Phakic IOL

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Phakic intraocular lenses have revolutionized refractive surgery globally by serving as a viable option for vision correction in patients who are not suitable candidates for conventional laser-based refractive surgeries. This specially compiled issue as a part of our ongoing CME series discusses in depth the special indications of phakic IOLs, the surgical procedure itself and the post-operative care and management. As is with most refractive procedures, the technique is as important as the pre-operative assessment, which is also touched upon in here. By being a reversible procedure that does not result in the loss of accommodation, Phakic IOLs are an ideal option for patients who are good candidates for them.

The authors have done a fantastic effort in contributing insightful and informative articles that highlight all facets of Phakic IOLs including the complications, in detail. I also wish to congratulate the editor for having put together this comprehensive compilation. I am sure that the members of the All India Ophthalmological Society will find this issue useful in their clinical practice.

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"Technological change is not additive; it is ecological. A new technology does not merely add something; it changes everything”

Refractive surgery has been the fastest growing subspeciality in ophthalmology over the past decade. Technological advancements have made it possible for more and more people to achieve spectacle independence. Even though cornea based laser refractive procedures remain the most important tool in the armamentarium of the refractive surgeon, lens based procedures, especially phakic intraocular lenses (IOLs) have expanded the horizon to new limits.

The concept of phakic IOLs was introduced as far back as in the 1950s, however, the high rate of complications limited their use. The advent of posterior chamber IOLs in the 1980s brought about a revolutionary change. Continuous improvements in the technology have helped to develop lenses which not just correct the refractive power accurately, but are also safe for long term use, and customised to every patient’s eye measurements.

As a result, today phakic IOLs have found widespread acceptance among refractive surgeons and patients alike. Patients with extremes of ametropia and those with corneal thinning who could not opt for refractive correction earlier were the prime candidates for phakic IOL implantation. However, due to its high safety and reversible nature, many surgeons have now started to offer them as a first line option along with cornea based procedures.

This CME series discusses in detail the evolution of various generations of phakic IOL, the pre-operative workup, surgical steps, management of complications as well as the recent advances in this field. The surgical procedure is relatively simple and can be performed by any anterior segment surgeon well versed with cataract surgery. Also, unlike cornea based refractive procedures, there is no requirement of high end costly laser machines. I sincerely hope this CME series can encourage all ophthalmologists in the country to perform this procedure and offer the advantage of spectacle correction to all those who desire the same.

Dr. Partha Biswas
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Evolution of Phakic IOLs

Sanjay Chaudhary

INTRODUCTION:
The latter part of the 20th century witnessed a revolution in refractive surgery. A number of technologies were introduced during this period. Most of the development happened on the cornea especially Laser Vision Correction (LVC) procedures. LVC were effective for low to moderate degrees of myopia or hyperopia, but had its limitations for higher degree of refractive errors. This led to the revival in interest in Lens based refractive corrections, esp. the Phakic IOLs.

LIMITATIONS OF LASER VISION CORRECTION (LVC):
Laser Vision Correction (LVC) which includes all types of laser based refractive procedures working on remodeling the surface of the cornea to correct refractive errors have maintained the highest popularity globally for the last 25 years, for the patients and the treating doctors. However, no one procedure is perfect, and that is why we have several types of laser treatments like Aspheric Lasik, Topo-guided Lasik, Wavefront-guided Lasik, Smile, Surface ablations etc. These procedures are highly accurate for refractive correction. Their limitations include post-op dry eyes, haloes and glare, epithelial ingrowths, late flap dislocations on minor trauma, ectasias and limit of refractive corrections to name a few. From a time when Residual Bed Thickness (RBT) of 250 microns was considered satisfactory, and refractive errors of even 14D were attempted, a general consensus has now shifted to a RBT of 300 microns with a flap of 100 microns, a maximum ablation of 130 microns or 40% of corneal thickness, or a maximum correction of -8.0 D myopia or myopic astigmatism.
(cylinder preferably not exceeding 3.0 D) in a healthy cornea with sufficient corneal thickness. Most of the laser machines use 12 microns of corneal tissue for a 1.0 D of myopic correction in a 6 mm optic zone and about 15 microns of tissue for a 6.5 mm optic zone with a 2.5 mm transition zone. So, a -8.0 D correction would use up 120 microns of tissue, and so would require a minimum of 520 microns thickness of cornea at the center. Some people are now moving on to a maximum of -6.0 D LVC correction, as flattening beyond this level results in higher spherical aberrations and a reduction in contrast sensitivity.

**ADVENT OF PHAKIC IOLS:**

Phakic IOLs’ biggest impetus was the limitation of the amount of refractive correction that can be safely treated with LVC procedures. Phakic IOLs were seen as another way of refractive correction, esp. for high refractive errors. A minimum Anterior Chamber Depth (ACD) of 3.0 mm (endothelium to crystalline lens) is required for the same and this is a limiting factor in hyperopes where very few eyes have adequate ACD due to smaller size of the eye. Its advantage over other lens based refractive procedures like the Refractive Lens Exchange (RLE) with monofocal or multifocal lens was its property of preserving accommodation in young people. RLE is also associated with a higher risk of retinal detachment (upto 8.0%).

**TYPES OF PHAKIC IOLS:**

There are 3 types of Phakic and are categorized by the way they are fixated.

1. Posterior Chamber like ICL, PRL.
2. Anterior chamber Iris Fixated like Artisan/Verosyce or Artiflex/Veriflex.
3. Anterior Chamber Angle supported like Acrysof Cachet.
POSTERIOR CHAMBER PHAKIC IOLS:

The first posterior chamber phakic IOL was designed by Fyodorov in 1986, and had a collar-button or mushroom configuration. It was a silicon IOL 8.0 mm in size, 3.2 mm optic with a concave surface projecting out of the pupil. Initial complications included lens touch with cataract formation, pupillary block glaucoma, endothelial touch, lens decentration and iridocyclitis. Several modifications to the design led to the present generation of posterior chamber phakic IOL called the Implantable Contact lens (ICL) (Staar surgical Switzerland) and later renamed to Implantable Collamer Lens (ICL). The material is called the Collamer and is made of 0.2% porcine collagen and 60% hydroxyethyl methacrylate copolymer. Since it is fixated to the sulcus and is not mobile, it corrects both spherical and cylindrical powers. The less used version of posterior chamber phakic IOL is Phakic Refractive Lens (PRL) (Medennium USA), which is a floating lens in the posterior Chamber (PC) and therefore is available only in spherical powers.

ANTERIOR CHAMBER IRIS FIXATED PHAKIC IOLS:

These were the earliest lenses to popularize the concept of Phakic IOLs. Artisan Phakic IOL marketed as Verisyse lens (Abbott Medical Optics-USA) is an iris claw lens and the claw holds the mid periphery of the iris, thereby least distorting the pupil contour and movements. This was a non-flexible PMMA lens and had to be inserted through a 5.0 mm incision which had to be closed with a suture. The large
A peripheral iridectomy (PI) was a must to maintain an aqueous flow within the eye. A flexible lens version was introduced to reduce the incision size to 3.0 mm and make the incision stitchless with more predictable astigmatism, called the Artiflex/Veriflex lens. Movements of the lens hinged on the iris was attributed to some cases of corneal decompensation and so the choice moved to having a lens away from the corneal endothelium, preferably the Posterior Chamber.

**ANTERIOR CHAMBER ANGLE SUPPORTED PHAKIC IOL:**

**Figure 2:A** Artisan/Verisyse  
**Figure 2:B** Artiflex/Veriflex

**Figure 3:** Acrysof Cachet lens
The concept of using an Anterior chamber angle supported phakic IOL was introduced by Strampelli in 1953 and later Barraquer in 1959. They were designed on the principle of angle supported Kelmen IOL. Those generation of lenses had a high incidence of endothelial cell loss, chronic low-grade uveitis, hyphaema and glaucoma (UGH syndrome), pupil ovalisation, peripheral anterior synechiae and sometimes cataract. Improved versions like the Nuvita, Vivate (IOLtech) and the latest Acrysof Cachet (Alcon) Phakic IOL were introduced with better outcomes, but by that time, the Posterior Chamber lenses had already established themselves, and there were few takers for this lens, which was subsequently withdrawn from the market.

References


Although the prevalence of high myopia in the general population is exceedingly low, they constitute a significant proportion of the patients presenting for refractive surgery. Moderate and high myopes are 10 and 16 times more likely to present for a refractive correction in comparison to low myopic population.¹

Risk of regression, ectasia and compromise in the optical quality are some of the limitations associated with keratorefractive procedures in high ametropia. Hence, the need for an alternative form of treatment. The phakic intraocular lens is implanted between the cornea and the crystalline lens, and does not alter the asphericity and biomechanics of the corneal tissue.

Termed ‘duophakia’ or ‘artiphakia’ the natural crystalline lens is retained, and an additional lens is fixated in the angle (angle supported phakic IOLs) or enclavated in the mid peripheral iris tissue (iris supported phakic IOLs). Newer designs entail placement in the posterior chamber (posterior chamber phakic IOLs).

Potential complications of anterior chamber phakic IOLs include progressive endothelial cell loss, iris chaffing at the site of enclavation, associated chronic uveal inflammation, pigment dispersion syndrome and lens disenclavation, displacement or decentration.

These models have now been largely replaced by posterior chamber phakic IOLs, which will be predominantly discussed in the chapter.

Choosing the right patient and a thorough preoperative evaluation is of utmost importance to achieve optimal outcomes.
INDICATIONS FOR PHAKIC IOLs INCLUDE:

- Age of 21 years or greater.

- Refractive stability (change in MRSE of not more than -0.25D over one year). Attainment of refractive stability in high myopic eyes might be at a later age vis-à-vis low to moderate myopia. Slight variations in subjective testing and errors in gaining an ideal refraction in high myopia, are potential disadvantages while judging the refractive stability. One can also assess the stability of axial length measurement over serial visits.

- Corneal tomographic abnormalities
  Eyes with a thinnest pachymetry lower than 475 microns, calculated residual stromal bed of 280 microns or less following keratorefractive procedures, corneal ectatic disorders including keratoconus and pellucid marginal degeneration are contraindicated for keratorefractive procedures, and ideally suited for phakic IOL implantation.

- Toric phakic IOLs in keratoconus
  High safety and efficacy of phakic IOLs have been demonstrated in early stages of stable keratoconus. The results for more advanced cases of keratoconus, however are slightly inferior to toric implants for moderate to high myopia. This is secondary to increased optical aberrations and a difficulty in gaining a precise refraction in advanced keratoconic eyes. Implantation of an Intracorneal ring segment prior to ICL in such eyes allows better centration of the cone, improving visual outcomes.

  Progressive flattening induced by crosslinking results in a subsequent hyperopic shift. Thus one should allow adequate time for disease stabilization i.e. at least six months, prior to phakic IOL implantation. Though cases of progressive flattening following CXL have been noted beyond six months, the refractive effects in these eyes were insignificant or exceedingly low.

  The biomechanical impact of a penetrating corneal incision in a keratoconic eye is another concern. However, no significant changes in the biomechanical properties of the cornea have been demonstrated following ICL implantation.2-4
• High refractive errors
Correction of high refractive errors entail deeper stromal ablations with associated risk of regression and ectasia. Additionally, increased induction of higher order aberrations results in a decline of visual quality postoperatively. Phakic IOLs are implanted in the posterior chamber, resulting in a larger effective optic zone at the corneal plane, roughly by a factor of 1.25. This results in greater optical quality, reducing the risk of glare and halos, particularly in eyes with larger mesopic pupils.

The ICL allows correction of power ranging from -18.0 D to -3.0 D and +3.0 to +21.50 D in half D increments. The toric ICL has the same overall design as the spherical ICL with the addition of a toric D component (+1.0D to +6.0D cylinder).

• Internal anterior chamber depth (from the corneal endothelium to the anterior lens capsule) greater than or equal to 3.0 mm.

• Corneal endothelial cell count of more than 2,500 cells/mm².

• Mesopic pupil size of less than 6.0 mm

• Absence of ocular comorbidities including uveitis, glaucoma, cataract and risk of retinal detachment.

PREOPERATIVE EVALUATION AND WORKUP:
A thorough preoperative evaluation entails the following measurements

• Visual acuity
Corrected and uncorrected distance visual acuity for both distance and near should be recorded.

• Manifest and cycloplegic refraction
The refractive status should attain stability for a minimum period of one year prior to surgical correction. Cycloplegic refraction is imperative to unravel pseudomyopia secondary to spasm of accommodation and latent hyperopia. The refraction is carried out for a back-vertex distance of 12 mm. Contact lens over refraction can be done for high myopia.
• **Intraocular pressure**

An increase in the intraocular pressure (IOP) is a contraindication for phakic IOL implantation. The IOP is measured using applanation tonometry (Goldmann tonometer) or pneumotonometer. Goldmann tonometry overestimates and underestimates IOP measurements in thicker and thinner corneas respectively.

• **Slit lamp bio-microscopic evaluation**

This allows assessment of the adnexa, ocular surface, tear film and crystalline lens. Blepharitis and meibomian gland dysfunction should be treated to reduce the risk of postoperative inflammation and dry eye. Corneal dystrophies like fuchs endothelial corneal dystrophy (FECD) is a contraindication for phakic IOL implantation. One should ascertain the absence of glaucoma, ocular inflammation and cataract formation. High hyperopes must be carefully evaluated for narrow intraocular environment.

• **Quantitative and qualitative evaluation of the tear film function**

Corneal conditions like superficial punctate keratitis may be seen in conditions of dry eyes. A Schirmer’s test should be performed and the tear film break up time (TBUT) assessed. The health of the tear film should be restored prior to surgical correction.

• **Dilated fundus evaluation**

A well dilated fundus evaluation with indirect ophthalmoscopy is of particular importance in myopic eyes with increased incidence of peripheral retinal degenerations. The risk of retinal detachment following phakic IOL implantation is 0.9%, which is attributed to fluctuations in the anterior chamber.\(^5\) Peripheral retinal degenerations should be appropriately treated prior to lens implantation. One should rule out zonular defects which may predispose to vitreous luxation and subsequent decentration of posterior chamber phakic IOLs.

• **Corneal topography/tomography**

Corneal topography is an important investigation prior to refractive correction. Advancements in technology have enabled progress beyond traditional keratometry by the use of sophisticated imaging systems which utilize multiple data points at both the
anterior and posterior surface of the cornea. Standard keratometry measures the corneal curvature on two principal meridians at points 3 and 4 mm apart in the center of the cornea and assumes that the remainder of the central and peripheral cornea is a perfect spherocylindrical surface. However, as corneal irregularities increase, these two measurements do not suffice. In such cases, placido disc measurement of the corneal surface helps to highlight the irregularities in shape.6 The placido disc mires appear widely separated in flat areas while steeper portions show closely placed mires. Topographers use computerized keratoscopic imaging to digitally reconstruct the corneal surface and represent it as a color-coded map. As a general rule, cooler colors such as blue represent flat areas while warm colors such as red indicate steep areas. These maps portray not only the central region of the cornea but also the peripheral and mid-peripheral areas where surface abnormalities may lie.

Computerized corneal topography examination is an important part of the preoperative evaluation. Corneal tomography is the creation of three-dimensional images from two-dimensional cross sections. The commonly used corneal topography/tomography systems include slit scanning (Orbscan, Bausch and Lomb, Rochester, New York), Scheimpflug imaging (Pentacam, Oculus Inc., Germany and Galilei, Zeimer Ophthalmic systems, Germany), high speed anterior segment optical coherence tomography (Visante, Carl Zeiss Meditech, Jena, Germany).

The Orbscan II is a hybrid system which combines a projective slit scanning device with a reflective placido technique.7 The images are represented as color maps including a curvature map, anterior and posterior elevation map and pachymetry map. Though the Orbscan is relatively accurate for corneal topography in normal population for myopes and keratoconus eyes, its posterior elevation data is unreliable. Pachymetry measurements are also less reliable than Scheimpflug devices as the posterior surface of cornea is assumed or extrapolated rather than directly measured. The Pentacam utilizes rotating Scheimpflug imaging technology to generate a complete image of the anterior segment of the eye.
The use of corneal tomography in the preoperative evaluation for phakic IOLs allow to rule out corneal ectatic disorders, assess disease stability after cross-linking process, measure the anterior chamber depth and the axis and magnitude of corneal astigmatism.

- Specular microscopy
  This helps to assess the status of the corneal endothelium. Minimum endothelial cell count of 2,500 cells/mm² is indicated for phakic IOL implantation.

- Pupil diameter
  The pupil diameter is measured under low light (mesopic) conditions of less than 5 lux. The average mesopic diameter ranges from 4-8 mm and may be measured using a Rosenbaum card or an infrared pupillometer such as Colvard Pupillometer (Oasis, Glendora, CA). An assessment of the pupil diameter preoperatively is useful in identifying eyes at risk of postoperative glare and halos. A dark-adapted pupil diameter of greater than 6mm allows light from beyond the treated optic zone to create a glare or a halo effect around the viewed image.

- Ocular dominance
  Ocular dominance is tested for patients undergoing monovision correction. Monovision is a method of presbyopia correction wherein the dominant eye is corrected for distance vision (targeted emmetropia) and the non-dominant eye corrected for near (targeted myopia). Ocular dominance can be tested using sighting tests e.g. hole in card test, sensory tests (binocular rivalry test) or by assessing asymmetry in visual acuity and contrast sensitivity.

- Contrast sensitivity
  Contrast sensitivity testing is an important estimate of the complete visual system function. Measured under varying conditions of luminance and glare, it denotes the relationship between the optical efficiency of the eye and the minimum retinal threshold for pattern detection. Spherical and cylindrical refractive errors as well as higher order optical aberrations such as spherical aberrations and coma have an impact on the contrast sensitivity function of the eye.\(^8\)
• Measurement of white-to-white diameter

In the preoperative planning, the critical parameter in sizing the ICL is the white-to-white (WTW) measurement. Since the phakic IOL was designed so that its haptic rests horizontally on the ciliary sulcus, the length of the IOL should ideally be equal to the horizontal sulcus diameter. The conventional method for sizing the ICL is an addition of 0.5mm to the horizontal WTW for an anterior chamber depth (ACD) of less than 3.5 mm and 1.0 mm for an ACD of more than 3.5 mm. WTW measurements can be performed using various devices including using a Pentacam, Orbscan, UBM or digital calipers (Figure 1,2).

WTW measurements with automated techniques offer convenient and repeatable measurements. However, measurements with manual calipers afford greater accuracy, especially in eyes with limbal anomalies including a thick arcus, pterygia and dense pigmentation.

If the phakic IOL is too short for the sulcus, the lens vault may be insufficient increasing the risk of anterior sub capsular cataract formation and rotation, secondary to an unstable fixation. If the implant is oversized, the lens vaults excessively, crowding the angle and possibly causing secondary angle closure glaucoma.

Figure 1: Measurement of white-to-white diameter with Pentacam (Schiempflug image)
• Anterior chamber depth

ACD can be measured using optical devices including IOL master, anterior segment imaging devices like Orbscan and Pentacam or A scan ultrasound. No significant difference was found between the former methods. However, corneal indentation secondary to contact ultrasound may result in an erroneous ACD measurement. The geometry of the chamber and the opening of the irido-corneal angle are critical issues to ensure safe implantation. Another important caveat to remember is that the central anterior chamber depth may be erroneously high secondary to increased corneal curvature and thinning in cases of advanced keratoconus. In such cases it would be ideal to subtract not more than 0.2 mm from the central AC depth, to compensate for the false high reading.

Calculation of lens power: ICL/TICL calculation and implantation software allows calculation of spherical and cylindrical power, length and generates the ICL/TICL implantation diagram (Figure 3). The calculations are based on preoperative measurements including refraction, anterior chamber depth and white-to-white.
Lens vault

Ideal lens vault is approximately 250 to 750 µm, which is roughly half to one and a half corneal thickness. (Figure 4). Vault can be measured using anterior segment OCT (Figure 5).
There are concerns about high vault (1000 µm) leading to angle crowding and resulting in angle closure or synechiae formation. High vault may also increase iris chaffing and pigment dispersion, resulting in pigmentary glaucoma. In such cases, the lens should be replaced by a smaller size implant. On the other hand, low vault (125 µm) may cause ICL contact with the crystalline lens and increase the risk of cataract formation over time.\textsuperscript{78-79}

- Peripheral iridotomy

A peripheral iridotomy is performed one to two weeks before the surgery to provide an outlet for the aqueous flow around the lens. Alternatively, it may be performed intraoperatively after phakic IOL implantation with a Vannas scissors or a vitrectomy cutter. It should be sufficiently wide (at least 500 microns), positioned superiorly (from 11 to 1 o’clock) and well away from the haptics placement. The newer model of Visian ICL with centraflow (V4C) has a central artificial hole called the KS aquaport. This improves the aqueous circulation within the eye improving the lens metabolism and reducing the incidence of cataract.\textsuperscript{9} This obviates the need for a peripheral iridotomy and reduces the risk of complications such as hyphaema and inflammation.

In conclusion, a thorough preoperative evaluation allows selection of appropriate sized implants, thereby reducing the risk of complications such as angle closure glaucoma and cataract formation.

References:


INTRODUCTION:

Insertion of a posterior chamber phakic IOL is a simple surgical procedure which can be performed by any anterior segment surgeon. However, one must be aware of the various surgical complications, and how to manage them. This chapter deals with the surgical steps of a routine uncomplicated procedure, while the next chapter will discuss about the various surgical complications.

PRE-OPERATIVE PROTOCOL:

In our practice, topical antibiotics are given 6 times daily in both the eyes starting three days prior to the procedure.

ON THE DAY OF THE SURGERY:

- Dilatation drops are instilled starting one hour prior to the procedure.
- For Toric phakic IOL, marking of the 0-180 degrees axis is done pre-operatively at the slit lamp using a marker pen.
- 5% povidone iodine solution is used to paint the peri-operative area, and the same is instilled into the cul-de-sac 5 minutes prior to the procedure.
- The surgery is done inside the operation theatre maintaining all aseptic and antiseptic precautions.
- The surgery is performed under topical anesthesia. Proparacaine 0.5% solution is instilled starting 5 minutes prior to the procedure.
LOADING OF THE PHAKIC IOL (ICL):

- Since the loading of the ICL is crucial to its smooth and controlled implantation, it is recommended that the surgeon does it himself/herself under the magnification of the microscope.
- The injector is half filled vertically with methylcellulose; the other half is then filled with balanced salt solution, and mixed with the methylcellulose thoroughly. (Figure 1)
- The lens is present in a vial, from where it is carefully taken out by a specific applicator. (Figure 2)
- The lens is placed carefully into the groove of the cartridge, located between the wings of the open cartridge. (Figure 3)

**Figure 1:** Mixture of methylcellulose with balanced salt solution in cartridge

**Figure 2:** Implantable collamer lens is taken from glass vial with special applicator
• The lens is pulled gently with an Aus de Aur forceps to the nozzle of the cartridge. (Figure 4)

• The plunger is pressed in one smooth maneuver, making sure the lens is not trapped anywhere between the wings.

**Figure 3:** A and B: Implantable collamer lens is set properly in the groove of cartridge

**Figure 4:** Implantable collamer lens is held with aus de aur forceps and gently moved forward to the nozzle of the cartridge

**IMPLANTATION OF ICL V4C IN EYE:**

• Under topical anesthesia, two side ports, and a temporal clear corneal incision (2.8 mm) is made. (Figure 5)

• For toric phakic IOL implantation, the required axis is marked over the cornea with a marker.

• The anterior chamber is filled with viscoelastic substance.
**Figure 5:** Main port is made temporally and implantable collamer lens is injected through it

- The ICL is inserted through the main port slowly in a controlled atraumatic fashion over 10-15 seconds and placed in the anterior chamber first. (Figure 6)

- Some viscoelastic substance is injected on top of the ICL.

**Figure 6:** A and B: Slow gradual dislodging of implantable collamer lens in anterior chamber

- Then each haptic is carefully tucked under the iris using a special ICL manipulator, taking utmost care not to touch the anterior surface of the crystalline lens. (Figure 7)
The phakic IOL now vaults over the crystalline lens.

For Toric phakic IOL, the axis of the lens is aligned with the calculated axis.

The viscoelastic substance is removed completely, and the chamber is formed with BSS.

For Toric phakic IOL, the alignment is checked once again.

The newer generation ICL (V4c) has a central hole, the KS-Aquaport, 360µ in size, which eliminates the need for creating a surgical peripheral iridectomy (PI) which was required for the earlier generations.

The ports are hydrated and the case is closed. (Figure 8)

Figure 7: Injecting gel over the implantable collamer lens and tucking it under the iris

Figure 8: Anterior chamber is washed properly and incision is closed by hydration
POST-OPERATIVE PROTOCOL:
• Antibiotic-steroid combination is given 6 times daily in the operated eye for one week.
• Low dose steroid drops are given for two more weeks.
• Topical non-steroidal anti-inflammatory eye drops are instilled for one month.

POST-OPERATIVE EVALUATION: (TO BE REPEATED ON 1ST AND 7TH POST-OPERATIVE DAY)
• Complete ophthalmological evaluation.
• Intraocular pressure measurement.
• Anterior segment OCT to measure the vault.
• Specular microscopy, if necessary.
Complications of Phakic IOL and their Management

Pranita Sahay, Jeewan S. Titiyal

**INTRODUCTION:**

There has been a continuous evolution in the design of phakic IOLs ever since its first implantation by Strampelli and Barraquer in the early 1950s.\(^1\) Changes have been observed in the design of IOL, material of IOL (PMMA/Silicon/Collamer/Acrylic) and position of haptic fixation of these IOLs (angle-supported/iris-fixated/posterior chamber) to improvise its outcome in terms of long term safety and efficacy. The complications related to phakic IOLs are predominantly determined by the site of haptic fixation. The major concerns with angle supported and iris fixated IOLs are corneal decompensation, glaucoma, and uveitis considering the proximity of their haptic to the angle structures, peripheral iris and cornea. On the other hand, the major concerns with posterior chamber IOLs are cataract, pigment dispersion, angle closure glaucoma and uveitis considering their proximity to the lens capsule and posterior pigmented layer of the iris. Based on the available data on the long-term safety of phakic IOLs, currently the use of angle-supported phakic IOL has gone out of clinical practice considering a high complication rate associated with its implantation. Hence, there are only two models of phakic IOL that are currently US-FDA approved and are widely used in clinical practice - Visian ICL (Staar Surgical group) a posterior chamber phakic IOL and Verisyse (Abbott Medical Optics) an iris-fixated phakic IOL.

The specific complications related to each type of phakic IOL will be discussed in detail in the following section.
POSTERIOR CHAMBER PHAKIC IOL:

The posterior chamber phakic IOLs are located between the posterior pigmented layer of the iris and the anterior surface of the crystalline lens. The first posterior chamber phakic IOL that was used in clinical practice was PRL (Zeiss-Meditec, Germany). In an attempt to increase the biocompatibility of the posterior chamber phakic IOL, the STAAR company introduced ICL which was made of collamer. It attracts fibronectin on the surface of these IOLs making them invisible to the immune system. The original model of ICL has undergone considerable change in its design to decrease the associated complications. The major changes being increase in the size of the optic, increase in the back curvature of the IOL to increase the vault and incorporation of a central hole (Centraflow) to improve the aqueous flow between the posterior and anterior chamber and thereby eliminating the need for pre-operative laser iridotomy.

Recently, various indigenous companies have come up with their own model of hydrophilic acrylic posterior chamber phakic IOLs. These include Implantable Phakic Contact Lens (IPCL; Care Group, Baroda, India), Refractive Implantable Lens (RIL; Appasamy Associates, Chennai, India) and Eyecryl Phakic IOL (Biotech Vision Care, Ahmedabad, India). However, long term results of visual outcome and associated complications with these phakic IOLs are not available as yet. Hence, complications associated with the most commonly implanted phakic IOL, that is ICL will be discussed in details below.

Intra-operative Complications:

A careful loading of the ICL in the correct orientation onto its cartridge is the most crucial step to ensure appropriate unfolding of the ICL in the anterior chamber. There are a few complications that we have observed in day-to-day practice especially in the early cases of a novice surgeon.

Dropping of ICL

ICL is supplied in a glass vial filled with fluid. A foam tipped applicator is used to take the ICL out of the vial and place it over the cartridge. This step requires extreme caution as any unstable or jerky movement can result in dropping down of the ICL. Hence, this step should ideally be performed over a sterile table under visualization of a microscope.
Chipping of ICL

Chipping of edge of the ICL has been observed in few cases. (2) Chipping can occur at either the leading edge or trailing edge. One should be extremely cautious while pulling the ICL onto the cartridge with the ICL forceps. Irregularities/sharp edges in the forceps or an improper/shallow hold of the ICL with the forceps can result in chipping of the leading edge of the ICL [Figure 1]. Therefore, it is always advisable to check the forceps under the microscope before loading the ICL onto the cartridge. Also, loading of the ICL should be performed under the microscope to ensure that the ICL is held at the central point of the leading edge with an adequate length of the ICL being grasped in the ICL forceps. If chipping of the ICL is noted at the step of loading of the lens, then the surgery should be deferred and the ICL should be sent for exchange.

Chipping of the trailing edge of the ICL occurs when there is inadequate viscoelastic in the cartridge resulting in the ICL getting stuck between the foam tipped applicator of the plunger and the cartridge while injecting it into the anterior chamber. The chipping of the trailing edge of ICL is often noted after injection into the anterior chamber. In such a scenario, the ICL should be explanted and exchanged with a new ICL. Sharp edges of the chipped ICL can result in damage to the lens capsule and development of cataract.

![Figure 1: Chipped haptic of posterior chamber phakic IOL while loading the IOL](image-url)
Reverse ICL

Opening of the ICL in a reverse orientation is the most dreaded complication while injecting the ICL in anterior chamber. The cause for reverse opening of the ICL are faulty loading of the ICL in incorrect orientation, the three holes of the ICL not being properly aligned while pulling onto the cartridge, unequal distribution of OVD in the anterior chamber resulting in flipping of ICL while injecting it. To avoid this complication an accurate assessment of the hole in the leading right haptic should be done before pulling it onto the cartridge. The alignment of the three holes in the optic should also be checked. A slow injection of the ICL into the anterior chamber should be performed so that there is enough time to assess the direction in which the ICL is opening and accordingly manually rotate and adjust the cartridge to ensure that the three holes in the optic appear aligned and the ICL opens in the correct orientation. Inverted ICL can result in shallow post-operative vault and central lens touch in the immediate post-operative period [Figure 2]. Cataract may develop if the ICL is left in this position for long.

The clinical assessment of the holes in the haptic for orientation of the ICL in the post-operative period is practically impossible as it is placed in the ciliary sulcus; hence ASOCT can be used in this scenario. ASOCT imaging that shows the reverse anterio-posterior orientation of the ICL with the concave surface of the ICL facing up in case of inverted ICL.

Reverse ICL is an indication for ICL explant followed by injection of the same or a new ICL based on the clinical assessment of the integrity of the explanted lens.² ³ Flipping of the ICL in the anterior chamber should not be attempted as it can result in damage to the lens capsule as well as the corneal endothelium.
Iatrogenic damage to the anterior lens capsule can occur while making the main port incision with a 2.8 mm due to sudden aqueous egress and collapse of the anterior chamber. Hence it is advisable to inject OVD through the side port to have a stable anterior chamber before making the main incision.

**Early Post-Operative Complications**

**Raised IOP and Glaucoma**

Early post-operative transient rise in IOP is seen in few cases which primarily occurs due to retained OVD or steroid response in steroid responders.\(^4\) Infrequently, blockage of the peripheral iridotomy in the immediate post-operative period resulting in raised IOP has been reported in cases with V4 model.\(^4\) While cases with retained OVD that present with raised IOP in the immediate post-operative period require a short course of topical anti-glaucoma medication, steroid responders may require treatment for 4-6 weeks with tapering of steroid. Cases with blocked peripheral iridotomy require augmentation of the iridotomy along with a short course of topical anti-glaucoma medication.
The incidence of glaucoma in patients with posterior chamber phakic IOL implantation is much less compared to the other types of phakic IOLs. Prophylactic iridotomy which was previously required in all cases undergoing implantation of V4 model is now deemed unnecessary with the current V4C model having a central aquaport.

The reported incidence of glaucoma varies from 0% to 5% at 2 years follow-up.\(^5,6\) However, a high incidence of ocular hypertension (13%) requiring anti-glaucoma medication has been reported in a 10 years follow-up study with the V4 model.\(^6\) It has been seen that the irido-corneal angle narrows by 40% in the first post-operative month following which it remains stable, but an increase in the pigmentation of the irido-corneal angle is observed which may be the cause for raised IOP in the long run in some of these cases.\(^6,7\) At present, there is limited data to show a direct association between the above stated angle changes with high vaulting in these cases and its correlation with development of glaucoma.

This complication can be avoided by proper sizing of the ICL, adequate aspiration of the OVD at the end of surgery and judicious use of steroids in the post-operative period. Prophylactic pre-operative peripheral iridotomy was required in cases undergoing implantation of V4 model of ICL.

\textit{Pigment dispersion}

Pigment dispersion, although more common with angle fixated and iris fixated phakic IOL, has been reported with ICL both in the early as well as late post-operative period.\(^8-10\) The etiology for pigment dispersion in cases with ICL implantation can be either the pre-operative laser iridotomy (V4 model) or constant friction of the ICL with the posterior pigmented layer of the iris in cases with high vault [Figure 3]. The released pigments deposit in the trabecular meshwork and often result in raised IOP which is often difficult to control even with maximum anti-glaucoma medication. A proper pre-operative assessment and sizing of the ICL can avoid this complication. To avoid the long term complications of glaucoma in cases with pigment dispersion occurring as a result of high vault, explant of ICL is deemed necessary for optimal outcomes.\(^10\)
Uveitis

ICL is composed of collamer which makes this IOL biocompatible. The surface of these IOLs attract deposition of fibronectin that provides an immune privilege status to the IOL in the eye. Therefore, the risk of uveitis in patients following ICL implantation is extremely low.\textsuperscript{11,12} There are only few isolated case reports of anterior uveitis in cases of ICL which were managed with topical steroid therapy.\textsuperscript{2,13}

Visual Dysfunction

Visual dysfunction in the form of glare, halo and night vision problems can be extremely disturbing to the patient in the post-operative period. Glare and halos are reported by 26\% - 55\% of the patients in the immediate post-operative period. The pupil size, size of the ICL and small optic size of ICL, difference in the mesopic pupil size and optic zone of ICL and white to white (WTW) diameter are the factors that show an association with its occurrence.\textsuperscript{14-16} Patients with a large pupil diameter, small size of ICL (<12mm), small optic zone of ICL and small WTW are at higher risk for developing these complications.\textsuperscript{14,16} However, most of the patients undergo neural adaptation with time and the incidence of visual dysfunction decreases by 3 months.

There were few concerns with the introduction of the V4C model (with a central hole)
regarding the increased risk of visual dysfunction due to scattering of light by the hole. However, no difference has been observed in the V4 and V4C model in various prospective comparative studies in the occurrence of visual dysfunction.

The EVO plus (V5 model) has an increased size of the optic zone (5 mm - 6.1 mm) compared to the V4C model (4.9 mm - 5.8 mm). Hence, the symptoms of night time vision problem and the extent of glare experienced by these patients are less in patients implanted with the V5 model of ICL compared to the V4C model.17

**Endophthalmitis**

Implantation of ICL carries the risk of endophthalmitis like any other intra-ocular surgery. However, it is rare following ICL implantation with a reported incidence of 0.0167%, approximately indicating 1 case of endophthalmitis after 6,000 cases.18 Acute bacterial endophthalmitis with staphylococcus epidermidis is the most commonly reported etiological agent which was managed with intravitreal antibiotic injection.18-20

**Toxic Anterior Segment Syndrome (TASS)**

As with endophthalmitis, TASS can occur following any intra-ocular surgery. Management of TASS is done with intensive topical steroids.21 Explantation of ICL may be required in cases with poor control of inflammation with standard therapy.22

**Late Post-Operative Complications:**

**Cataract**

Development of cataract is one of the major concerns on long term follow-up in cases with implantation of posterior chamber phakic IOL considering the proximity of these IOLs to the crystalline lens [Figure 4]. Patients with low post-operative vault are especially predisposed to developing cataract with anterior sub-capsular cataract being the most common morphology in these cases. The USFDA trial reported 2.7% incidence of cataract at 3 years follow-up with the V4 model of ICL and requirement for cataract surgery with ICL explantation in 0.6% cases for visually significant cataract.11 The incidence of cataract increases with time and the risk is 6-7% at 7 years23, 20-28% at 8
and 54.8% at 10 years follow-up. However, the requirement for cataract surgery with ICL explantation for visually significant cataract is reported in 1-2% cases at 7 years, 4.9% cases at 8 years and 18.3% at 10 years follow-up.

Figure 4: Anterior subcapsular cataract in a case with phakic IOL in situ and shallow vault (A) Retroillumination image showing anterior subcapsular cataract in a case with phakic IOL in situ; (B) Shallow vault of 100 microns on anterior segment optical coherence tomography

The risk of developing cataract with V4C model of ICL is less compared to V4 model, 3.1% vs 6.9% at 2 years follow up. This can be because of the better aqueous humor circulation to the lens anterior capsule in V4C model due to the presence of central aquaport.

Cataract in the early post-operative period mostly occurs as a result of surgical manipulation leading to lens touch and prolonged exposure to OVD resulting in lens epithelial changes. The increase in the incidence of cataract with time is related to the progressive decrease in the ICL vault with time. It has been reported that the ICL vault decreases by 26-28 micron per year. Hence, an immediate post-operative vault >550 microns is safe for these patients considering the long term risk of cataract. Also, one should be careful while injecting the ICL and tucking the haptic to avoid lens touch. The duration of OVD exposure should also be kept minimal with proper aspiration of OVD at the end of procedure.

Management includes explant of the ICL with cataract surgery in cases with visually significant cataract [Figure 5] while cases with cataract not affecting the visual acuity can be observed.
Endothelial cell loss and Corneal decompensation

Significant endothelial cell loss and risk of corneal decompensation are major concerns for angle fixated and iris fixated phakic IOLs. ICL is considered relatively safe in this regard with a surgically induced endothelial cell loss of 6.5% at 1 year and then 1.2% subsequently every year. Long term studies have suggested an average endothelial cell loss of 6.2 ± 8.6% at 8 years follow-up with no case of corneal decompensation. However, with the V4C model the endothelial cell loss is further less (<1% at 5 years). Prospective comparative studies have shown that there is no significant difference in the endothelial cell loss between V4 and V4C model at 5 years follow-up.

Posterior Segment Complications

It is important to perform a proper fundus screening in all cases of moderate-high myopia undergoing ICL implantation and prophylactic laser barrage in cases with any treatable lesion. As such myopic patients are at an increased risk for retinal detachment, any intra-
ocular surgery in these cases may further add on to the risk. However, various studies that have assessed the incidence of RRD in cases with ICL implantation and have not found any direct correlation of this intervention with the development of RRD. The reported incidence of RRD in these cases vary from 0.32% to 0.7%. Management of retinal detachment in these cases are done as a routine case with either scleral buckling or pars-plana vitrectomy. Sometimes ICL explant with phacoemulsification and IOL implantation may be required prior to retinal detachment surgery for better intra-operative visualization of the retina. The other reported retinal complications include choroidal neo-vascular membrane and sub-macular hemorrhage (0.24%).

The angle supported and iris fixated phakic IOLs are now largely out of clinical practice. Hence complications associated with these IOLs are briefly described below.

**ANGLE SUPPORTED PHAKIC IOL:**

The angle supported phakic IOLs are placed in the anterior chamber with the haptics placed in the irido-corneal angle. The distance of these IOLs from the lens although reduces the risk of cataract, its proximity to the cornea, angle structure and iris results in increased risk of endothelial cell loss, secondary glaucoma, uveitis and distortion of the pupil shape.

A prophylactic pre-operative laser iridotomy or intra-operative surgical iridectomy is essential in these cases to avoid post-operative pupillary block glaucoma. Also, pigment dispersion, chronic uveitis and direct damage to the trabecular meshwork by the IOL haptic can result in raised intra-ocular pressure in the late post-operative period. Most of the cases are managed with topical anti-glaucoma medication but intractable cases may require IOL explant and glaucoma filtering surgery.

The angle supported phakic IOL rest close to the iris surface with its haptics being in close proximity to the peripheral iris. Therefore, constant change in the pupil size in response to light and movement of the iris results in friction between the iris surface and the IOL causing pigment dispersion as well as breakdown of the blood aqueous barrier resulting in ocular inflammation. Conservative treatment with topical
steroids for management of post-operative uveitis may suffice in most of the cases; however, recalcitrant cases may require explantation of the IOL for optimal control of the ocular inflammation.\textsuperscript{30,31}

The intermittent movement of the angle supported phakic IOL and its contact with the posterior layer of the cornea is hypothesized to be the cause for the ongoing endothelial cell loss in these patients. An inappropriately small sized angle supported phakic IOL is a risk factor for this complication. Barraquer et al., in the first case series of 259 patients implanted with angle fixated phakic IOL, reported that 60% cases required explantation of these lenses due of complications like corneal decompensation and uveitis–glaucoma-hyphema (UGH) syndrome.\textsuperscript{32} With the improvement in the design of these angle supported IOL, the degree of endothelial cell loss and risk of corneal decompensation has decreased. However, the ongoing endothelial cell loss associated with these IOLs is worrisome and needs attention. Therefore, an appropriate pre-operative assessment of the patient’s endothelial cell count and anterior chamber depth along with sizing of the phakic IOL based on the patient’s corneal diameter is crucial to avoid the long-term sight threatening complication of corneal decompensation in these young patients. Also, all cases with an angle supported phakic IOL in situ should be meticulously followed with specular microscopy to detect damage to the corneal endothelium and explant these IOL whenever found to be clinically necessary. Management of cases of corneal endothelial decompensation in these cases is done by phakic IOL explantation followed by endothelial keratoplasty (DSAEK/DMEK).

Pupil ovalization is a complication specific to angle supported phakic IOLs. An oversized angle supported phakic IOL can cause ischemic and inflammatory damage of the peripheral iris by compressive forces of the IOL haptic resulting in sectoral iris atrophy, iris retraction and pupil ovalization. It has been observed that the incidence of pupil ovalization increases with time (8.7% at 6 months and 17.4% at 2 years).\textsuperscript{33} Most of the cases with minor pupil ovalization can be observed or treated with miotics in the early post-operative period; however, cases with severe ovalization of the pupil may require explantation of the IOL.
Excessive intra-operative manipulation and lens touch can result in focal cataract in the immediate post-operative period. Also, use of air and viscodispersive agent can induce changes in the lens epithelial cells and induce cataract. Hence, use of these agents during surgery should be avoided.

As the anatomical position of the angle fixated phakic IOL is far from the crystalline lens, there are less chances of cataract due to the direct contact of the IOL with the patient’s crystalline lens. However, cataract is the leading cause for IOL explant in cases of angle supported phakic IOL as reported in a case series by Alio et al., wherein 64% of the cases undergoing IOL explant had cataract as the indication for surgery.\(^{34}\) The management of cases developing cataract following implantation of angle supported phakic IOL includes explant of the phakic IOL followed by cataract surgery and posterior chamber IOL implantation. However, if the cataract is not visually significant and non-progressive in nature, it can also be observed.

The other reported complications of angle supported phakic IOL include IOL rotation due to under-sizing of the IOL, glare and halos, and posterior segment complications.\(^{30,31,33}\)

**IRIS FIXATED PHAKIC IOL:**

Iris fixated phakic IOLs are fixed onto the iris tissue in the mid-peripheral region. The original model of iris fixated IOLs has undergone considerable modification to increase the vault of the IOL from the iris, still their proximity to the iris tissue and cornea results in complications like uveitis, pigment dispersion, iris atrophy, pupil distortion, glaucoma and corneal decompensation.

Pigment dispersion has been reported in patients implanted with these IOLs although these IOLs vault over the iris surface.\(^{8,9}\) Constant movement of the iris in relation to the IOL results in release of pigments which are deposited over the corneal endothelium as well as over the IOL surface. It occurs more commonly in cases with hyperopic lenses. Cases with severe pigment dispersion are at increased risk of glaucoma and explantation of IOL is therefore necessary to avoid long term complications.\(^{9}\) Baikoff et al. gave the concept of crystalline lens rise (CLR) (distance between the anterior pole of the crystalline lens and
an imaginary line joining the 3 and 9 o’clock position of the anterior chamber angle) for planning patients for iris fixated phakic IOL.\textsuperscript{8} Cases with CLR > 600 microns are at greater risk of compression of iris between the IOL and the crystalline lens and hence at greater risk of pigment dispersion.\textsuperscript{8} Hence, iris fixated phakic IOLs should be avoided in these cases.

Uveitis has been reported in 2.3\% to 10\% of cases with implantation of iris fixated phakic IOL.\textsuperscript{35} The cause for inflammatory reaction being the same as pigment dispersion, that is constant friction of the iris surface with the IOL. It is more common in patients with a dark iris and intra-operative iris damage. Management includes topical steroids while intractable cases may require IOL explantation for optimal control of inflammation to avoid long term complication of glaucoma.

The reported endothelial cell loss with these IOLs is 3.9\% at 1 year, 7.5\% at 5 years and 21.5\% at 10 years.\textsuperscript{36,37} The risk factors for progressive endothelial cell loss in these cases is shallow anterior chamber depth, small gap between the corneal endothelium and the phakic IOL and ongoing sub-clinical ocular inflammation.\textsuperscript{37} Explantation of these IOLs were required in approximately 6\% cases in a case series reported by Jonker et al for progressive endothelial cell loss.\textsuperscript{37}

The disenclavation of the iris clawed lens is another dreaded complication of these IOLs with a reported incidence of 29.4\% cases.\textsuperscript{38} Its occurrence in the early phase is associated with the surgical technique while the late post-operative period is associated with progressive atrophy of the enclavated iris and subsequent slippage of the IOL.\textsuperscript{39} Although re-enclavation can be easily performed in these cases without significant endothelial cell loss, if left untreated it can result in progressive endothelial cell loss and corneal decompensation.\textsuperscript{40}

Cases of iris fixated phakic IOL presenting with corneal decompensation require explant of the phakic IOL along with endothelial keratoplasty for visual rehabilitation. The risk of developing cataract following implantation of iris-fixated phakic IOL is less compared to posterior chamber phakic IOL considering its distance from the lens capsule. The other reported complications
include pupil ovalization and decentration, glare and halo and posterior segment complications.

**CONCLUSION:**

The incidence of cataract and glaucoma after phakic IOL implantation has decreased over the past decades owing to advancements in phakic IOL design, material and better sizing. Present day posterior chamber phakic IOLs are relatively safe for intra-ocular implantation. Most of the post-operative complications described above may be avoided with proper pre-operative planning and appropriate surgical technique. Careful follow-up of these cases in the post-operative period can help in early detection of complications and timely intervention to avoid long term ocular morbidity.

**References**


Phakic Intraocular Lenses: Recent Advances

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Phakic intraocular lenses (IOLs) constitute an important treatment modality in the armamentarium of a refractive surgeon. Advantages over keratoablative procedures including greater stability, reversibility and preservation of accommodation have established these implants as a standard treatment for moderate to high myopia.

Earlier models including Artisan or Verisyse (Abbott Medical Optics, CA, USA) and Artiflex/Veriflex (Abbott Medical Optics, CA, USA) entail enclavation of the implant in the mid peripheral iris tissue (iris supported phakic IOLs) or implantation in the anterior chamber. Potential complications of anterior chamber phakic IOLs include progressive endothelial cell loss, iris chaffing at the site of enclavation, associated chronic uveal inflammation, pigment dispersion syndrome and lens disenclavation, displacement or decentration. These models have now been largely replaced by posterior chamber phakic IOLs, which will be predominantly discussed in this chapter.

**IMPLANTABLE COLLAMER LENS**

The Implantable Collamer Lens or ICL (Staar Surgicals) is a single-piece foldable plate-haptic posterior chamber implant. It is composed of Collamer (collagen copolymer), a biologically inert material with high biocompatibility. The ICL received CE mark in 1997 and US FDA approval in 2005 for myopic correction. Since then, various advancements have ensued in the implant design including increased vault height, addition of perioptic holes for viscoelastic removal, the central flow aqueous port and larger optic zone diameter. (Figure 1)
Increased vault height

The currently available V4 model has a steeper radius of curvature, allowing an additional 0.13 to 0.21 mm of anterior vaulting in comparison to the earlier designs, thereby reducing the incidence of cataract formation.

Storage in balanced saline solution

Earlier designs entailed storage in sodium chloride with subsequent hydration secondary to ocular environmental changes upon implantation. The implant enlarged by roughly 1.05 times within three days, reducing the true spherical power to 0.78 times. Additionally, the toric implant was vulnerable to rotation before it fully enlarged and became fixed in the ciliary sulcus. In order to overcome these limitations, subsequent V4 models are stored in balanced saline solution (BSS) and do not undergo hydration following implantation.

Central hole for aqueous transmission

The V4C or EVO Visian ICL is the currently available model and has a central 360 micron hole – the KS aquaport. Kawamorita and co-workers using computational analysis, demonstrated an increase in the velocity of aqueous humor in the central hole ICL model. This allows lesser disturbance in the aqueous circulation, with lower incidence of cataract secondary to metabolic changes. Additionally, the central hole obviates the need for a peripheral iridotomy with reduced risk of associated complications such as hyphema and inflammation.

Figure 1: Evolution in design of the Implantable Collamer Lens
(Image courtesy: Staar Surgicals)
Expanded optic zone

Since the ICL is implanted in the posterior chamber of the eye, the effective optic diameter at the corneal plane is larger than the actual diameter. Thus the effective optic diameter ranges till a maximum of 7.3 mm. Patients with larger mesopic pupil diameters may experience a diffraction effect such as night time halos and glare. The EVO+ Visian ICL has an expanded optic zone till 6.1 mm, compared with 5.8 mm in the EVO Visian ICL. This 0.3 mm difference allows reduced night vision disturbances in eyes with larger pupils.

Currently available Visian ICL is manufactured in four overall lengths of 12.1, 12.6, 13.2 and 13.7 mm, with optic diameters ranging from 4.9 to 5.8 mm. The EVO Visian ICL is approved for correction of myopia ranging from -0.5 D to -18.0 D, hyperopia between +0.5 D to +10.0 D and astigmatic correction of +0.5 D to +6.0 D. The EVO+ Visian ICL affords myopic correction between -0.5 D to -14.0 D.

IMPLANTABLE PHAKIC CONTACT LENS:

The Implantable Phakic Contact Lens or IPCL (Care Group, India) is a single piece plate-haptic implant composed of a hybrid hydrophilic acrylic material. IPCL has been commercially available since 2014, with the introduction of the current design IPCL V2.0 in 2017. Recent publications have demonstrated the safety and efficacy of the implant over a three-year follow-up period.3-5

The implant has an optical diameter of 6.6 mm and affords a myopic correction of -1.0 D to -30.0 D in steps of -0.5 D, hyperopic correction of +1.0 D to +15.0 D in steps of 0.5 D and astigmatic correction of +0.5 D to +10.0 D in steps of 0.5 D cylinder. The currently marketed model (IPCL V2.0) has certain advantages over the previous design.

Central hole for aqueous transmission

The central 380 microns optic hole allows the physiological transmission of aqueous currents with lower incidence of lens metabolic changes and subsequent cataract formation. It additionally obviates the need for a preoperative peripheral iridotomy.

The central hole is conical in shape (with an anterior diameter of 380 microns and posterior diameter of 420 microns) as against the
cylindrical configuration of the ICL (uniform diameter of 360 microns). This allows lower scattering and subsequent loss of light in the IPCL i.e. less than 10 and 15% loss with IPCL vis-à-vis 14 and 28% loss with ICL in photopic and scotopic conditions respectively. (Figure 2)

Figure 2: Light scattering induced by the central optic hole with the posterior chamber phakic intraocular lens implants (Courtesy: Care Group, India)
“Spring effect” haptics

The specifically engineered haptic footplates allows change in curvature following implantation. This enables the implant to compensate for an error of 0.5 mm in white-to-white diameter measurement to provide an ideal vault.

Presbyopic IPCL

The presbyopic IPCL is a trifocal apodized implant with 5 to 9 diffractive rings in the central 3.5 mm optic diameter.

Apodisation entails a reduction in the step height of the diffractive ring segments, allowing a progressive shift of light energy split towards the distant foci, as pupillary dilatation occurs. This significantly minimizes loss of incident light resulting in lower incidence of glare and halos. Additionally, the dynamic energy transfer (DET) allows 50% energy distribution for distance, 30% for near and 20% for intermediate in central 3 mm aperture. The total loss of energy during DET is 8%. The presbyopic IPCL affords near addition of +1.50 D to +3.50 D in 0.50 D increments with a corresponding intermediate correction of 0.80 D to 1.80 D.

EYECRYL PHAKIC INTRAOCULAR LENS:

The EyeCryl phakic intraocular lens (Biotech Vision Care Pvt Ltd, India) is the most recent addition to posterior chamber phakic IOLs. The implant is a single piece plate-haptic hydrophilic acrylic material. The optic size varies from 4.65 mm to 5.50 mm, with an overall length of 12.0 mm to 13.5 mm. The implant affords a spherical correction of -3.0 D to -23.0 D (with 0.5 D step) and astigmatic correction of 0.5 D to 5.0 D (in 0.5 D step). Studies demonstrating clinical outcomes of EyeCryl phakic IOL are required to establish long term safety and efficacy.

In conclusion, various advancements have been made in the field of phakic intraocular lenses over the past decade, making it a safe and effective modality of treatment for refractive errors.
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