration. If the vitreous is present in AC, one needs to do limited vitrectomy (if vitrectomy is done excessively in a large PCT, the epinuclear plate may fall back). I usually try to prolapse the epinuclear plate out of the rrhexis margin by a rounded repositor. Once it is in the anterior chamber, I put my viscoleastic cannula under the epinuclear plate and start injecting methylcellulose by pressing the posterior lip of the wound, maintaining the chamber depth all the time; epinuclear plate flows out of the wound along with the viscoelastic. I call this method ***viscoexpression.*** Some of the epinuclear plate may also come out while doing IA for cortical matter.

In my experience the epinuclear plate causes less inflammation & post-operative complication in the capsular fornices than in the vitreous cavity. Therefore, I will rather leave the epinuclear plate, than be more aggressive & drop it into the vitreous cavity. If, however, the epinuclear plate is present superiorly, an attempt should be made to remove it, as it may slip into the pupillary space. Secondary vitrectomy with cortical removal can be done through parsplana if it obstructs the visual axis.

Management of cortex

As far as possible, the cortex needs to be removed, it is not very difficult. In case of PCT, certain areas (cross-incisional) may not have any vitreous, that part of the cortex can be handled with ease. Best method for handling the cortex in presence of PCT is with vitrectomy cutter. Cut the vitreous & then go to suction mode & now it can be used as an irrigation/aspiration cannula.

Secondly, if one does not have a good cutter / vitrectomy is not working then the I/A system can be used for cortex removal only in areas where there is no vitreous. Another sideport may be made for this. If vitreous is in anterior chamber, *mechanical suck & spit* is a better controlled system than irrigation and aspiration. In a well-formed chamber with visocleastic, with a 27 gauge cannula go underneath the capsulorrhexis margin, hold the cortical fibres & do not try to suck these, instead pull them out of the incision & then spit them out. Take the cannula back, & repeat the same process. Sometimes the spitting can be done in the AC & can be then removed later. While sucking if the vitreous is caught, spit the cortical matter within the eye, which can be washed afterwards. Sometimes, cortical matter may be removed after insertion of IOL with viscoelastic. Better to leave the cortex behind if vitrectomy cutter is not available.

Tips to insert IOL in presence of PCT & choice of IOL

If the PCT is small & the hyaloid phase is intact, place the IOL within the bag. When you are implanting the lens in the bag, some precautions need to be taken:

(i) One can tie a 10-0 thread to the trailing haptic, which can be used for the retrieval of the IOL, if it starts sinking.

(ii) Dialling of the IOL should be avoided, if it gets entangled with the vitreous, it can enlarge the PCT. IOL should be placed in such a way that even if the tear gets extended, the long axis of the IOL should be at 90^0 to the long axis of PCT/or axis of extension of PCT. The haptics should be away from site of extension of the tear.

If in doubt, put the IOL in the sulcus over the CCC margin. Take a sinsky hook/dumbbell dialer, pull one of the haptics towards the center well beyond the CCC margin, then take the sinsky hook underneath the rhexis, the haptic will move into the capsular bag. Then remove the sinsky hook. If need be, second instrument can be used (rounded repositor) which goes on top of the haptic & underneath the rhexis margin to guide the haptic into the bag. (Reverse optic Capture).

I prefer to use the foldable lens. If the rhexis is not very large & if one is going to do proper vitrectomy, the 3 piece foldable lens (with diameter 13 mm) can be placed over the sulcus. If rhexis is ideal – the optic can be prolapsed into the bag (optic capture). Usually single piece lens should be avoided, as it can cause lot of iris chaffing.

If the PCT is associated with rhexis margin tear and small zonular dialysis – then it is better to put the ECCE IOL (big optic IOL) for better centration. If zonular dialysis is large – best choice is either to put the ACIOL/scleral fixated IOL/Retroiris fixated IOL. Even doing secondary implantation of the IOL in these situations may be a good idea. After 6-12 weeks, the capsule really forms up, reassessment & exact IOL choice becomes easier. ½ dioptre less power is required if lens is to be placed in the sulcus.

Ensuring complete anterior vitrectomy

Put the IOL & after constricting the pupil, put Tricot in the anterior chamber. One will be able to see each & every fiber of vitreous in the A.C. Even if one has done excellent vitrectomy earlier, this step is a must after placing the IOL.

Do not put the tricot before placing the IOL/constricting the pupil – as it may seep into the vitreous cavity & can reduce the visibility.

If you do not have a vitrectomy machine, the vitreous in the A.C. is not as harmful as in the section. Even when the pupil constricts fully with pilocarpire, post-op, some vitreous strands may be seen going towards the section. So I mechanically sweep the iris repositor from the peripheral angle to the center. So all the vitreous can be pulled into the center. I actually put the vana's scissor at the pupillary plane to cut the vitreous in the center. If vitreous remains in the section, it causes lot more traction & associated complications.

Indication for referral to posterior segment surgeon

Indications – lack of good vitrectomy machine, impending nucleus drop, nucleus/large fragment of nuclear/epinuclear plate, and/or IOL drop.