Chapter - 6

SMALL INCISION CATARACT SURGERY

The place and relevance of manual small incision cataract surgery

Modern cataract surgery aims to achieve a better unaided visual acuity with rapid post surgical recovery and minimal surgery related complications. Early visual rehabilitation, better unaided visual acuity and surgical safety can be achieved in a great measure by reducing the incision size. Incision size depends on the mode of nucleus delivery and the type of intraocular lens used. It is about 10-12 mm in standard extracapsular surgery, about 5.5 mm to 7.0 mm in manual small incision surgery and 3 mm to 5.5 mm in instrumental phacoemulsification, depending upon the technique and implant. The advantages associated with the smaller incision have made phacoemulsification the ideal technique for cataract surgery and the preferred one where the resources are available. However, this technique cannot be employed as the standard procedure in developing countries due to certain reasons. Manual small incision cataract surgery offers similar advantages with the merits of wider applicability, better safety, a shorter learning curve and lower cost.

Phacoemulsification requires expensive instrumentation which may not be available at all centres, whereas manual SICS requires only a minimum addition to the standard cataract surgery instrument armamentarium. Case selection is very important for an average surgeon doing phacoemulsification, and duration of surgery and incidence of intraoperative complications varies with the nucleus density. Certain cataracts, like hypermature Morgagnian or traumatic cataracts are difficult to handle with phacoemulsification. Manual SICS can be performed in almost all types of cataracts and time spent on nucleus delivery does not vary with the cataract. Capsulorrhexis is mandatory for phacoemulsification, whereas manual SICS can be comfortably done with the can-opener or the envelope capsulotomy skills acquired previously. Published data shows that intraoperative complications like posterior capsule rupture are more common in phacoemulsification as compared to manual SICS. Endothelial loss in phacoemulsification depends on the density of the nucleus, whereas in manual SICS, the skill of the surgeon plays an important role. Overall, endothelial cell counts after surgery are comparable after phacoemulsification and manual SICS. Surgically induced astigmatism following phacoemulsification with rigid IOL implantation and manual SICS have been found to be comparable, the difference between groups not reaching statistical significance in a recent large study. The cost of a foldable IOL is much higher, placing it out of the reach of many of our patients. Disadvantages of rigid IOLs of a small size are well known. A standard large optic rigid IOL can be used with ease with manual SICS. The final visual acuity has been observed to be similar after both techniques. Phacoemulsification depends upon the machine and machine failure can have serious consequences during a procedure. In SICS, however, the surgical skill and experience of the surgeon play a significant role in the results. Another advantage of manual SICS over other methods of cataract surgery is the shorter duration taken, making it particularly applicable to high volume cataract surgery.

Transition to phacoemulsification is easier if one has mastered manual SICS, as familiarity of steps common to both (scleral tunnel incision, capsulorrhexis, hydroprocedures, etc.) helps reduce the incidence of complications while learning phacoemulsification.

PREOPERATIVE ASSESSMENT OF A PATIENT FOR SICS

Preoperative assessment of a patient for SICS is similar to that for other means of cataract extraction, with special focus on identification of certain factors which are likely to modify the procedure and put a patient at a heightened risk of complications. It is a good practice to exclude patients with certain risk factors in the initial phase, rather than having to explain postoperatively why the patient developed a significant complication. As experience and confidence is built up, more cases are likely to fit the inclusion criteria.

A good endothelial count, well dilating pupil, intact zonular apparatus and ocular tone are required to perform this procedure safely.

Assessment of the cornea with slit lamp under high magnification should be done to rule out pathologies with a low endothelial count (glaucoma, Fuch's dystrophy, etc). Where possible, endothelial counts should be obtained. Evidence of chronic iritis and keratitic precipitates should be carefully looked for. Iris pupil examination under mesopic light conditions should be done to see for evidence of posterior synechiae, pigment on the lens, pupillary abnormalities. Pupil examination should also be done after dilatation to know the status of the pupil (whether dilating satisfactorily or not), and the lens (grading of the cataract, zonular status). Posterior segment evaluation gives us important information about the visual prognosis after surgery. IOP measurement is a must before SICS. Hypotonic eyes are inadequate for SICS as it is very difficult to make a satisfactory tunnel wound with hypotony. Nucleus prolapse into anterior chamber is also difficult in hypotonic eyes. Patients who have had filtering surgery are not the ideal candidates for SICS for the above reasons. Patients who have had recurrent episodes of anterior uveitis with synechiae formation are unsuitable for SICS. The inadequate pupillary aperture creates difficulties in performing a capsulorrhexis and in nuclear prolapse into the anterior chamber. A weak posterior capsule predisposes to vitreous prolapse and there is an increased chance of zonular weakness. Post-operative inflammation is also more intense and incidence of CME higher. Certain absolute contraindications to SICS include Fuch's dystrophy, microphthalmos, congenital anomalies, zonular dialysis and lens subluxation.

PREOPERATIVE PREPARATION

Preoperative preparation for SICS is the same as for other cataract surgery, except for a few points. This surgery can be done in some patients under topical anaesthesia, but this is not recommended unless a high degree of proficiency with the procedure is attained. A peribulbar block provides adequate anaesthesia in almost all patients. Subconjunctival and subtenon infiltration of lignocaine have also been found to be effective. Some movement of the eyeball is acceptable and does not interfere with smooth execution of the surgery. Preoperative diamox, mannitol, or superpinky is to be avoided as hypotony favours certain complications. A gentle massage is usually enough. A normotensive or hypertensive state of the eyeball maintains the vascular dynamics of retinal and uveal tissue and facilitates a number of steps of SICS (side port entry, tunnel dissection, curvilinear capsulorrhexis, hydroexpression).

SCLEROCORNEAL POCKET TUNNEL INCISION

Wound construction is of vital importance in SICS. The ultimate outcome and the ease of delivering the nucleus are dependant on wound architecture.

There are two aspects of the incision for SICS which we must consider. One is the self sealing nature of the wound, and the other is the induced astigmatism.

For a wound to be **self sealing**, it should conform to the principle of ‘square incisional geometry’. This is a general concept which states that an ideal self sealing wound has a length equal to its width. In reality, however, the length is usually smaller, and there is a definite relationship between the probability that a wound is self sealing and its approximation to square geometry.

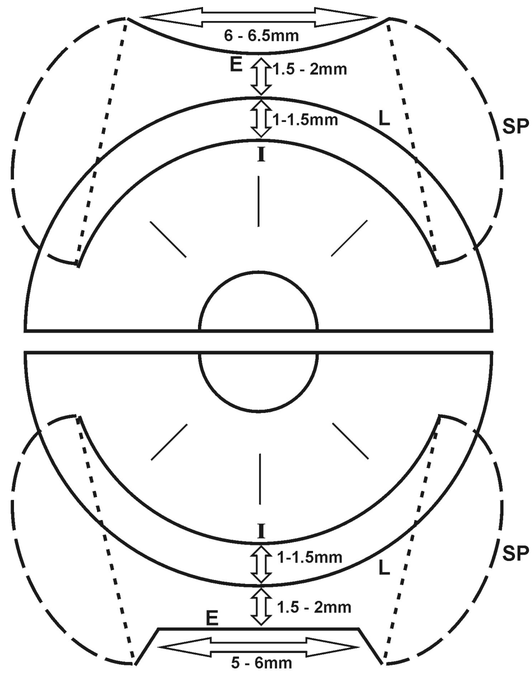
There are two incisions in the scleral tunnel wound for SICS- the external scleral incision and the internal corneal incision.

The external wound dimensions have an important bearing on the self sealing nature of the wound, with smaller incisions being more reliably self sealing than larger ones. A small external wound, however, presents an obstacle to the delivery of the nucleus and IOL implantation. Hence it should be fashioned in a way which lends itself to stretching. The dimension of the wound depends upon the preoperative assessment of the nucleus size and the technique used to deliver the nucleus (phacosandwich or snare or pre-chopper will help reduce incision size, whereas use of wire vectis will require a larger incision width). There are two types of external incisions in vogue today. The frown incision is a parabolic groove convex towards the limbus with the centre being 1.5-2 mm behind the limbus and chord length being 6-7mm. The other incision is the straight scratch incision 5 – 6.5 mm in length 1.5 mm behind the limbus with backward extensions at both ends creating side pockets.

The internal incision is in the cornea and does not lend itself to stretching. Hence it should be made large enough to accommodate the nucleus or the implant. Generally an 8-9 mm inner lip suffices. The internal incision should be parallel to the limbus. It should extend to the limbus but should not cut the limbus on either side. These features give the maximal security and anti-astigmatic effect to the wound.

So, we see that the properties of a self sealing wound for SICS include an approximation of square geometry, a relatively small external incision with a geometrical shape that lends itself to stretching and a tunnel that flares to a larger internal incision. The self sealing is ensured by the remoteness of the two incisions brought about by the collapsed tunnel in normal conditions.

The other important aspect of wound construction is the **induced astigmatism** caused by the wound, which should be minimal, and if possible favorable, to counteract existing astigmatism. Corneal wounds cause the greatest, limbal intermediate, while scleral wounds cause least astigmatism. Temporal wounds are purported to cause less astigmatism than superior wounds and have a counterbalancing effect on the natural ATR shift that occurs with age. However, most surgeons are familiar with the superior location, and the larger wound size and conjunctival dissection in SICS make this site less appropriate for wound placement. An important concept in understanding incision design in SICS is that of the incisional funnel. This is an area bounded by a pair of curvilinear lines whose shape is based upon the relationship between astigmatism and two characteristics of the incision – length and distance from limbus. Incisions made within this funnel are astigmatically stable. Short linear incisions made close to the limbus and longer incisions farther away are equally stable. The frown incision or the Chevrolet ‘v’ incision incorporate a larger incision into this funnel and hence are more desirable. Though moving farther away from the limbus makes an incision more stable, it increases the surgical difficulty by limiting access and maneuverability. Clear corneal tunnels have significant demerits – difficulty in obtaining square geometry due to limited length of tunnel, difficulty in anterior chamber manipulation or ‘oarlocking’, and less security due to long healing time and lack of fibrosis.

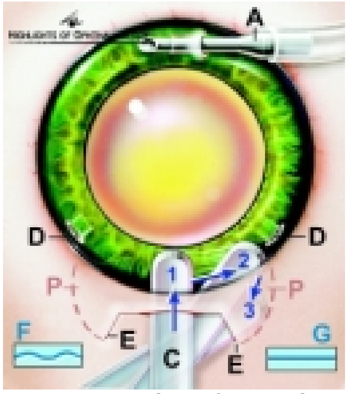


E = External Incision; I = Internal Incision; L = Limbus; SP= Side Pockets

Incision Anatomy : The upper part of the figure illustrates the frown incision whereas the lower illustrate the straight or scratch incision with backward extensions which are almost perpendicular to limbus

With the above facts in mind, we shall move on to the procedure of wound construction. The external incision can be made with a guarded diamond knife or keratome or a blade knife or a Bard-Parker blade no.11 /15. The desired size of the incision should be marked with a calliper. The tunnel is constructed with a bevel up angled metal or diamond crescent. It is of utmost importance to have good sharp instruments so that the proper plane of dissection is maintained and wound architecture is not destroyed. A 3 mm sharp tip angled keratome is used to make the inner incision. A lance tip or MVR 20G knife is used to make the side port entry and the AC maintainer bevel incision.

The eye is made hypertensive by either the AC maintainer or by making a moderately beveled side port incision and injecting viscoelastic. This is of great importance at the beginning of surgery as this makes the eye coats taut and facilitates utmost controlled dissection. Most unintended misdirected scleral dissection, premature entry into the anterior chamber or failure to achieve a full sized scleral pocket tunnel occur as complications of dissection in soft floppy tissue. The incision area is prepared by dissecting a fornix based conjunctival flap, severing the attachment of tenon and lightly clearing episcleral tissue. All episcleral tissue should not be removed as it aids in the healing process. Light and directed cautery (preferably wet-field) is applied, taking care to avoid deep cautery as this leads to shrinkage of tissue and astigmatic complications.



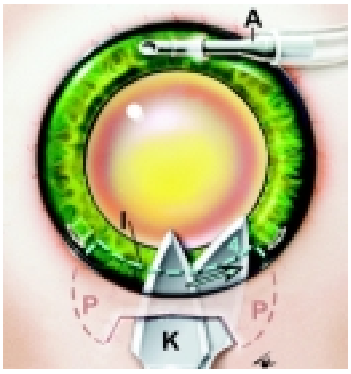
Construction of Tunnel

A - AC maintainer; D - Side port; E - External incision; C - Crescent knife; P - Side pocket; 1,2,3 - direction of movement of knife

The desired size of the **external wound** is measured with a calliper and marked behind the limbus. The frown convexity should be 1-1.5 mm behind the limbus and the ends about 3mm. Similarly, the ends of the straight incision lie about 2 mm behind the limbus. The external incision is about 0.3 mm deep and should be of uniform depth.

At the bottom of this groove, dissection is extended anteriorly till it reaches the limbus, where an increased resistance is felt. The direction of the crescent is modified to remain along the dome of the cornea and dissection is carried into 1.5- 2 mm of clear cornea. The dissection is now carried laterally with sideways sweeping movements of the crescent on either side with great care so as to remain in the plane of dissection. Conscious effort is made to tilt the knife along the contour of the cornea to maintain uniformity of the tunnel roof and avoid buttonholing laterally. Towards the lateral edge of the tunnel, the knife is swept sideways 45˚ - 60˚, resulting in a funnel shaped tunnel. While the knife is at the lateral edge of the wound, dissection must be carried obliquely backwards. This creates a **lateral pocket** on both sides. These pockets serve to accommodate the bulk of the nucleus during its exit.

The **internal incision** is created after the capsulotomy through the side port incision. For the purpose of continuity it is described here. A sharp angled 3.2 mm keratome is slid into the tunnel with a slight side to side movement to prevent premature perforation. When the keratome tip reaches the anterior end of the tunnel, it is tilted downwards to create a dimple and enter the anterior chamber. After this entry, viscoelastic is injected into the AC if required and the internal incision enlarged by forward and lateral movements of the sharp keratome. In this way, the curve of the internal incision is maintained along the limbus. The keratome should not be used to cut tissue while withdrawing (laterally and backwards) as opposed to the crescent, as this creates an irregular internal wound that may cut across the limbus and is closer to the limbus resulting in a small tunnel. During the tunnel construction, the eye is fixed with toothed forceps held away from the wound. Holding the lips of the wound damages the tunnel and compromises its integrity.



Construction Of Internal Incision

A - AC maintainer; K- 3.2mm Kerotome; P - pockets;
I - internal incision;
4- direction of movement

Complications can occur at each of the above steps while making the tunnel incision. Too superficial an external wound will cause a thin superficial flap or may result in buttonholing of the flap. In such a situation, the groove can be deepened and dissection started at a deeper plane without compromising the tunnel. Too deep a groove will increase the difficulty of corneal dissection and increase the chances of a premature entry into the anterior chamber. Scleral disinsertion can occur due to a deep groove and will result in large amount of postoperative ATR astigmatism. In both situations radial sutures are necessary to ensure secure wound closure and prevent postoperative astigmatism. A tear of the lateral edge of the external wound is quite common especially when too much force is being applied during dissection due to a blunt instrument. This happens due to the slight anterior rotation of the crescent knife during anterior dissection. If large, this can be repaired at the end of the surgery with 10-0 suture. Undue haste during tunnel dissection can lead to a premature entry into the AC. This leads to compromise of the features of the tunnel and creates problems during surgery like iris prolapse, etc. This is best prevented. It may become necessary to close the wound and initiate a new one at another site. If the inner lip has not been properly fashioned, it is better to use sutures to close the incision to prevent postoperative complications. A blunt keratome while making the internal incision or side port entry can cause a Descemet's membrane detachment. In such an eventuality, the membrane must be uncurled and kept in position using an air bubble tamponade. It may be sutured back in place if the detachment is large. Blunt instruments necessitating the use of undue force can lead to sudden uncontrolled entry into the AC and injury to the iris and lens, including zonular dialysis.

CAPSULAR OPENING

The capsular opening is made after the tunnel has been fashioned. This can be via a side port before actual entry into the anterior chamber from the main wound or after the AC has been entered, depending upon the technique and type of capsular opening used.

Three types of capsular openings are commonly used – **curvilinear capsulorrhexis, can opener capsulotomy** and the **envelope capsulotom**y. Details and merits or demerits of individual types of openings are discussed elsewhere. Here we shall focus on special features with regards to SICS. If one is using a capsulorrhexis, it should be of a fairly large size (6-6.5 mm) to allow the nucleus to prolapse into the AC. Relaxing cuts (2-4 in number) should be given at the rhexis margins if one feels that the opening may pose a problem to smooth nucleus prolapse. An effort should be made to keep the capsular rim near 12 o'clock position narrow, which will facilitate tipping up of the superior pole of the nucleus.

Use of dye in cases where the red reflex is inadequate allows safe completion of the capsulorrhexis. A can opener capsulotomy as practiced for conventional extracapsular cataract surgery works well for SICS also. However, an envelope capsulotomy is preferred as it is easy in all cataracts, and allows many of the benefits of capsulorrhexis.

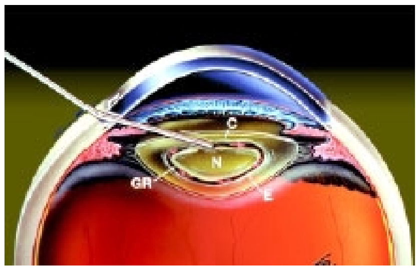
HYDROPROCEDURES

Hydroprocedures were first described by Michael Blumenthal, the originator of the mini-nuc technique of SICS. The aim of hydroprocedures in SICS was originally to reduce the nucleus size down to the smallest core endonucleus to facilitate exit from a small incision. Faust coined the term hydrodissection. The aim of hydroprocedures in SICS is to separate various layers of the cataractous lens – nucleus, epinucleus and cortex from the capsule. This facilitates free rotation of the nucleus in the bag and its prolapse into the anterior chamber. It also provides an epinuclear cushion to prevent pressures exerted on the nucleus from being transferred to the capsule and the zonules. Thorough hydroprocedures play a pivotal role in SICS and are a key to smooth progress of the surgery.

Hydroprocedures are carried out with a 1-2 cc syringe (disposable or glass). The smaller syringe gives more control over the amount and rate of fluid injected and glass syringes usually have a smoother movement as compared to disposable ones. The cannula may be 26-30 G in size, suitably angled and must have a smooth rounded tip. Always check the patency of the cannula and smooth functioning of the syringe before starting the hydroprocedures.

Hydrodissection refers to the almost complete dissection of the cortico-nuclear mass from the lens capsule with the mechanical help of a fluid wave produced by injecting BSS or Ringer's lactate exactly in between the anterior capsule and the cortex. Conventional hydrodissection was carried out between superficial cortex and the epinucleus. This has now been replaced with cortical cleavage hydrodissection. This procedure, first described by Howard Fine, involves tenting up of the anterior capsule slightly with the cannula and injecting a small amount of fluid with a jerk. Gimbel described sweeping the cannula between the capsule and the cortex before injecting fluid. Before the hydrodissection, AC is emptied of viscoelastic which had been introduced earlier for capsulorrhexis by slight pressure on the posterior lip of the incision. This safeguards against a sudden rise in pressure on injecting fluid. The cannula is introduced either from the side port (preferable) or the main incision. The tip is guided about 1 mm behind the rhexis margin in the subcapsular plane at 12 o'clock and a small amount of fluid injected with a jerk to produce a fluid wave after slightly tenting the capsule. The fluid wave is seen to transverse the whole lens as it separates the cortex from the posterior capsule. Fluid injected slowly and smoothly does not produce a wave and returns to the AC. The procedure is repeated in all the 4 quadrants. Visual confirmation of the wave and a shallowing of the AC indicate the dissection. A gentle tap on the nucleus completes the hydrodissection and deepens the AC. The nucleus is gently rotated with the cannula both clockwise and anti-clockwise. Free rotation signifies successful hydrodissection. When an intact rhexis is not available, this procedure must be done with great care with minimal amount of fluid to avoid undue forces on the capsulotomy margins and produce extension of a tear.

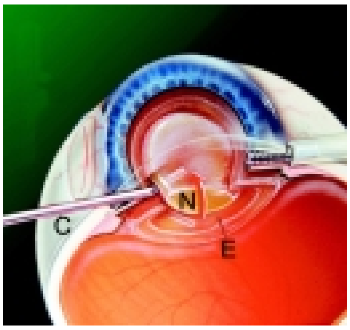
Hydrodelineation, also known as hydrodelamination and hydrodemarcation, refers to the separation of epinucleus from the nucleus by a fluid wave between the two, with the aim of debulking the nucleus. It is performed with the same instruments as in hydrodissection. The focus of the microscope is shifted to the posterior capsule where possible and under direct vision the cannula is introduced into the cortex and nucleus till it is posterior to the central hard core of the nucleus, or till it meets resistance where the soft outer nucleus ends. After withdrawing the cannula a fraction of an mm., a small amount of fluid is injected in a jerky pulsed dose. This gives rise to a golden ring under the microscope, as fluid goes around the nucleus. The advantage of starting the hydro delineation posteriorly and progressing anteriorly is the ability to visually monitor the depth of penetration to avoid puncturing the posterior capsule. While injecting fluid slight pressure on the posterior lip of the incision will assure that inadequate rise of pressure does not occur in the bag or the AC. If the ring does not appear or appears only partially, it is necessary to introduce the cannula at a different site and repeat the procedure. Beginners can start this



Hydrodelineation

C - Cortex; N - Nucleus;
E - Epinucleus; GR - Golden Ring

procedure by aspirating the anterior cortex till the anterior hard surface of the nucleus is exposed and under direct vision inject fluid into the cleavage plane. With experience, the feel of the hard nucleus gives the feedback to proceed. Certain authorities do not favour removal of the anterior cortex as this protects the endothelium from the hard nucleus.



Hydrodelineation

C - Cortex; N - Nucleus; E - Epinucleus

In very soft cataracts, several cleavage planes may be isolated and the size of the nucleus reduced to a great extent. In hard cataracts, the inner nucleus may extend right upto the capsule and a cleavage plane may not be identifiable.

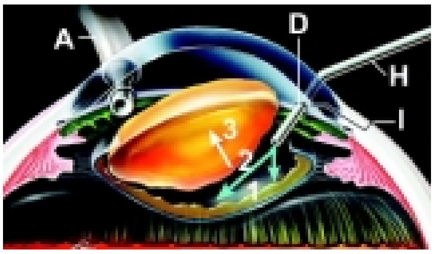
There are certain points to remember while contemplating or performing hydroprocedures. An intact rhexis makes the procedures very safe, and any deviation from the rhexis warrants extra caution and control to ensure that inadequate pressure or force inside the capsular bag does not compromise the safety of the procedure. If the hydroprocedures are being carried out through the side port, it is absolutely necessary to use the minimum fluid possible so that integrity of the posterior capsule is maintained. Only 0.1 – 0.3 cc via a 1 cc syringe is to be used. It is best that beginners use side port for subincisional hydro procedures only, and the main incision for the rest of the procedures. These procedures may be carried out with the AC maintainer in the on or off position. Certain conditions require inordinate care during hydroprocedures. High myopes, vitrectomised eyes, traumatic cataract, pseudoexfoliation, posterior lenticonus and complicated cataracts are especially prone to develop complication if hydroprocedures are not carried out with utmost control. Hypermature cataracts do not require hydroprocedures. Posterior polar cataracts deserve a special mention. A significant number of these are associated with posterior capsular deficiency and hydrodissection in these can lead to the devastating complication of a nucleus drop due to expansion of the defect. In such cases, only a controlled hydrodelineation should be done to preserve an epinuclear cushion to work on.

Insufficient hydrodissection is the most common complication which makes subsequent manipulation of the nucleus difficult and provokes excess strain on the capsule and the zonules.

NUCLEUS MANAGEMENT

Once the nucleus has been freed and minified in the capsular bag, subsequent maneuvers are undertaken to deliver it out of the eye safely. This involves various steps. First, the equator of the nucleus is prolapsed out of the capsular bag, and then the whole nucleus is delivered into the anterior chamber. Additional attempts to further minify the nucleus may be attempted and then the whole nucleus is delivered out of the anterior chamber taking care to avoid injury to the endothelium.

Provided the capsulorrhexis size is adequate, good hydrodissection will cause one pole of the nucleus to tilt forward into the AC. As mentioned earlier, a narrow anterior capsular rim at 12 o'clock will allow the 12 o'clock pole to pop out easily. The hydro cannula can be carefully maneuvered under the rhexis margin to go underneath the edge of the nucleus while injecting fluid to dislodge the equator out of the bag. In cases where the nucleus is not partially out of the bag, two Sinskey hooks are introduced and the nucleus rotated to confirm successful hydroprocedures. During this bimanual rotation, uneven pressure applied to one hook will cause the nucleus to tilt and gradually dislocate into the AC. Rotate the nucleus if necessary to bring the tip of the tilt up towards the wound (12 o'clock).

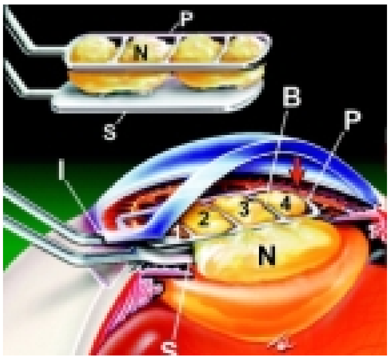


Nucleus Prolapse

A - AC Maintainer; D-side port; I-Incision; H-Hydro cannula

Once the equatorial edge of the nucleus is out of the bag, the whole nucleus is gradually rotated into the AC by **cartwheeling** in a clockwise or anticlockwise fashion. When an AC maintainer is not being used, this should be done after injecting viscoelastic both below the prolapsed pole of the nucleus and some amount above it. The nucleus floats in a 'sea of viscoelastic'. Two Sinskey hooks are used for ease. One of these is placed on the lens equator or just under the prolapsed tip of the nucleus and the other is used to rotate the nucleus out of the bag. Alternate support with one and rotation with the other hook –'walking on the equator' -will lead to the nucleus rotating into the AC. The procedure is similar to a tyre tube being removed. With experience only one instrument is required. If a small pupil hinders the above procedure, a different method involving '**somersaulting**' or '**tumbling**' the nucleus end over end may be employed to get the nucleus into the AC.

Many surgeons prefer to reduce the size of the nucleus further before taking it out, in an attempt to keep the incision size the smallest possible. This involves dividing the nucleus into smaller parts using one of the various instruments available for the purpose today. All these procedures are visco-dependent and demand a high degree of skill. The **wire snare** is a steel wire loop which passes through a small lumen and opens up as it comes out. The nucleus in the AC is engaged firmly with the loop and the loop withdrawn, cutting the nucleus into two. If required this can be repeated. The smaller fragments are then removed from a 4 mm incision. Another instrument is the **pre-chopper**, which is embedded into the nucleus in the closed position and when the blades are opened, a cleft is created in the nucleus. The nucleus is then divided into two and removed. The **phaco-fragmentome or nucleotome** technique uses sharp instruments of various sizes which divide the nucleus into two or more pieces. This procedure requires support in the form of a spatula inserted below the nucleus, against which the sharp nucleotome is pressed to divide the nucleus. **Phacofracture** technique utilizes a wire vectis below to support the nucleus and a Sinskey hook anterior to it to break the nucleus unequally. One fragment is removed followed by realignment of the other such that its long axis is vertical. This piece is then removed with either visco- or hydro- or vectis expression. Great care must be exercised in all these maneuvers in the AC to keep away from the endothelium, and the posterior capsule.



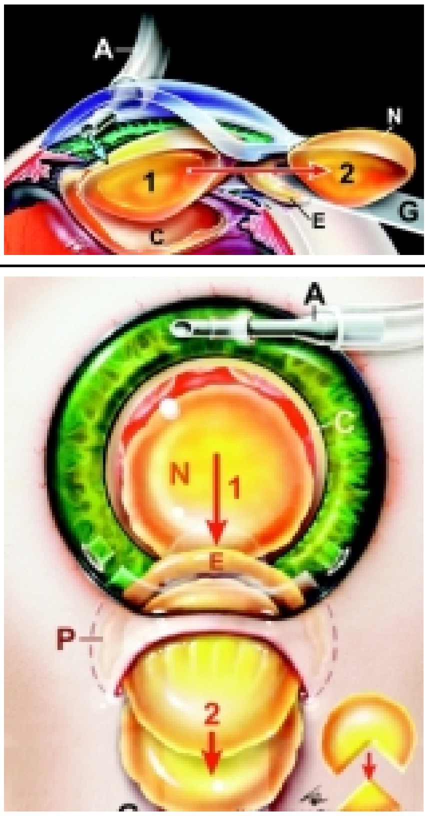
Phaco Fragmentation

N-Nucleus; P-phaco-fragmentome; S-spatula; B-Blade; I-Incision; 1,2,3,4 - Nuclear fragments

NUCLEUS DELIVERY

The nucleus may be delivered out of the AC by either hydro-expression, visco-expression, vectis assisted delivery, or the fish-hook technique. In the classical

Blumenthal technique, the AC maintainer is kept on and once the nucleus is in the AC, a glide is introduced half to 1/3 nucleus diameter behind it through the main wound. The nucleus is made to engage the wound by gentle stroking of the glide, which causes the flow of irrigating fluid through the wound to push the nucleus towards the mouth of the wound. At first, fluid leaks from both sides of the nucleus. Stroking is continued till the nucleus snugly fits the inner aspect of the wound. Once this happens, pressure inside the AC rises. Now, the posterior lip of the scleral wound is stroked. This allows the nucleus position inside the tunnel to change and it rocks from side to side while finding its way out of the tunnel. This can be assisted by gentle side to side movements applied to the pole of the nucleus presenting at the outer wound. During the exit through the tunnel, epinucleus is shed off. This can be easily expelled using the hydrostatic pressure created by the AC maintainer. If a nucleus is too large, either the incision can be enlarged to accommodate it or chipping can be performed. With the nucleus still engaged in the wound, a bent 26 G capsulotome or 24 G needle is introduced into the presenting pole of the nucleus and a triangular piece chipped off. The nucleus is the pushed back into the AC, realigned so that its smallest diameter engages the wound and expressed using the described technique.



NUCLEUS DELIVERY

A - AC Maintainer; P-Side pocket; E-epinucleus; N-nucleus; C-Cortex; G-Glide; 1,2 - Egress of the nucleus

Visco-expression utilizes pressure generated by viscoelastic injected through the side port to expel the nucleus. A glide in the main wound may be used in a similar fashion to that described above. Alternatively, viscoelastic cannula introduced through the main wound with slight pressure on the posterior lip while injecting will guide the nucleus to engage in the wound. The **irrigating vectis** technique utilizes both mechanical and hydrostatic force to deliver the nucleus. The irrigating vectis is connected to a syringe filled with BSS or viscoelastic. This is carefully introduced behind the nucleus and after visually confirming that its margins do not engage the iris, it is withdrawn slowly till the superior pole of the nucleus is engaged in the wound. BSS or viscoelastic is not injected till this stage. Now, the superior rectus bridle is pulled tight and irrigating fluid injected slowly to build up pressure. The vectis is now slowly pulled out while injecting and pressing down on the posterior lip of the wound. As the maximal diameter of the nucleus clears the wound, irrigation must be reduced to prevent sudden forceful expression and sudden shallowing of the AC.

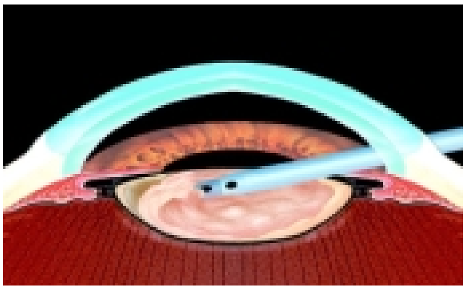
The **fish-hook** technique utilizes a hook fashioned out of a 30 G ½ inch needle. The tip is bent backwards towards the hub and another slight bend is given between the tip and the hub. This hook can be mounted on a 1-2 cc syringe. After injecting viscoelastic behind and in front of the nucleus, the bent 30 G hook is inserted between the nucleus and the posterior capsule with the tip pointing to the right. The tip is turned upwards while slightly withdrawing the needle, so that it engages in the nucleus. Now the nucleus is pulled out of the incision. This technique is fast and the nucleus can be extracted from the bag without prolapsing it into the anterior chamber.

The nucleus may not engage into the inner lip of the tunnel if the inner wound is too small, the tunnel irregular, when the AC is leaking from the incision or a side port, or when the iris obstructs the outlet due to a premature entry near the iris root. It is appropriate to re-examine and if necessary re-fashion the tunnel rather than struggle in a shallow AC.

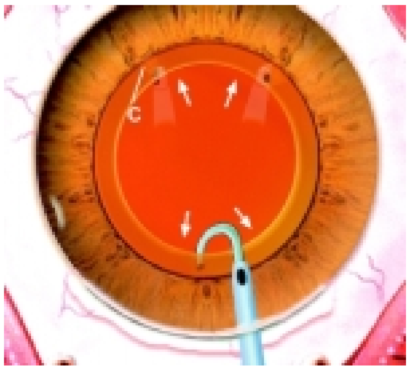
EPINUCLEAR AND CORTICAL REMOVAL

Epinucleus remaining after the nuclear removal can either be expressed with the same techniques used for nucleus expression (hydro-, visco-expression) or it may be aspirated with manual or automated aspiration. The epinucleus in the AC is removed by stroking the scleral lip while the AC maintainer is on. Epinucleus in the bag is manipulated out with a Sinskey hook or iris spatula and then flushed out. When the visco technique is used, the cannula is taken behind the epinucleus into the bag and viscoelastic is injected with simultaneous pressure on the posterior lip of the wound. Automated aspiration has the advantage of requiring less irrigation, in a closed chamber with a deep AC with the PC pushed back and less chance of endothelial damage. Manual aspiration consists of capturing the epinucleus by aspiration with a Simcoe cannula and mobilizing the mass out of the bag and the eye.

Cortical removal is by automated aspiration or manual aspiration. **Automated aspiration** has distinct advantages, but has a learning curve. **Manual I/A** has the advantage of flexibility, easy learning, safety margin and better surgeon control. **Bimanual I/A** through two side ports is the ideal method of performing I/A with a closed chamber from a collapsed tunnel. Main incision manual or automated aspiration creates some difficulty in manipulation and complete cortical cleanup because the configuration of the tunnel causes the outer wound to be posterior and lower than the inner wound. 12 o'clock cortex is especially difficult to deal because of the difficult approach. It is wiser to remove cortex from this area in the beginning as adjacent cortex keeps the bag open and aspiration as a single sheet is possible. The I/A cannula may be tilted to make it vertical such that the aspiration port is aligned to one side as opposed to the top. This is brought in contact with the cortex and aspiration carried out. This procedure is difficult with the SICS tunnel. Alternatively, a **J-shaped cannula** with aspiration port at the tip may be used. This facilitates going along the wound 'over the top' into the bag behind the rhexis margin. The cannula is mounted on a 2 cc BSS filled syringe and inserted sideways into the wound. It is rotated and the tip is guided under the anterior capsular margin. The cortex is engaged and gently stripped into the central part of the bag. It is aspirated using the regular I/A cannula. **Side port Simcoe aspiration** offers the advantage of a better approach to the sub-incisional area besides a closed deep chamber. Other methods are the **iris massage maneuver** to loosen cortex and bring it to the centre (though this invariably damages the iris), **ice-cream scoop maneuver** (turning the Simcoe tip anteriorly and towards the middle while aspirating cortex), and the **post IOL implantation**



Automated Irrigation / Aspiration



J-shaped cannula for I/A of subincisional cortex

aspiration (rotation 360˚ of a PCIOL with a dialler after insertion to loosen cortex, mobilize it and facilitate aspiration).

After having removed visible cortex, the posterior capsule may be polished with a sand blasted olive tip polisher or a scratcher. The anterior capsular undersurface should be vacuumed especially in younger aged patients as this step reduces post-operative uveitis and posterior capsular opacification.

In the presence of a posterior capsular tear, the flow and aspiration pressure must be reduced and manual aspiration is carried out towards the tear (never away from the tear) without traversing the vitreous. Ideal technique is the dry technique under viscoelastic (described by Anis Aziz). Here the AC is filled with viscoelastic to open the capsular bag and push the vitreous back. A Simcoe cannula with very little or no irrigation is used to gently aspirate cortex from the fornices of the capsular bag. Vitrectomy is required if air injected into the AC is not freely mobile.

IOL IMPLANTATION

The most commonly implanted IOL after SICS is the rigid 6-6.5 mm optic sized IOL. This usually passes freely through the tunnel if its width is also 6.5 mm. However, if the tunnel width is less (5.5 mm), it is better to enlarge the tunnel sufficiently to ensure free passage of the lens. Increasing the width of the tunnel to 6 mm from 5.5 mm does not lead to a compromise of the safety of the incision or a significant increase in astigmatism. Attempting to push an IOL through an insufficient incision causes corneal trauma and may damage the self sealing nature of the tunnel.

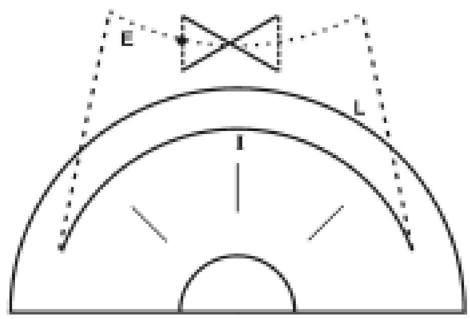
The IOL holding forceps should preferably have a curve (Shepard's or Kratz forceps) to negotiate the tunnel, which has an entry 1.5-2 mm posterior to limbus. The capsular bag should be inflated with viscoelastic or kept open by fluid from a AC maintainer. The area adjacent to the tunnel is cleared of debris and blood to prevent these from being carried into the AC with the IOL. The IOL of the correct power is held longitudinally by the forceps and manipulated through the tunnel into the AC. The IOL is held tilted upwards at the time the leading haptic is being introduced into the tunnel. As the haptic enters the AC, the lens is made horizontal and gently pushed inside. Once the leading haptic reaches the 6 o'clock margin of the capsulorrhexis, the IOL is tilted slightly downwards to make the leading haptic pass under the rhexis margin. This can be done by lifting the trailing haptic. When the leading haptic is in the bag and the IOL is in the tunnel, the IOL is released and the forceps withdrawn. A Sinskey hook or a lens manipulator is used to maneuver the IOL into the bag. The optic haptic junction or the positioning hole is engaged and the lens rotated in a clockwise manner with simultaneous backward push till the trailing haptic slips into the bag. The trailing haptic can also be grasped with a McPherson forceps and the IOL is pushed and rotated while bending the haptic inferiorly so that the elbow of the haptic passes under the rhexis margin and it slips into the capsular bag.

In the absence of an intact rhexis, the IOL insertion into the bag is difficult. The IOL should be kept pressed downwards at all times. Still, the haptics may spring back out of the bag. In the event of a PC rupture, the decision whether to implant an IOL is based on the extent of capsular support available.

After IOL insertion, thorough AC wash is given to remove viscoelastic from the AC. Viscoelastic behind the IOL is removed by lifting the IOL slightly with the I/A cannula.

WOUND CLOSURE

No suture is required to close the incision if the tunnel has been well fashioned and is of 5.5 mm to 6.5 mm in size. The integrity of closure can be checked by applying gentle pressure on the eye and observing for the egress of fluid, or by injecting a small amount of BSS from the side port and observing the deepening of the chamber. The side ports are hydrosealed. The conjunctiva is apposed over the wound with a bipolar cautery or by simply drawing it over the wound. If a suture is required, an infinity '∞' suture is applied. The first bite is taken from the inner lip of sclera to exit on the outer aspect on the left side. The next bite is taken on the right side of the wound from the corneal to the scleral side. The suture

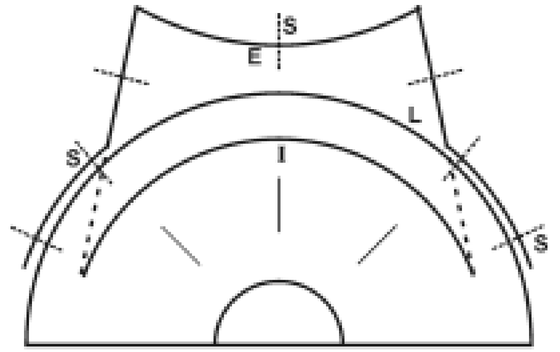


E = External Incision; I = Internal Incision; L = Limbus

Wound Closure : An infinity suture with knot buried in the wound is again crossed over to the left side to take a bite from the corneal side to exit in the wound and the knot is tied in the section. The area is then covered by conjunctiva.

CONVERSION TO ECCE

If at any stage of the surgery, there is a requirement to convert to standard extracapsular surgery, it may be easily done. If the cause for conversion is loss of wound integrity, it is best to extend the wound in the direction in which it is torn or compromised. This will preserve wound integrity at the other side. The other guideline is pre-existing astigmatism, with movement towards the flatter axis. The procedure for extension is such. Two straight vertical parallel incisions are made from both ends of the tunnel to the limbus. From the point these touch the limbus, the wound is extended along the limbus on both sides to the desired extent. At the end of the surgery, the limbal aspect of the wound is sutured as for standard cataract surgery using radial sutures. The tunnel, which has now been converted into a flap in the process of conversion, is sutured with a single interrupted suture along the sides of the flap.



E = External Incision; I = Internal Incision; L = Limbus; S= Suture

Conversion to ECCE and Subsequent Closure

SUMMARY OF INDIVIDUAL TECHNIQUES

Blumenthal's Mini-Nuc technique

The procedure starts with the introduction of the AC maintainer and all steps are performed with the AC maintainer in the on position, under positive pressure. After the ACM fixation, a side port is made and a capsulotomy is performed. The tunnel incision is made and hydroprocedures carried out. The delivery of the nucleus is assisted by the positive pressure generated by the ACM and it is guided by the glide out of the eye. I/A is carried out through a side port using an aspiration cannula. The IOL is inserted and the incision checked for leakage. The ACM is the last to be removed. The side ports and ACM port may be sealed with stromal hydration.

Irrigating vectis

The procedure differs from the above in that here the side port is made first and the eye made tense by injecting viscoelastic. The incision is fashioned next and subsequent steps performed as above. Use of the irrigating vectis to deliver the nucleus is described above. I/A is done using a Simcoe cannula and the IOL is implanted. The incision may need to be sutured as it is usually bigger than with the Blumenthal technique.

Phacosandwich

This technique also resembles the above. However, here two instruments are used to deliver the nucleus out of the eye. The vectis below and the Sinskey or spatula above firmly grasp the nucleus which is pulled out through the wound shedding its epinuclear cover in the passage. The theoretical advantage is that the presence of an instrument on top of the nucleus may afford protection to the endothelium against inadvertent contact with the nucleus on its way out of the eye. The nucleus usually breaks with the pressure from the two instruments and each fragment can be extracted along its long axis from a smaller wound.

Fish hook technique

This technique utilizes the envelope capsulotomy followed by hydroprocedures. Prolapse of the superior pole of the nucleus alone is enough to proceed with the procedure. The whole nucleus need not be brought into the AC. Eventually, the nucleus is extracted by a fish hook passed beneath the nucleus. The fish hook is fashioned from a 30 G needle and has two curves. A u-shaped curve at the terminal end forms the hook to engage the nucleus and a slight curve along the middle of the needle ensures smooth passage into the eye. After IOL insertion, the envelope capsulotomy is enlarged by removing the anterior flap.

PROCEEDING TO SICS FROM ECCE

A surgeon well versed in ECCE planning to switch over to SICS must do so with utmost patience and perseverance. Observing surgical safety during learning is of prime importance as our primary aim is to restore sight. The best way to implement change is to modify 1-2 steps at a time from your routine extracapsular technique. Also, the value of having good instruments while learning cannot be overstressed. Follow a single technique, step by step, as taught by a master in the same. Only after gaining reasonable experience and confidence should one switch over to another technique.

To begin with, practice doing a large rhexis in all cases, along with hydroprocedures and nucleus prolapse before delivery. Once these steps are mastered, one should focus on making a good tunnel. This is the step that deviates the most from ECCE. A beginner failing to achieve a satisfactory tunnel can easily convert to ECCE. In the beginning, make short wide tunnels and secure them with sutures. Move on to smaller incisions and longer tunnels once you are comfortable. It is a very good idea to practice making tunnel in goat’s eyes which are easily available. This should be done with an ACM. There should be no ego involved in converting to ECCE in case of doubt or loss of confidence. Be relaxed and do not publicize in advance your capability to do sutureless surgery. It will only add to the pressure on the learner.

There is no substitute to visual learning. Attending workshops, watching videos, and if possible reviewing recordings of your own surgery can be of immense help. Specific problems encountered while operating should be discussed with an expert.

Learning SICS is easy and it has a learning curve less steeper and less expensive than for phaco. However, we must not forget that one exists. An open minded approach and perseverance will ensure smooth learning and eventual mastery.