AIOS, CME SERIES (No. 15)

Implants in Ophthalmology

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Dr. Yogesh Shah
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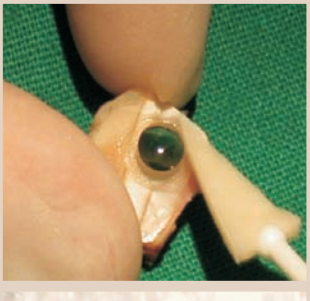

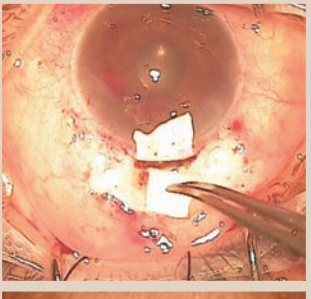

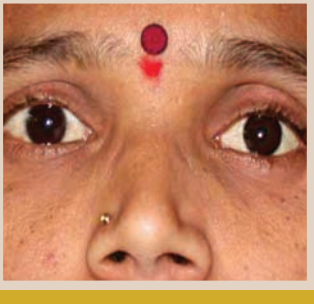

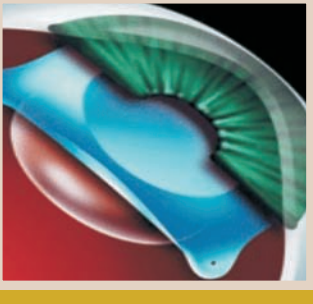

ALL INDIA OPHTHALMOLOGICAL SOCIETY

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Editorial

This C.M.E. booklet is on an offbeat & innovative topic of "IMPLANTS IN OPHTHALMOLOGY". When one thinks in depth about various implants, we realize that this topic touches almost every structure of eye and every sub-speciality in Ophthalmology. However it is uncommon to find a book which covers various sub-specialities and implants used by them. With this idea at the back of our mind, we have selected commonly used implants in various parts of the eye.

The authors of each chapter have vast experience in their own field & each one of them could write a book on the topic itself. However keeping in mind the size of CME booklets, they have provided basic information which will be useful to General Ophthalmologist as well as Post Graduate Students. Wherever possible we have tried give references so that this booklet may become a starting point for Ophthalmologists to gather desired information and knowledge in detail.

Dr. Yogesh C. Shah
Dr. Sushmita G. Shah
Netra Mandir,
Borivli, Mumbai.

Acknowledgement

We are thankful to Academic and Research Committee, AIOS and Chairman **Dr. Rajinder Khanna**, President **Dr. Taraprasad Das** & Secretary **Dr. Rajvardhan Azad** for entrusting us with this task.

We are thankful to CARE GROUP for supporting us in every respect for this booklet.

We are thankful to **Dr. Santhan Gopal K. S.**, Organizing Secretary 66th AIOS, Banglore for his help and co-operation.

We are specially thankful to entire staff of NETRA MANDIR, Borivli, Mumbai for their dedication and personal devotion, which helped us to gather and print the scientific material.

We are also thankful to **Balaji Printers** for their valuable contribution.

Foreword

It gives me immense pleasure to write this foreward for this CME booklet "IMPLANTS IN OPHTHALMOLOGY"

I am happy to see that masters from various sub-speciality have contributed to cover variety of topics extending from commonly used Intra Ocular Implants to highly specialized forms of Implants used in Cornea, Retina, Glaucoma, Uvea and Oculoplasty practice.

Panophthalmic coverage of various implants along with references by various authors, I am sure will prove to be useful educative material for all.

Dr. Rajvardhan Azad
Secretary AIOS.

Foreword

Dear Colleagues,

Belonging to a country that has a nefarious record of the largest number of curable blindness, it becomes obligatory for all members of the ophthalmic faternity that we raise our efforts and skills to the next level to wipe out this dark blemish from our forehead. Keeping in view the advancement in cataract surgery and the IOL designing we have made a sincere effort to upgrade all members of AIOS to the latest in IOLs. An insight into the other implants used in various sub-specialities has also been provided.

I take this opportunity to thank our esteemed colleague **Dr.Yogesh Shah** whose herculean effort has made this possible.

I also want to thank

Dr. R. B. Jain, Dr. K. P. S. Malik, Dr. T. P. Das, Dr. R. V. Azad, Dr. S. Natarajan, Dr. Lalit Verma and all members of the ARC team for their co-operation.

It has been a collective effort of all ARC members.

I do hope you'll find this effort of the ARC Team useful.

Dr. Rajinder Khanna
Chairman ARC

INDEX

INTROCULAR LENSES

History of Intraocular Lenses

Dr. Sushmita G. Shah
Cornea, Anterior Segment & Refractive Surgery Services
Netra Mandir, Borivli, Mumbai

Dr. Tarjani Y. Shah
Shri Ganapati Netralaya

Italian oculist Tadini in 18th century considered intraocular lens(IOL) implantation and in 1795, Casamata implanted a glass IOL which sank posteriorly.

First Generation IOLs

English ophthalmologist Sir Harold Ridley is credited with the first successful intraocular lens implantation in 1949. Following observations during World War II that fragments of acrylic plastic from airplanes were well tolerated, he designed the first IOL which was a biconvex PMMA PC IOL of diameter 8.32 mm and power +24D. It was similar in size & shape to human lens. However, when implanted in a 45 year old lady, it led to high myopia & astigmatism. The common problems with Ridley's IOLs were inferior decentration & posterior dislocation, inflammation, secondary glaucoma etc. Parry and later Epstein further modified the posterior chamber intraocular lenses but they did not gain much popularity.

Second Generation IOLs

The second generation of IOLs belonged to an era of anterior chamber IOLs(AC IOLs).Barron was the first to implant an ACIOL made of PMMA with steep anterior curve and short radius of curvature. This IOL led to corneal decompensation. Various workers like Strampelli, Choyce, Danheim, Barraquer provided their own designs.

Third Generation IOLs

The next generation of IOLs were iris supported lenses which had optic just in front of the iris plane and were fixated at least in part by the iris at the pupil. Noteworthy amongst these was Binkhorst Iris clip lens with four closed loops, 2 in front and 2 behind which was subsequently modified by Fyodorov. Worst designed the Iris Claw lens which was a single piece lens with superior and inferior haptics with narrow slits that insert into the stroma of midperipheral iris for fixation. The current day Phakic IOL (Artisan) is a modification of Worst's Iris Claw lens.

Fourth Generation IOLs

The fourth generation IOLs were modified AC IOLs like Choyce Mark VIII & Mark IX lens, flexible loop AC IOL etc. Kelman designed various types of ACIOLs like Kelman II lens, Kelman flexible tripod IOL, Kelman quadraflex AC IOL and Kelman multiplex 4 point fixation lens. The last of the four lenses designed by Kelman is the current day AC IOL which is routinely used.

Fifth Generation IOLs

The fifth generation of IOLs are the presently used Posterior Chamber IOL(PC IOL). They happened with the realization that posterior capsular membrane provided the ideal support for an intraocular lens. Posterior chamber IOLs which are supported in the capsular bag or can be placed in the sulcus evolved.

Types of IOLS and Materials

Dr. Sanjay R. Sonawale
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From the time when they were first introduced, Intraocular lenses have seen continuous change in the designs and materials used in their manufacture in a quest to find the perfect replacement for the natural crystalline lens removed during the cataract surgery.

In mid to late 1970s it was realized that capsular membrane was ideal support for intraocular lens. IOLs developed and designed after that are called Posterior Chamber IOLs (PCIOL) and Fifth generation IOLs.These are supported in the capsular bag or by haptics placed in the ciliary sulcus.

General overview of these IOLs is as follows:

Shearing

These were IOL with an optic and 2 flexible J shaped haptics which fixated well in the ciliary sulcus.

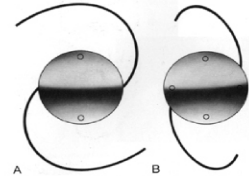
J Loop IOLs

They showed tendency to elongate the capsule and erode into ciliary body. Hence they were modified and were called Modified J loop IOL .

Simcoe's C Loop IOL

J loop haptics were modified to larger C shaped loop to bring greater area of contact with ciliary sulcus and help in distribution of forces over larger area leading to greater stability of lens in the sulcus.

C loops were shortened leading to further increase in stability of lens and are called as Modified C loop IOL.



A Modified C-loop
B Modified J-loop

Angling the Loops

IOL with 10 degrees anterior angulated haptics pushes optic more posterior. This reduces chances of PCO formation, pupillary capture and contact of optic to iris, thus reducing post operative inflammation.

This also brings IOL closer to the nodal point of the eye, but in the process increases chances of myopia.

IOL with colored haptics

This was done for better visualization of IOL haptic during insertion.

IOL with positioning holes

These were introduced for easy manipulation and dialing of IOL in the position but can also serve as nidus for inflammation and may lead to visual disturbances like diplopia and haloes. Instead of hole, a loop or small notch on the haptic serves the same purpose.

One Piece IOL

Both optic and haptics are carved from the same piece thus avoiding any joint.

Three piece IOL

The two haptics are made of different material usually polypropylene and attached to optic in separate step. They have slightly higher tendency of microbial lodging at optic-haptic junction and may have weaker junction compared to one piece IOL

Disc Lens or Plate lens

These lenses are without haptics or with closed loop haptics. These lenses have smaller diameter. Yag capsulotomy may increase the chance of posterior dislocation of lens. They are not so commonly used now a days.

Variations in Optic size and Shape

Smaller optics (5mm - 5.5mm) are used in rigid PMMA lenses to reduce the size of wound during Phacoemulsification, but small optic size leads to higher chances of edge glare. Larger optics (7 mm) were introduced to reduce the chances of papillary capture as well as to reduce optical aberrations. Most commonly preferred optic size is 6 mm. IOL with oblong optic was introduced to control both optic glare and size of wound.

Plano Convex and Biconvex IOL

Earlier Plano convex lenses were modified to biconvex due to high chances of PCO formation but this lead to reduced stability of lens in the bag.

Laser ridged IOL

Provides a space to keep centre of IOL away from PC and hence facilitates YAG capsulotomy, while the ridge retards PCO formation.

Meniscus lens

They have convex anterior surface and concave posterior surface

Aspheric lens

They improve optical quality by reducing higher order aberrations like Spherical aberrations and thus improving contrast sensitivity and quality of vision especially in low lights.

Multifocal Intraocular lens

They have more than one focal point for distance as well as near. Hence patient need not wear spectacles postoperatively. Lot of new designs are coming up in this segment, currently available ones are Diffractive & Refractive lenses.

Ultra violet absorbers

Earlier IOLs were not capable of absorbing UV light. Chromatophores are added to the polymer of the lens optic to enable them to block UV rays. Commonly used Chromatophores are benzotriazole and benzophenones

Surface modification

To reduce low grade chronic inflammation especially in eyes with uveitis and pediatric cataracts, IOLs with surface coated with heparin can be used. Surface coating with hydrogels, chondroitin surface coating and surface passivation by fluorocarbons are other ways of surface modification.

Sutured Lenses

These are the lenses which are supported by sutures passed through haptics and supported to the sclera. They are used in eyes which are devoid of posterior capsular support and where anterior chamber IOL cannot be implanted.

Ideal lens should be non-reactive, non-carcinogenic & non-biodegradable (Biologically compatible), transparent, with high optical resolution, UV filtering & accommodating for near and distance (Optically compatible). Since Phacoemulsification has become the preferred mode of cataract removal, focus of IOL design and manufacture has also shifted towards the goal of producing lenses that can be inserted through smallest incision possible, should withstand stress of fabrication, implantation and must have memory to return to

the original form after subjection to stress of implantation. (MECHANICALLY COMPATIBLE).

In the currently available Lenses commonest materials used in the manufacture of these IOLs are

1. PMMA (polymethylmethacrylate)
- Acrylic of ethacrylic and methacrylic acid
- Hard and rigid
- Inert and non autoclavable
- Causes mechanical irritation and ethothelial loss if touches endothelium while insertion
- Hydrophobic – so causes adherence of cell and bacteria
- Refractive Index 1.47 and1.55

2. Flexible Acrylic
- Acrylic lenses are available in two varieties, hydrophilic and hydrophobic
- Copolymer of phenyl ethylacrylate and phenylethylmethacrylate.
- Good viscoelastic and three dimensional stability
- Viscoelasticity is temperature dependant with increase elasticity at higher temperature

3. Hydrogels
- HEMA or 2 Hydroxyethylmethacrylate
- Polymerization in ethylene glycol medium
- Hydrate to farm soft, swollen, rubbery mass
- Hydrophilic hence repel cells and microbes
- Refractive Index - 1.43 to 1.48

4. Silicone - Elastomer Polydimethylsiloxane
- Capable of large and reversible deformations
- Good memory
- Surface deposits are common
- Additives in silicone IOL are
    - UV chromophore
    - Phenyl group to increase Refractive Index from 1.41 to 1.46

5. Polymer with thermo mechanical properties
- HEMA + Methacrylate cross linked with ethylene glycoldimethacrylate
- UV chromophore –(4 methacrylony 2 hydroxy benzophenome or MOBP)
- Hydrated with water content of w20%
- Rigid below 25^0C and flexible at higher temp.
- RI 1.47

Multifocal IOLs

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Cataract surgery is a refractive procedure in true sense. The goal of modern cataract surgery is not removal of opaque lens from the visual axis and replacing it with an artificial lens to provide 6/6 vision, but it aims at quality of vision along with unaided near, distant and intermediate range of vision that the natural young accommodating lens provides at the age of 20 years.

Multifocality can be achieved by implanting 1) Unifocal lens which can accommodate 2) Bifocal lens which provides 2 focal points; one for distance and second for near, or 3) Multifocal lens which provides multiple focal points for distance, intermediate and near vision.

Types of lenses

Diffractive Lenses: These are usually bifocal lenses wherein bifocality is grinded on the posterior surface of lens. Tecnis & ReSTOR are examples of such lenses.

Refractive Lenses: These are usually multifocal lenses wherein multifocality is grinded on the anterior surface of lens. Array, ReZOOM, MF 4 are some of the examples.

Accommodative Lenses: These are unifocal lenses which give some amount of accommodation due to anterior shift of its optical portion during the act of accommodation. Clam Shell, Hinged Crystallens IOL are examples of accomodative lenses.

Physics

In bifocal – diffractive type of lens there are two primary foci. One casts a sharp mage on the retina while other casts blurred image Fig I, 3-A,B,C. Brain accepts the sharp image and ignore the other blurred image. Hence after implantation of these lenses patient takes some time to get adjusted to the lens.

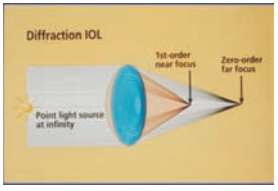


Fig I, 3-A Diffraction

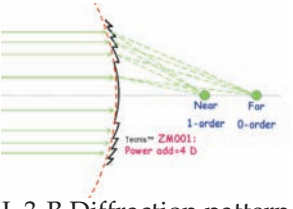


Fig I, 3-B Diffraction pattern

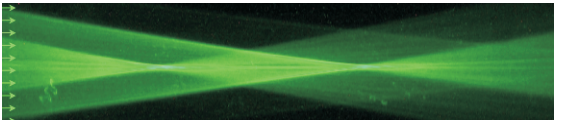


Fig II, 3-C Two focal points of Diffractive lens

In Multifocal – Refractive type of lens there are multiple foci – for distance, near and intermediate zones Fig II, 3-D. Hence with these lenses there are more than one unwanted images on retina which brain has to learn to ignore. Refractive variety of Multifocal lenses have zonal progressive design. Though alternate zones show dominance for distance and near, each zone has progressive power for distance, intermediate and near vision.

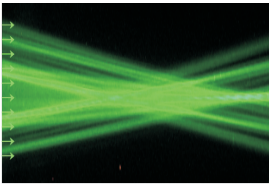


Fig I, 3-D Multiple focal points of Refractive lens

Patient selection

As a beginner, it is advisable to select Hyperopic patient rather than Myopic since their unaided distance as well as near vision is less than normal. A housewife or someone whose needs are relatively less is

a good patient in the beginning. In general, very demanding patient can be avoided. Patient with high astigmatism or some other ocular pathology may be avoided. If pupil size is smaller than 2.5mm, he is not a good candidate for refractive multifocal lens as they do not get full advantage of near vision since these lenses are pupil dependant. Patients actively involved in night driving are once again not ideal candidates due to problems of glare and halos with these lenses. Best results are achieved when bilateral implants are done at short interval and hence patient ready for other eye operation within a month or two is ideal.

IOL power calculation

This can never be over emphasized in the practice of multifocal lens. Surgeon's personalized factor should be determined by analyzing first 25 to 30 surgeries and A Constant modified accordingly. Any standard formula can be used for calculation of IOL power but application of correction factor in high Hyperopic or Myopic patient is advisable. Accurate measurement of corneal power and antero - posterior length of eye should be emphasized in every case. Multifocal lens with addition of + 4 D for near is desirable.

Various Multifocal lenses

Array (Fig I,3-E) was the first multifocal lens to be introduced. It is a silicon lens with PMMA haptic. It has 5 zones, 1st 3rd and 5th being distant dominant and 2nd and 4th being near dominant zones. Light allocation is 50% for distance, 37% for near and 13% for intermediate vision. The optic diameter is 6mm. It can be introduced with AMO unfolder through a 2.8 mm incision.

Fig I,3-E Array

ReZOOM *(Fig I,3-F)* is modification of Array with 3rd generation silicon material. The zonal design is improvised to improve near vision and reduce glare and halo.

Fig I,3-F ReZOOM

Tecnis *(Fig I,3-G)* was the first Aspheric Multifocal lens with 360* posterior square edge & anterior optiedge. It is a lens of the diffractive variety and gives excellent distant as well as near vision. Multifocal rings grinded on the posterior surface come closer to each other as we go to the periphery of lens. Tecnis is a silicon lens. Design based on normative topographic asphericity in general population it can neutralize positive asphericity of cornea in large number of patients. Thus it takes care of spherical aberration and improves contrast sensitivity.

Fig I,3-G Tecnis

Preziol *(Fig I,3-H)* manufactured by an Indian company(Care Group) is an excellent acrylic foldable multifocal IOL of refractive variety. This lens maintains good centration and quickly gets stabilized in the capsular bag. The lens can be introduced in the eye with specially designed injector system through a 2.8 mm incision. Preziol is also available as non foldable PMMA lens, which can be used with SICS surgery.

Fig I,3-H Preziole

ReSTOR *(Fig I,3-I)* is acrylic diffractive multifocal IOL with apodized design. There are 16 rings distributed over central 3.6mm. The peripheral rings are spaced closer to each other. The central rings are 1.3μ elevated and are for near vision while peripheral rings are only 0.2μ elevated and are for distant vision. The anterior peripheral surface is modified to act as refractive design.

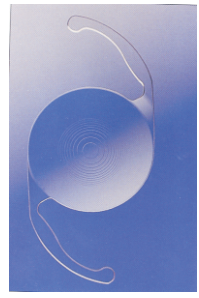


Fig I,3-I ReSTOR

MF 4 and Twin-Set lenses are practiced by some surgeons with good results. In Twin Set (available as a pair of IOL) multifocal IOL the distant dominant lens is introduced in a dominant eye. The other lens that is near dominant is used in non-dominant eye.

Clinical Applications

Multifocal IOL can be available with the addition of +3.5 or +4 D. In general IOL with addition of +4 D for near gives greater satisfaction.

Post operative refraction in a patient having multifocal IOL is an art. We need to realize that Autorefractometer is likely to be less accurate. During subjective refraction it is difficult to analyze end point. Having achieved 6/6 for distance during subjective refraction, patient may continue to have 6/6 vision inspite of adding more minus power in trial frame. This is because of the fact that addition of plus 3.5 D for near vision incorporated in IOL can neutralize minus power that we may keep on adding in the trial frame. And hence over correction with minus number can be an error. It is also wise not to be in a hurry to give addition for near vision in spectacle correction since most patient take some time to get habituated with this different focusing system implanted in their eyes. Ophthalmologist or the optometrist doing refraction can easily identify multifocal IOL during retinoscopy by noticing a black circular ring at the junction of 2 zones in IOL. Such vigilant skill will help to avoid unnecessary mistakes in glass prescription.

The cost of multifocal IOL obviously is an issue in routine practice. Fortunately Indian multifocal IOL is very reasonably priced and many Indian eye surgeons are happy with these lenses.

Evidence based medicine suggests that quality of distant vision (Contrast sensitivity) in dull illumination and for higher frequency on FACT chart is inferior to monofocal IOL[1]. The quality of vision seems to be little better with diffractive variety of IOL as compared to refractive variety[2]. However the refractive IOL has an edge over the other in terms of better intermediate zone vision. Some surgeons have tried mix and match i.e. diffractive IOL in one eye and refractive IOL in other eye to achieve advantages of both.

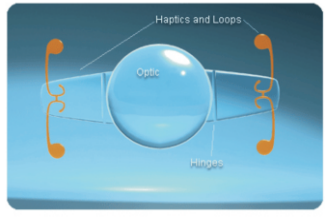
Complications

1. Halos and glare are quite common but patient gets adjusted to it within a short time.
2. Night driving difficulties are quite common. Multifocal lenses may be avoided in people involved with night driving job.
3. Centration of lens in post-operative period is very important. Decentration of more than 0.5 to 1mm can result in poor visual quality and even side effects like diplopia or increased glare and halo.
4. Though it is best to implant both eyes with multifocal lens, people with monocular lens in one eye and multifocal in other eye can get adjusted to it. However it may take long time for rehabilitation. This knowledge is important when one faces a situation wherein, having implanted multifocal lens in one eye, second eye has an intraoperative complication preventing the surgeon from implanting multifocal lens in second eye.

Accommodative IOL

All accommodative or presbyopic IOLs have monofocal optic. However the lens design allows anterior shift of the optical part of the IOL and hence, there is increase in plus power of lens. The anterior shift normally can yield about 2 D addition, which is not the full addition required by the patient. Hence unaided near vision may not go to N6. This disadvantage is to some extent compensated by little improved quality of vision in dull illumination since this lens has monofocal optic.

There are various designs, which enable the optic to shift anteriorly. One commonly used is hinged IOL- Crystallens((Fig I,3-J). The lens has a small hinge on the either side at optic – haptic junction. When ciliary muscle contracts the haptics are compressed pushing the optic forward due to the hinge. The other variety is Clamshell IOL in which the lens is made up of 2 parts, the anterior ring which is open in the center and which fixes the second posterior ring having the optic in its center. The anterior plate provides support to the posterior ring like fulcrum. During accommodation the posterior optical plate moves forward towards the opening in the center of anterior ring increasing plus power of focusing system.



FigI,3-J Crystallens

Future

In future we may have a lens which can fill up the capsular bag, like injectable IOL, that gives good quality of vision like young lens and also can accommodate like a natural human lens. Though we have advanced quite a lot in multifocal practice, I am sure that further research in this field will help us create an IOL which will have good qualitative as well as quantitative unaided vision, property to negate corneal positive asphericity and possibly a customized lens which can also take care of other higher order aberrations of individual eye.

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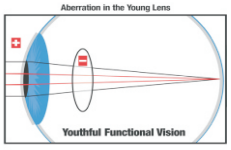
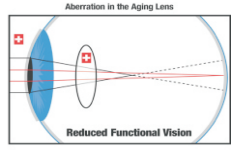


Fig I,4-B Negative asphericity of young lensFig



I,4-C Positive asphericity of aging lens

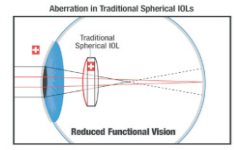


Fig I,4-D Positive asphericity of Traditional IOLs

Tecnis was the first –ve aspheric lens to be introduced in market. Such IOL neutralizes +ve asphericity of cornea reducing spherical aberration & thus improving quality of vision (*Fig I, 4-E*). From the data collected with help of aberrometry from a large population, an average asphericity was calculated. This data is used for manufacturing aberrometry guided -ve aspheric IOL so as to neutralize +ve asphericity of cornea.

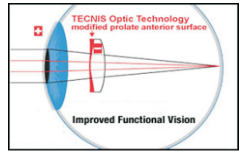


Fig I,4-E
Negative asphericity of Tecnis IOL

However, +ve asphericity of cornea is not the same in every individual eye and hence, in a patient not having much of +ve asphericity of cornea, using –ve aspheric lens like Tecnis is eventually going to leave behind –ve asphericity. Thus once again this will not help to remove spherical aberration in this given eye and hence good quality vision can not be achieved. In fact if one is left with small +ve asphericity, it is better than having –ve asphericity because the later one is not so well tolerated. With this concept B&L designed zero Aspheric IOL or a neutral lens. Such a lens (Akreos AO, Sofport AO) will not counter +ve asphericity of cornea but at least it will not over correct if patient does not have much of +ve asphericity in cornea. This lens also has an added advantage of giving better depth of vision.

An ideal approach for choosing IOL is by determination of corneal asphericity for each eye and choosing a lens, which will give optimum result.

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Anterior Chamber IOLs

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The first attempt to implant an IOL was by a Swiss surgeon Casaamata in 1795 where he tried to place a glass sphere beneath the cornea after cataract removal which failed as the glass sphere fell to the bottom of the eye. It was a setback that took over 150 years to overcome. It was in 1948 when Sir Harold Ridley (Moorfields Eye Hospital) reconceived the idea and with the help of Rayner Optical Company designed the first modern Intra Ocular Lens. This changed the way the world would see after cataract surgery.

Anterior Chamber IOLs are technically less traumatic and easier to implant but due to the postoperative problems associated with these lenses, they are universally branded as inferior. Most of these complications though can be attributed to faulty design and inferior manufacturing techniques, the newer AC IOLs can be implanted with success without the agony of postoperative nightmares.

Implantation of Anterior Chamber IOLs in today's scenario is only limited to a few conditions. They are

1. As secondary IOLs after Intra Capsular Cataract Extraction
2. In Eyes with insufficient capsular support due to intraoperative traumatic posterior capsular rupture
3. Zonular compromise
4. After removal of Sublaxated Crystalline lens
5. After removal of posteriorly dislocated PC IOL
6. Any other condition where there is inadequate support for placement of PC IOL

The pursuit to find an ideal AC IOL has lead to a constant change in the shape, size and design of these lenses leading to the present day AC IOLs. In 50's and 60's, it was the Danheim's, Barraquer's and

Choyce's designed AC IOLs, which were up market. In early 70's, due to advanced manufacturing techniques and better lens material, good AC IOLs with relatively fewer post operative complications were developed. These include Rayners Choyce VIII, Percesion Cosmet, Kelman's Tripod, Kelman's Quadriflex along with a few others.

Some other AC IOL's are

1. Ridley's Lens (1949 –50)
2. Strampelli rigid AC IOL (1954)
3. Epstein collar stud lens
4. Choyce AC IOL's series
5. Binkhorst Iris clip lens
6. Fyodorov lens
7. Boberg-Ans semi flexible AC IOL etc.

The post operative complication of AC IOL include

1. Uveitis
2. Glaucoma
3. Hyphaema
4. Corneal decompensation
5. Cystoid macular odema
6. Chronic inflammation
7. Constant low grade pain
8. Pupillary block
9. Pupillary distortion and iris capture
10. Increased chance of retinal detachment
11. Fibrosis of the angle
12. Iris atrophy and fibrosis

Contraindications of AC IOL's are

1. Chronic closed angle glaucoma
2. Pre existing glaucoma surgery filtering bleb
3. Rubeosis
4. Aniridia
5. Compromised cornea
6. Corneal Dystrophies

Sclerated Fixated Lens Implantation

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Implantation of intraocular lens has become the standard of care in aphakic state. The lens is best placed in the capsular bag, which affords stable fixation at a position closest to the nodal point of the eye.[1] If the IOL is implanted as a secondary procedure, even in presence of capsular support, mostly sulcus fixation has to be resorted to. In absence of any capsular remnants, the options available are anterior chamber lenses, iris fixated lenses and scleral fixated posterior chamber lenses.

Transsclerally Sutured PCIOL

It was initially described by Malbran et al in aphakes post ICCE in 1986[2]. Original techniques involved the ab interno approach that is passing the needle from inside to outside the eye (Figure 1,6-A) which gave way to the ab- externo approach, in which the sulcus positioning of the suture is more predictable[3]. Besides the accurate suture placement, it avoids the risk of catching the vitreous with the needle and incarcerating it at the fixation point[4]. In an effort to improve the stability of IOL, four point fixation was suggested, but the advantage is balanced against the greater risk of complications from multiple suture passes through sclera, uvea and vitreous cavity.

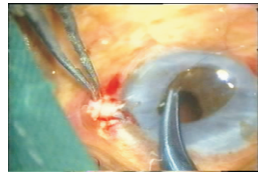


Fig I,6-A Abinterno approach

To avoid suture erosion of the knots, scleral flaps have become popular to cover the knots or are rotated into the scleral tissue. Recently, the adequacy of 10-0 prolene has been questioned in maintaining the long term stability of scleral fixated lenses and use of 9-0 prolene is being advocated instead.

Author's Technique (Two point ab-externo fixation)

Preoperative hypotony and vitreous shrinkage is achieved by tying superpinky and infusing intravenous Mannitol. The eye is anaesthetized by a peribulbar block using 3cc of 0.5% Bupivacaine and 3cc of 2% Lidocaine hydrochloride. Eye speculum and bridle suture are applied. Conjunctival peritomy is performed from 11 to 1 o'clock position and at 2 and 8 o'clock positions followed by cauterization. Air-aqueous exchange of anterior chamber is performed using two 26 G needles introduced at the limbus. Two 3X3mm partial thickness scleral flaps at 2 and 8 o'clock positions & a 6mm sclerocorneal tunnel at 12 o'clock are dissected. Sclerotomies are created using a 26 G needle from the temporal scleral bed and a straight needle(STC-6) on 10-0 prolene from the nasal scleral bed introduced 1mm posterior to the limbus exactly 180^0 apart. Automated two port anterior vitrectomy is performed at this time if required. The straight needle and the 26 G needle are entered perpendicular to the scleral surface, advanced towards each other in the posterior chamber and the former is docked into the lumen of 26 G needle *(Figure I, 6-B)*. The 26 G needle is retrieved from the temporal scleral bed along with the prolene suture which is seen stretched across the posterior chamber. The sclerocorneal tunnel is entered and the prolene suture is hooked out. It is divided into two and tied to the IOL eyelets *(Figure I, 6-C)*. The PCIOL is placed in the ciliary sulcus and the prolene suture ends are made taut. An anchoring knot is placed on the scleral bed adjacent to the exiting IOL holding prolene suture end using 10-0 nylon suture *(Figure I, 6-D)*. The two are tied together and another bite is taken from the proximal end of the undersurface of the scleral flap *(Figure I, 6-E).* A controlled and balanced tension on the 10,0 nylon suture causes the scleral flap to fall back and cover the mesh of suture knots *(Figure I, 6-F)*. The sutures underneath the scleral flap are trimmed and a similar procedure is repeated on the opposite scleral bed. The conjunctiva is repositioned with the bipolar cautery or conjunctivo-limbal suture. The corneo-scleral section is closed with an infinity shaped suture.

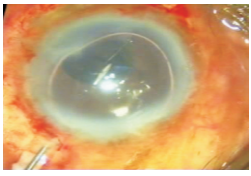


Fig I,6-B Docking

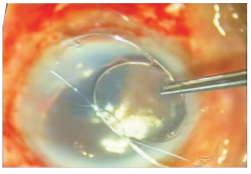


Fig I,6-C Tying the IOL

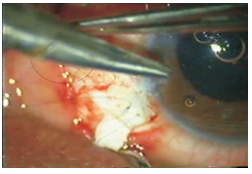
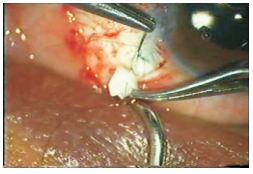
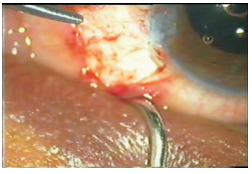


Fig I,6-D Anchoring knot



FigI, 6-E Suture bite from undersurface of scleral flap



FigI,6-F S cleral flap falling back

Complications:

1. Suture related: erosion/broken suture.
2. Cystoid macular edema: Reported incidence is 5.5%[5] in one series. This is attributed to vitreomacular traction and light induced retinal injury.
3. Endophthalmitis: Pathogens can gain access at the time of surgery or at a later date via the exposed sutures.
4. Hyphaema/vitreous haemorrhage: Keeping the suture anterior(0.5mm 1mm behind the surgical limbus) and avoiding the 3 and 9 o'clock positions reduce the risk of bleeding by avoiding the ciliary body tissue and the long posterior ciliary arteries.
5. Lens tilt/decentration: When using two point fixation, the points should be exactly 180 degrees apart. A lens tilt more than 10 degrees has been reported in 11.4-16.7% of patients[6].
6. Retinal detachment: It is more common when the anterior hyaloid face has been disturbed with/without vitreous prolapse.
7. Suprachoroidal haemorrhage: Factors contributing to it are suture placement at 3 and 9 o'clock, posterior suture passes at 2mm behind the limbus and double suture passes at each fixation site.

In conclusion, various methods have been described for secondary IOL implantation in absence of posterior capsular support, with each having a range of technical difficulty and postoperative complications. Used appropriately, the above method can result in a good visual outcome.

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Phakic IOLs

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Phakic IOLs are the intraocular lenses inserted into the phakic eyes for the correction of ametropia and presbyopia. Phakic IOLs constitute an evolving technique in the field of refractive surgery for the correction of moderate to high refractive errors. Laser refractive surgery in such cases is limited by the amount of corneal tissues available and predictability of the results. The implantation of phakic intraocular lens neither affects the shape nor the thickness of cornea and provides predictable refractive results. Phakic IOLs are also stable and potentially reversible and preserves the accommodation in comparison to prelex another treatment option for high refractive errors.

Types

Phakic IOLs are divided into foldable and non-foldable varieties and are implanted into anterior and posterior chamber. The anterior chamber IOLs are further divided into angle supported and iris clawed IOLs. Toric IOLs for the correction of astigmatism and ametopia are being implanted both in the anterior and posterior chamber. The anterior chamber IOLs are also available as bifocal lenses to correct presbyopia.

Indications

Phakic IOLs are implanted for the correction of moderate to high myopia, compound myopic astigmatism, low to moderate hyperopia and compound hyperopic astigmatism. Phakic IOLs are also used for myopia with presbyopia or hyperopia with presbyopia. The anisometropic amblyopia is the added indication for Phakic IOL.

Inclusion Criteria

Endothelial cell count should be atleast 2500cells/mm, the anterior chamber depth more than 3mm, the pupil round and the angle

of the anterior chamber open. Accurate manifest refraction, detailed slit lamp examination, Intraocular pressure, ultrasound or optical anterior chamber depth, white to white measurement of the cornea, backvertex distance are recorded. The phakic IOLs need customized approach and high precision measurements. Adequate sizing is 99% of the job.

Exclusion Criteria

Exclusion criteria included the presence of inflammation of the anterior or posterior segment, chronic keratitis, corneal dystrophy, iris atrophy or rubeosis, aniridia, cataracts, vitreous pathology, retinal disease, microphthalmos, nanophthalmos, glaucoma, or previous intraocular surgery.

Materials and Designs of IOLs

The non-foldable rigid IOLs are made up of polymethyl methacrylate (PMMA) and the foldable IOLs are manufactured from silicon, acrylic, hema copolymer and collamer. The anterior chamber phakic IOLs are designed as convex concave optics after bad experience with biconcave lenses. These lenses have vaulted design (0.5 mm) of the posterior surface to ensure optimal space in front of the natural lens and prevent pupil block. This design also takes care of the forward displacement for human lens during accommodation, which is 0.6 mm maximum.

Anterior Chamber Angle Fixated IOLs

Baikoff introduced Z-shaped angle supported IOLs with large footplates. This model with 25 degree vaulting was estimated to be 2mm behind the cornea and 1 mm in front the pupil. The available range of power is from -8 D to -30 D, diameter from 12, 12.5, 13 to 13.5 and optic diameter of 4.5 mm. He modified the design to 20-degree vaulting and thinner optic edge. Later he also modified the surface of the lens with Florin to improve bicompability. To avoid glare, halos and pupil distortion he designed new lens with optic diameter of 5mm. The edge of the lens was reduced by 20 percent to increase the distance from endothelial cells and a new concavity was given to posterior surface of the lens to increase the distance from natural lens.

The phakic AcrySof is a foldable, single-piece design, made of the same acrylic material as posterior chamber AcrySof IOL. The new design has larger 6mm optic, comes in an overall length of 12.5 mm to 13.5 mm and ranges from –6 D to –16.5 D. Insertion is performed with the Monarch II IOL delivery system (Alcon).

Kelman Duet

The Kelman Duet (Tekia) is an angle-supported lens with independent PMMA haptics and frame, and a third-generation silicone optic. This lens comes in two separate pieces that are assembled inside the eye, and it has several advantages. The haptic can be exchanged leaving in the optic in the eye and vice versa.

Iris-fixated Phakic IOL

In 1986, Worst introduced iris claw lens to correct myopia in phakic patients. The IOL is manufactured by Ophtec, Netherlands under the trade name of ARTISAN *(Fig I,7-A)* and it has two different diameters for the optical part, 5.0mm and 6.0mm, with a power range of -3.0 to –23.5D and –3.0 to –15.5D in 0.5D steps respectively. The thickness of the IOL in the optical axis is 0.2mm, and the total height is about 1mm. It is a one-piece ultraviolet light- absorbing perpex CQ (polymethyl methacrylate) compression molded lens with an overall diameter of 8.5mm and a total height of 0.9mm. The weight of 15 D lens is 10mg in air. The rigidity of the PMMA requires the gap between pincer arms in the relaxed state between 0.05mm to 0.025mm.

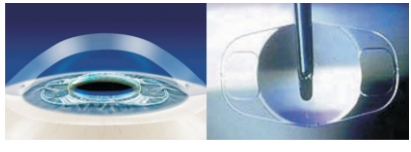

Fig I,7-A Artisan

Artiflex is a flexible version of the Artisan "iris claw" lens, which has a special injector that allows it to be implanted through a 3.2mm incision. Like the Artisan, the iris claw haptics of the Artiflex are made from PMMA. The greatest risk of foldable anterior chamber lenses is the unfolding movement. The ARTIFLEX lens is introduced into the anterior chamber with the specially designed spatula through a small incision.

The withdrawal of the spatula automatically releases the IOL and allows it to unfold in the eye. The IOL is moved to center on the pupil and enclaved. Like ARTISAN, ARTIFLEX also has the advantage of one-size- fits- all. The toric version of ARTISAN and ARTIFLEX need additional care and accuracy during implantation. The need continues to exist for a safe bio-compatible and easily fixated anterior chamber IOLs.

Presbyopic Phakic IOL

The challenge in refractive surgery is Presbyopia, which affects most people older than 40 years. The Bifocal refractive Phakic IOL is an anterior chamber angle supported lens marketed under the name of Newlife (IOL Tech) and Vivarte (CIBAVISION)*(Fig I,7-B)*. The optic is soft 28% hydrophilic acrylic and the haptic is PMMA and footplates are hydrophilic acrylic. The 5.5mm diameter optic is divided into center 1.50mm for distance, the intermediate 0.55mm for near and periphery 1.45mm for distance vision.

Fig I,7-B Vivarte

The overall size of the lens varies from 12mm to 13mm. The IOL power ranges from –5D to +5D with +2.5D addition for near vision.

Posterior Chamber Phakic IOLs

Posterior chamber IOLs have evolved in the past decade, and problems such as the risk of secondary cataract have been minimized. The Staar Surgical ICL is made of a collagen copolymer, a compound combining acrylic and porcine collagen (<0.1% collagen). It's refractive index is 1.45 at 35* C. The material is soft, elastic, and hydrophilic. The Visian ICL (STAAR Surgical) *(Fig I,7-C)* has reduced the risk of secondary cataract to 1%.

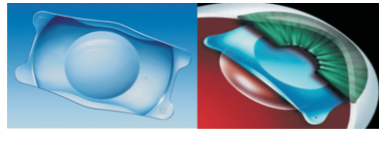

Fig I,7-C Visian ICL

Phakic ICL for myopia correction is available from –3 D to –23 D, optical diameter 5.50mm. Phakic ICL for hyperopia correction is available from +3.0D to +21.5D, optical diameter 5.50mm. Toric ICL for myopia correction is available from -3.0D to -23D, Cylindrical power in half diopter increments from +1.0D to +6.0D

Phakic Refractive Lens

The PRL *(Fig I,7-D)* is designed for the surgical correction of high hyperopia within the range of +3.00 to +15.00D diopters and myopia from –3.00 to –20.00D, with 0.50D power increments for both. The PRL has a single-piece plate design and is made of medical-grade silicone with a refractive index of 1.46. The material is soft, elastic and hydrophobic.

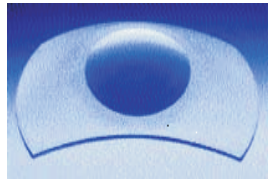

Fig I,7-D Phakic Refractive Lens

The hyperopic PRL model 200 has an overall length of 10.6mm with an optical zone of 4.5mm. The myopic PRL model 101 is 11.3mm long with an optic zone that varies from 4.5 to 5.0mm according to the lens. The PRL can be implanted through a 3.0 to 3.5mm clear corneal incision into the posterior chamber so that it is stabilized between the iris and the crystalline lens .The lens floats in the posterior chamber and it has no feet. Decentration and cataract formation was the frequent complication of older models of PRL lens. This design has the advantage of being available in one size and is easier to implant. However, inconsistent visual results and complications due to the potential instability of the lens are a concern.

New Phakic IOLs

Stick Lens

Stick lens is a single piece foldable acrylic posterior chamber IOL and it is used for correction of high myopia .The unique design makes

the lens literally stick to the anterior capsule of the crystalline lens.

ICARE IOLs

The ICARE IOL is the first anterior chamber lens that can be implanted with an injector. It is simple to use, gives a good refractive outcome and is very well tolerated. The single –piece IOL is made from acrylic hydrogel containing 26% water, a highly biocompatible and minimally traumatic material for tissues

Visante Optical Coherence Tomography:

The Visante OCT is designed to image the shape, size and position of anterior segment structures and take precise measurements of the distances between them, including corneal thickness and surface profile, anterior chamber biometry (anterior chamber depth), angle –to –angle distance, angle size in degrees, pupil diameter and thickness and radii of the curvature of the crystalline lens. It has also proved useful in determining the location of IOLs and their relation to crystalline lens.

IOL Formulae

1. Van der Hejide's formula
2. Holladay formula
3. Calculating the IOL power for vertex distance of 12mm

Surgical Techniques:

The phakic IOL implantation can be performed under general anesthesia, peribulbar anesthesia or topical anesthetic drops.The non-foldable rigid ARTISAN/ VERISYSE lenses are implanted through scleral tunnel with 2 side port incision. Preoperative miosis is induced with topical pilocarpin drops and the lens is inserted with lens holding forceps into anterior chamber vertically. The IOL is rotated horizontally to center on the pupil and the haptics enclaved in the mid peripheral iris with the help of enclavation needle. If the pupil is dilated during the procedure, acetylcholine can be injected intracamerally. High viscosity OVD is used during the procedure to protect the endothelium and the crystalline lens. Surgical prophylactic peripheral iridectomy or laser iridotomy is safer.

The foldable version of Artisan/ Verisyse known as ARTIFLEX is injected through 3 mm corneal incision. The pincer arms are placed in such way that, when the lens unfolds in the anterior chamber, the pincer arms gather mid peripheral iris tissue. This would avoid manipulation with enclavation needle. The other steps of the procedure are similar to Artisan implantation accept the wound does not require suturing.

Complications of Phakic IOLs

1. Postoperative inflammation
2. Glaucoma
3. Iris atrophy and IOL dislocation.
4. IOL decentration
5. Endothelial cell loss.
6. Cataract formation
7. Pupil block
8. Pigment dispersion leading to glaucoma.
9. Injury to corneal endothelium and crystalline lens

Summary

Phakic IOLs have made tremendous progress over the past 20 years and have gained credibility. Different types and designs, each one with specific features, are proving to be safe with stable results. With proper attention to details including postoperative care, the risk benefit ratio becomes acceptable for individuals desiring refractive surgery. Phakic IOL surgery is coming of age, becoming a mainstream option for seeking quality surgical vision correction.

CORNEAL IMPLANTS

Keratoprosthesis

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A keratoprosthesis is an artificial cornea, which is used when conventional keratoplasty does not work well – in a given patient. There are various styles and designs available and they are made of different types of materials. A brief description of the types and their choice is highlighted.

Recent advances in our understanding of the ocular surface physiology and surgical technique have increased our ability to deal with complex problems of these structures. These include stem cells, amniotic membrane, lid reconstruction techniques, and improved pharmacological interventions.

When all of these fail, as they often do in – advanced Stevens-Johnson syndrome, Ocular cicatricial pemphigoid, and Chemical injuries, then one has to take recourse to a keratoprosthesis. A clinical pointer to the need for these devices is the presence of keratinization on the ocular surface.

Keratoprostheses can be broadly categorized as bio-integrated and non-biointegrated. There are a variety of the later category, in which a PMMA cylinder is placed in the cornea through a central opening and retained in place using a variety of strategies.

The prototype device in this group is called the Dohlman design, which uses a nut and bolt design – to a variety of other types which are often sutured to the cornea. In general, these can have problems of integration with the cornea, and sometimes have problems due to leaks around the cylinder.

In contrast, the bio-integrated designs are first implanted in the soft subcutaneous tissues of the patients' malar region – to allow them to develop a soft tissue cover – which is then used to integrate them with the ocular surface of the affected eye.

With this design, there are two main designs – the OOKP or

osteo-odonto keratoprosthesis, conceived by Strampelli and improved by Falcinelli, in which a tooth is used as the carrier for the cylinder; and the Pintucci design, where a Teflon skirt is used as the carrier. The OOKP has a good track record.

Finally, there is also the Australian AlphaCor – which is a soft material that is placed intracorneally. This is not a true keratoprosthesis – since it cannot survive in a dry, hostile surface. It has been promoted as an alternate to a corneal graft in eyes with repeated graft failure, but where a moist surface persists.

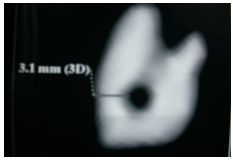
The use of keratoprostheses should be considered in bilaterally blind patients, who have an otherwise healthy posterior segment and visual potential. In such instances, referral to a center performing such surgery, can help rehabilitate such patients.

The Modified Osteo-Odonto Keratoprosthesis (MOOKP)

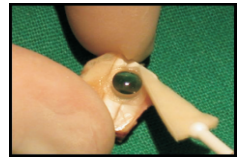
In the first stage, a canine tooth is harvested from the mouth of the patient after X-ray screening has determined that the tooth has a healthy and viable root structure. A surgical motorized saw is used to excise the canine root encased in alveolar bone from the jaw. The lamina is fashioned by sawing through the root of the tooth in a longitudinal fashion to expose the dentine and the root canal. The pulp in the root canal is scraped off and a hole is drilled in the widest part of the root – to a size of 3 to 4 mm depending on the width of the root at that point. An appropriate sized plastic cylinder of appropriate power (determined from the axial length of the eye to be operated) is then glued to the hole using dental cement. A subcutaneous pocket is created in the tissues of the cheek and the lamina-cylinder complex is placed and the pocket is sutured closed after installing antibiotic powder. In the eye, the symblephara are released, and scar tissue is excised as described earlier. A superficial keratectomy including the Bowman's layer is performed to expose the bare corneal stroma after which a full-thickness circular piece of cheek mucosa about 4 mm in diameter is placed over the cornea and sutured to sclera, also covering the muscle insertions.

Stage II is performed 2 to 3 months later to allow time for a connective tissue cover to develop around the lamina implanted in the cheek. If required the integrity of the lamina can be checked by performing a spiral computed tomographic evaluation *(FigII,1-A)*. During the second stage surgery, the lamina is retrieved from the

subcutaneous location and excess connective tissue is removed from the two ends of the optic cylinder, and trimmed over the rest of the lamina *(FigII,1-B)*. The mucosal graft on the ocular surface is incised superiorly and reflected from the superior sclera and cornea, in a downward direction. The inferior attachment of the mucosal graft is left undisturbed to ensure that the blood supply is retained.

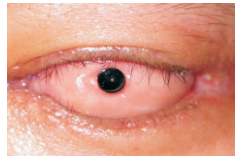


FigII,1-A Spiral CT showing integration of optical cylinder & lamina



FigII,1-B Optical cylinder with connective tissue collar

A Flieringa ring is sutured in place and a 3mm opening is created in the center of the cornea. Three radial incisions are made in the cornea extending till the limbus. The iris is torn at the root and removed and hypotensive anesthesia is used to control the ooze. Constant irrigation with balanced salt solution also helps wash the blood away and prevents a large clot from forming in the anterior chamber. The lens is then cryoextracted and the corneal radial cuts are sutured closed. A limited anterior vitrectomy is performed and the lamina is then placed over the cornea, such that the posterior part of the optic cylinder is in the anterior chamber – entering through the central corneal opening. The lamina is sutured into position using the connective tissue covering and episcleral bites. At the conclusion of suturing, indirect ophthalmoscopy is performed to ensure that there is a good view of the disc and posterior pole. If this is not seen, a cylinder tilt may be responsible and sutures need to be adjusted to straighten the cylinder. Any bleeding into the vitreous cavity can also interfere with the visualization. After the cylinder and lamina are in satisfactory position, the mucosal flap is replaced and a small opening is created over the optic cylinder to allow the anterior portion of the cylinder to protrude through the mucosa. The superior edge of the mucosal flap is sutured in place and this completes the operation *(FigII,1-C)*.



FigII,1-C Postoperative

Intracorneal Ring Segments

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Introduction

Intra Corneal Ring Segments(ICR) are semicircular PMMA devices, which when implanted into the corneal stroma, cause an alteration in its curvature and thereby lead to a change in its refractive power. It works on the principle that when volume is added to the corneal periphery or removed from the center, it leads to flattening of the central cornea reducing corneal power. The various ICR currently available are-

1. Ferrara rings
2. Intacs
3. Bisantis segments.

Indications For ICR Implantation

1. Low Myopia
2. Keratoconus and other ectatic corneal disorders
3. Post LASIK ectasia

Ferrara Intracorneal Rings

Ferrara intracorneal rings were introduced by Dr Ferrara in the early 80's. They are semicircular segments with an arc length of 160* and a triangular cross-section. For correction of myopia upto –7D, 6mm rings are used while for correcting more than -7D, 5mm rings are used. Studies[1,2] reveal decrease in Spherical Equivalent(SE) and increase in both uncorrected and best corrected visual acuity following implantation of Ferrara rings.

Surgical technique :

1. The center of the pupil is marked.

2. 5mm optical zone is marked.
3. Radial incision of 80% corneal thickness is made along the steepest axis.
4. Stromal channels are created using stromal spreader and the rings are implanted.

Intacs

Intacs are semicircular segments with a hexagonal cross-section and 150* arc length. Intacs have been approved by the FDA for correction of myopia from 1 to 3D. The various characteristics of Intacs and Ferrara rings are described in TABLE 1[3].

Surgical technique

1. Center of the pupil is marked.
2. A 1mm radial incision is marked 1mm inside the limbus. The incision could be made either along the steepest meridian or along the temporal meridian.
3. Intrastromal channels are initiated using pocketing hook and completed with the help of vacuum and channel dissectors. Intrastromal channels could also be created using Femtosecond Laser which is a photodisruptive laser.
4. Intracorneal rings are then implanted.

TABLE 1 : Comparison of two Intracorneal segments[3]

Characteristics	Intacs	Ferrara rings
Arc length (in degrees)	150	160
Cross section	Hexagonal	Triangular
Thickness(mm)	0.25-0.45	0.25-0.35
	(0.05 increments)	(0.05 increments)
Radius(mm)		
Inner	6.77	4.40
Outer	8.10	5.60

Advantages

1. It is truly a reversible procedure. At times, this is an advantage in a person nearing presbyopic age.
2. The centre of the cornea is spared.
3. No corneal tissue is ablated and hence there is no induced weakness of the cornea.

Complications

Complications of intracorneal rings include complications during surgery like improper centration, too shallow or too deep insertion, corneal perforation etc. Infectious keratitis has been reported in the postoperative period. Other postoperative complications include segment displacement, segment exposure and corneal melt, corneal scarring, deposits around the device, etc.

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IMPLANTS FOR GLAUCOMA SURGERY

Glaucoma Valve Implants

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Mainstay in the treatment for glaucoma is medical therapy. Laser is done as prophylaxis for angle closure glaucoma and as an adjunct, SLT is performed for primary open angle glaucoma. Surgery is reserved for advanced and complicated glaucomas. Conventional trabeculectomy with or without antimetabolites is most widely performed surgery with variable success and complication rates in various forms of glaucoma. To increase success rate of surgery in high risk cases, aqueous shunts are used. Also known as "valves" or "glaucoma drainage devices," we'll refer to them simply as "implants."

There are several different glaucoma drainage implants. These include the original Molteno implant (1966), the Baerveldt tube shunt, or the valved implants, such as the Ahmed glaucoma valve implant and the later generation pressure ridge Molteno implants. These are indicated for glaucoma patients not responding to maximal medical therapy, with previous failed guarded filtering surgery (trabeculectomy). The flow tube is inserted into the anterior chamber of the eye and the plate is implanted underneath the conjunctiva to allow flow of aqueous fluid out of the eye into a chamber called a bleb.

The ExPress Mini Shunt is a newer, non-valved device that was originally designed to provide a direct conduit from the anterior chamber to the sub-conjunctival space or bleb. In this position it was unstable and tended to erode through the conjunctiva. Now the more common use is as a modificition of the trabeculectomy procedure, placed under a scleral flap, replacing the sclerostomy step.

Indications

The glaucoma valve implant is indicated for glaucoma patients not responding to maximal medical therapy, with previous failed guarded filtering surgery or in cases where conventional drainage surgery is unlikely to succeed. Common situations where the use of a glaucoma implant as a primary procedure is indicated include

- Neovascular Glaucoma -- glaucoma associated with vascular disease of the eye (often diabetes).
- Uveitic Glaucoma- acute or chronic inflammation of the eye.
- Traumatic glaucoma -- glaucoma associated with injury to the eye.
- Silicone oil induced glaucoma -- glaucoma due to Silicone oil used to repair a detached retina.
- Infantile/Juvenile glaucoma -- often associated with developmental defects of the eye.

Valve Implant Surgery

In conventional surgery, a tiny drainage hole is made in the sclera. This procedure is known as trabeculectomy or sclerostomy. This opening allows fluid to drain out of the eye into sub-conjunctival space. Locally applied medications or injections may be used to keep the hole open.

With valve surgery, most of the device is positioned on the outside of the eye under the conjunctiva. A small tube is carefully inserted into the anterior chamber of the eye, just anterior to the iris. The fluid drains through the tube, into the area around the back end of the implant. The fluid collects here and is reabsorbed. Photograph below shows how an implant looks

There are few experimental studies on how implants work. What we do know suggests that these devices function by promoting simple passive diffusion of fluid out of a collection compartment. The tube provides a passageway for the movement of this fluid out of the eye and into a place where the capillaries and lymphatic system reabsorbs it back into the body.

Complications and Successes

Since the valve is a foreign body, there is often an inflammatory reaction immediately after surgery. This is commonly associated with a rise in IOP, witch usually stabilizes within four to six weeks. IOP levels seldom stabilize below the mid-teens after implant surgery even when medications are added to the treatment plan.

Hypotony and related complications like hyphaema, choroidal detachment, shallow anterior chamber are frequently encountered. Inflammation is the part of surgical complication.

Implants are sometimes used after other surgeries have failed, most often due to healing and scarring over of the surgical opening. When this happens, eye pressures return to the higher, pre-surgery levels. However, implants can have the same problems. The small opening in the tube in the anterior chamber of the eye may become clogged. Or excessive scarring around the external drainage portion of the device might block the reabsorption of fluid, again leading to inadequate IOP control. Other complications may include corneal injury, which can result from mechanical contact between the tube and the tissues of the eye. Tennon's cyst formation over the plate is not a rare complication. As with most surgeries, those implants with a smooth uncomplicated surgical course do the best over time.

Implants for non Penetrating Deepsclerectomy

Dr. Cyres Mehta
Dr. Keiki R. Mehta
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Non Penetrating Deep Sclerectomy(NPDS) is a procedure that surgically opens Schlemms canal, exposes Descemets membrane and bypasses the site of highest resistance to outflow in the juxtacanalicular trabecular meshwork.

Since the zone of maximal resistance to aqueous outflow has been found by Grant to lie at the juxtacanalicular meshwork level, unroofing the canal of Schlemm and the act of peeling the meshwork addresses outflow restriction at the site in question. So, is it necessary to open the anterior chamber?

To prevent the inevitable late stage fibrosis many materials like collagen(Koslov and Mermoud), Healon (Pharmacia), reticulated hyaluronic acid pieces (SKGel from Corneal in France), T-Flux triangular polymagma polymer implant (Dr Philippe Sourdille), Stainless steel T-BAR, HemaAcrylic Mehta Stealth implant (Dr Cyres Mehta) and even 1.0 chromic catgut (Dr David Myers) have been employed with varying success.

Absorbable Implants

Aquaflow

The Staar Collagen implant termed the Aquaflow *(Fig III, 2-A)* is a cylinder of lyophilized ,highly purified porcine derived collagen. It, by its sheer bulk prevents fibrosis of the subscleral space. Within 9 months the implant totally dissolves away leaving behind a space filled with porous collagen. This leads to formation of a large quiet bleb. The implant has been approved by the FDA for use in the US.

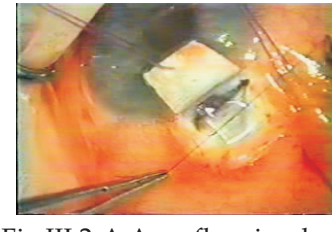

Fig III,2-A Aquaflow implant

SKGEL 3.5 and 4.5 IMPLANT

This is another absorbable implant. It consists of reticulated sodium hyaluronate, i.e. biosynthetically produced sodium hyaluronate (as opposed to hyaluronate produced from animal origin to minimise the risk of viral and slow viral contamination) which has been crosslinked using a phosphate buffer to produce a gel consistency. SKGel 3.5 consists of an equilateral triangle of 3.5 mm and SKGel 4.5 consists of a trapezoid of 3.5 by 4.5 mm. Both have a thickness of 500 microns. SKGel 3.5 is inserted in the scleral decompression space much the same as the Aquaflow. The difference in 3.5 and 4.5 is that, in the 4.5 variant, the implant partially protrudes out of the rear of the decompression space subconjuctivally. These implants are produced by CORNEAL LABORATORIE, France and have been popularized by Dr P.Sourdille.

Healon GV(pfizer)

Stegmann has popularized the use of Healon in Viscocanalostomy. He proposed that since Healon can be used to break and maintain separate the ocular tissues bonded together in trauma, it will by the process of Steric Exclusion prevent the inflammatory cascade from being intiated by virtue of its space occupying nature!

Non Absorbable Implants

The TFLUX *(Fig III, 2-B)* implant is produced by IOL Tech in La Rochelle, France. It consists of a T shaped implant made of a material developed by IOLTech, France known as Polymagma. Its basically a hydrophilic acrylic implant that aims to maintain the decompression space permanently while at the same time aiding filtration by the process of capillarity *(Fig III, 2-C)*.

Fig III,2-B Tflux implant

FigIII,2-C
Tflux implant sutured in place

The implant has an arm length of 4 mm wherein both arms are placed in the cut ends of Schlemm's canal. It has a single suturing hole in order to anchor it with a 10.0 nylon stitch. Implant migration is a possiblity if the implant is not sutured in the scleral bed as with all deep sclerectomy implants. It has a thickness of 0.1-0.3 mm.

TBAR is essentially the same, however is constructed of surgical grade stainless steel.

The MERMOUD X is made by Care Group, Baroda, India. It is essentially a PMMA X devised by Prof Andre Mermoud in an effort to produce an efficient non absorbable implant, which at the same time is affordable for use in developing countries.

MEHTA HEMA WEDGE *(Fig III, 2-D)* was developed for Dr Cyres K. Mehta (Author) by Care Group Baroda, India. Its an opaque sheet of 0.6 mm thick implant grade hydrophilic HEMA. Its under trial at the Mehta International Eye Institute Mumbai

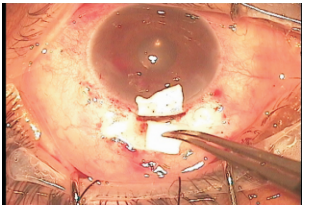

Fig III,2-D Mehta Hema Wedge

The BIOSPONGE being used in Russia is essentially HEMA with multiple channels and spaces to mimic the trabecular meshwork.

In conclusion, NPDS is a promising new surgery, however preserving the thin trabeculo–descemet membrane is technically challenging and shows a learning curve.

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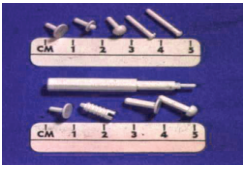
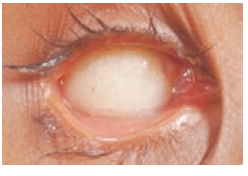
From the time of introduction of integrated orbital implants following initial clinical work by Perry, the coralline hydroxyapatite received FDA approval in 1989 thus beginning a new era in orbital implants *(Fig IV-B)*. Hydroxyapatite, a complex calcium-phosphate salt Ca_{10} $(PO_4)_6$ $(OH)_2$, is a component of human bone. The porous hydroxyapatite implant was processed from a specific genus of reef-building coral. The implant becomes incorporated into the orbital tissue thus minimizing the chance of displacement and extrusion, apart from providing better motility. The regular system of interconnecting pores resembles the Haversian system of human bone and provides a framework for fibrovascular ingrowth. Because of its rough surface, the hydroxyapatite implant is wrapped in donor sclera or other materials. The wrapping material is also essential to anchor extraocular muscles to the implant. A recent innovation is a coated hydroxypapatite implant to which the muscles can be directly sutured without additional wrapping. Motility peg insertion *(Fig IV-C)* provides an indirect attachment of the implant to the prosthesis, enhancing prosthesis motility[3]. Pegging of hydroxyapatite implant can sometimes be performed as early as 6 months after the initial surgery in patients desirous of having a better prosthesis motility, pending confirmation of vascularization[4]. Pegging may, however, increase the risk of implant exposure and infection[5].

FigIV-B Hydroxyapatite implant



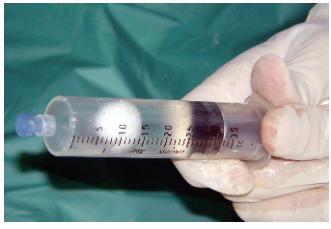
FigIV-C Motility pegs

Implant exposure (1-15%) *(FigIV-D)* seems to be a major complication with hydroxyapatitie implant[6]. The vastly different results are attributed to variations in the surgical procedure. Proper implant sizing and meticulous wound closure seem to minimize the risk of implant exposure.The use of hydroxyapatite significantly raises the cost of surgery. Less expensive synthetic bioceramic implant [7] made with aluminium oxide has advantages similar to hydroxyapatite.



FigIV-D Implant exposure

Porous polyethylene is another biointegrated implant material[8]. The 400-micron large pore size of this material allows fibrovascular ingrowth. The latest technique of saline impregnation *(Fig IV-E)* of the implant may accelerate fibrovascular ingrowth. Porous polyethylene is sufficiently pliable to allow direct suturing of the extraocular muscles and thus does not need to be wrapped. Its rough anterior surface, however, is a consideration to wrap. Wrapping the implant by the conventional technique (with one large posterior window and four anterior windows for recti) may delay implant vascularization. The recent scleral cap technique where the anterior surface of the implant is covered with a 10-12 mm diameter disc of donor or autologous sclera[9] may provide an additional barrier to minimize the risk of implant exposure without interfering with fibrovascular ingrowth *(FigIV-F)*. A new material formed by a combination of porous polyethylene with bioglass seems to provide improved vascularity. A titanium peg (called the "motility coupling post") preplaced in a porous polyethylene implant is a newer concept. The motility coupling post is placed at the time of surgery and is simply exteriorized after 4-6 months, thus eliminating a second procedure of implant drilling[10].



FigIV-E Saline impregnation

FigIV-F Scleral shell covering implant

A review of the current trends in the management of anophthalmic socket after enucleation and evisceration from the American Society if Ophthalmic Plastic and Reconstructive Surgery, revealed that high density porous polyethylene implants are most popular for enucleation and evisceration. Most orbital implants are not wrapped and most surgeons prefer not to place a motility peg or post in the implant.

Implant Size

Proper implant sizing is crucial. Implant that provides about 65-

70% of volume replacement is ideal, the remaining 35-30% being contributed by the prosthesis.

A smaller implant has a higher tendency to displace or migrate and develop superior sulcus deformity. A larger implant is known to improve both cosmesis and motility. However, an inappropriately large implant may produce tension on the conjunctival wound and result in wound gape and implant exposure. Implant sizing has mostly been empirical and is often decided in the operating room. Generally, a 16-18 mm implant is used in infants, 18-20 mm in older children, and 20-22 mm in adults. There are implant sizers that may help gauge the appropriate size. A recent trend is to use the axial length of the fellow eye (axial length in mm - 2 = implant diameter in mm) to choose the implant size[11]. One should remember to deduct an additional 2-mm from the axial length if the implant is traditionally wrapped but not when the scleral cap technique is used.

Implant Wrapping

Implant wrapping has certain specific advantages: it provides an additional barrier with reduced risk of implant exposure; enables easy attachment of extraocular muscles, thus providing for better prosthesis motility; entails a smooth external surface thus making the process of implant insertion easier; and helps volume augmentation by adding 1 to 1.5 mm to the implant diameter [12].

Donor sclera is the most popular wrapping material. Donor processed pericardium and fascia lata are commercially available. Autologous sclera can also be used if enucleation is done for an indication other than a suspected tumor. Other autologous material that have been used are temporalis fascia and fascia lata. Popular synthetic wrapping materials are polyglactin-910 mesh, polytetrafluoroethylene sheet [13] etc *(FigIV-G).*

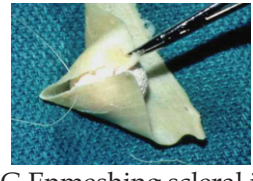
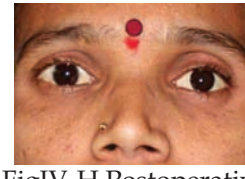


Fig IV-G Enmeshing scleral implant



FigIV-H Postoperative

TABLE 1 : Classification of Orbital Implants

Type	Definition	Example
Nonintegrated	No direct or indirect integration of the synthetic implant with the orbital structures or with the prosthesis	PMMA or Silicone spheres
Semi-integrated	Indirect (mechanical) integration of the synthetic implant with the orbital structures but not with the prosthesis	Allen implant
Integrated	Indirect (mechanical) integration of the synthetic implant with the orbital structures and with the prosthesis	Cutler's implant
Biointegrated	Direct (biological) integration of a natural or a synthetic implant with the orbital structures with or without integration with the prosthesis	Hydroxyapatite, Porus polyethylene, Aluminium oxide
Biogenic	An autograft or allograft of a natural tissue with direct (biological) integration with orbital structures but not with the prosthesis	Dermis-fat graft Cancellous bone

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Sustained drug delivery for management of posterior uveitis

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Severe cases of uveitis may require multiple rounds of sub-Tenon's or intravitreal steroid injections as well as systemic immunosuppression. Repeated intravitreal injections increase the potential risk for complications, such as endophthalmitis, cataract, vitreous hemorrhage, and retinal detachment. Therefore, alternative ways to deliver these drugs that are less invasive or require less frequent dosing need to be developed.

Sustained Drug delivery systems

A fluocinolone acetonide implant (Retisert; Bausch & Lomb, Rochester, New York) has recently been approved in USA by the FDA for clinical use in patients with posterior uveitis. It is the second nonbiodegradable polymer implant that has gained approval for ocular use and the first implant for chronic noninfectious endogenous uveitis affecting the posterior segment. The incidence of uveitis has been estimated to be as high as 52.4/100000 person-years. Approximately 15–22% of uveitis affects the posterior segment. This form of uveitis can be difficult to treat and may result in vision threatening complications such as chronic cystoid macular edema. In fact, posterior segment uveitis has been estimated to be responsible for 10% of blindness in the United States and similar data has been reported from India.

Since topical corticosteroids do not appear to reach therapeutic drug levels in the posterior segment, systemic treatment and periocular injections have been the mainstay of therapy for this disease. While oral corticosteroids are very effective, they are associated with a plethora of side-effects that can impact nearly every organ system.

Systemic immunosuppressants, such as antimetabolites and alkylating agents, have also been employed as second-line agents but are limited by their potentially severe side-effects and cost. Periocular and intraocular corticosteroid injections limit systemic side effects but often require frequent dosing every 2–4 months to maintain adequate disease control. Complications for periocular injections may include globe perforation, orbital fibrosis, and ptosis while those for intraocular injections include vitreous hemorrhage, retinal detachment, and pseudoendophthalmitis or endophthalmitis.

Due to the limitations of current therapies for posterior segment uveitis, the fluocinolone acetonide implant was developed as a method of delivering therapeutic drug levels over about 30 months. The currently available implant contains a total of 0.59mg of fluocinolone acetonide that is released at an initial rate of 0.6 microgram (μg) decreasing over the first month to a steady rate of 0.3 to 0.4 (μg)/ day. Pre-clinical studies showed that the implant was well tolerated with no detectable systemic drug absorption. The first pilot study to use this type of implant involved seven eyes of five patients with severe posterior uveitis. After an average follow-up of 10 months after device implantation, visual acuity was stabilized or improved and inflammation was controlled in all eyes. Subsequently, a single-center pilot study of 36 eyes of 32 patients implanted with either a 0.59mg or 2.1mg fluocinolone acetonide implant demonstrated an improvement in mean visual acuity at 30 months, no recurrences of ocular inflammation during the first 2 years after implantation, and a reduction in the dosage and rate of systemic and other local adjunctive therapies. An elevation in intraocular pressure (IOP), however, was noted which required pressure-lowering agents in 56.1% (versus 11% at baseline) and glaucoma filtering procedures in seven eyes (19.4%).

More recently, a multicenter randomized (results presented in American Academy annual meeting 2007) clinical study was undertaken to evaluate the safety and efficacy of the fluocinolone acetonide implant for 239 patients with noninfectious posterior uveitis.

Patients were randomized to receive either the 0.59mg or a 2.1mg implant, both of which were designed to release the drug over about 30 months. Both doses of implants reduced the rate of disease recurrence to 6.1% compared to 51.4% in the 34 weeks prior to implantation. Visual acuity remained stable or improved in 87% of patients, usually due to a reduction in cystoid macular edema. An improvement of three or more lines in acuity was seen in 21% of patients. Also, patients required significantly less systemic medications, periocular injections, and topical corticosteroids. As with the pilot study, over half of the implanted eyes required pressure-lowering drops and 33.1% required glaucoma filtering surgery as compared to 1.68% in control group. Cataract progression was also noted in 19.8% of eyes with 94.9% needing cataract surgery.

The fluocinolone acetonide implant is also currently being investigated in clinical trials for the treatment of macular edema from diabetic retinopathy and venous occlusive disease. Recently, an update of the multicenter, randomized clinical trial for the treatment of diabetic macular edema was reported. A total of 179 patients were randomized to receive the implant or standard of care. At 3 years after implantation, eyes with the implants exhibited significantly less macular edema, with 58% of implanted eyes having no evidence of edema versus 30% of standard of care eyes. Improvement in visual acuity of three or more lines was seen in 28% of implanted eyes versus 15% of standard of care eyes. Adverse events included cataracts requiring surgery in 95% of initially phakic eyes and IOP elevation in 35% of eyes. Thirty-six eyes (28%) required a filtering procedure and six eyes (5%) were explanted to manage IOP.

The results of a 12-month pilot study on the use of the fluocinolone acetonide implant for macular edema from central or branch retinal vein occlusions was also recently reported. Nineteen eyes (three with branch vein occlusion and 16 with central vein occlusion) received the implant. Eleven eyes showed greater than two lines of improvement in visual acuity. Central retinal thickness by optical

coherence tomography was also significantly decreased after implantation. As seen in previous studies, IOP elevation occurred with seven eyes requiring glaucoma filtering surgery.

Conclusion

Future technologies for drug delivery systems to posterior segment would consists of suture less incision with biodegradable matrix and utilize nano techniques. Transscleral iontophoresis is one potential solution. Increased intraocular longevity through the use of injectable particulates or biodegradable implants may minimize the number of intravitreal injections required for drug efficacy and thereby improve safety.

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Scleral Buckle

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Scleral buckle revolutionized retinal reattachment surgeries in the previous century by scientifically neutralizing the forces which cause Retinal Detachment (RD).

Rhegmatogenous RD involves Posterior Vitreous Detachment (PVD) leading to retinal tear / hole through which fluid enters the subretinal space and keeps the retina detached. Scleral buckle indents the ocular coats from outside so that Retinal Pigment Epithelium (RPE) gets elevated and comes in contact with the break in neurosensory retina. This changes the fluid currents in the vitreous cavity and fluid no longer enters the sub-neurosensory retina. Subretinal fluid is either drained or gets absorbed on its own to reattach the retina back in its position.

Scleral buckle can be made of solid silicone or silicone sponge. Popularity of silicone sponge is less due to increased risk of postoperative infection leading to silicone sponge extrusion.

Solid silicone can be placed as an implant within the scleral coat or as an explant just outside the scleral coat, which is the preferred technique.

Solid silicone is available as circumferential element which is implanted parallel to the Ora Serrata (Spiral of Tillaux) or as meridional segments which are placed radially. The following table shows the width of the Scleral Buckle number and its width-

MIRA No	Buckle width
240	2.5 mm
276	7 mm
277	7 mm
279	9 mm
280	10 mm
281	12.5 mm

Odd numbered buckles (277,279,281) have a central gutter of 2.5mm width into which a 240 buckle fits to distribute the buckle indentation smoothly over its entire length. Even numbered buckles (276, 280) have an eccentric gutter so that the 240 silicone band is placed relatively anterior and there is more indentation posteriorly.

Effects of Scleral Buckle:

- **Effects that lead to retinal reattachment**
  - Relief of vitreous traction due to indentation of retina
  - Reversal of the action of epiretinal membrane from that which tries to detach the retina to that which helps and maintains retinal attachment by changing the direction of the resultant vector force acting inwards in a normal concave scleral contour to outwards in a convex scleral contour in the region of a buckle.[1]
  - Scleral buckle alters the direction and magnitude of fluid currents in the vitreous cavity, reducing the quantum of fluid entering the subretinal space. Indentation of the RPE brings it closer to the retina. Retinal tear within 3 mm from RPE (without actual closure of the retinal tear) allows more fluid from subretinal space to be absorbed than what flows in from the vitreous cavity into the subretinal space, leading to eventual approximation of retina and RPE.[2]

- **Effects on axial length, refractive error and volume changes**
  - Radial silicone sponge induces minimal increase in axial length, but clinically significant astigmatism.[3,4]
  - Circumferential silicone buckle usually induces myopia due to increase in axial length and anterior displacement of lens but high buckle may sometimes decrease axial length.[3,4] Circumferential buckle extending over one to two quadrants can induce astigmatism.[4]
  - Radial silicone sponge has minimal decrease in intraocular volume compared to circumferential buckles.[5]

Complications due to buckle:

- Increase in intraocular pressure and secondary glaucoma can occur due to volume changes in globe and anterior shift of lens. It may be compounded by use of internal tamponade like air or gas.
- Anterior segment ischaemia can occur especially with high buckle or if recti are disinserted.
- Infection and extrusion of buckle occurs in 1% of cases.[6] Soaking with antibiotics reduces incidence of infection in silicone sponge.[7] High buckle may rarely cause buckle intrusion.
- Postoperative squint is usually transient and permanent diplopia occurs in only 4% cases due to myoscleral adhesion or orbital scarring.[8,9]

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Vitreous Substitutes

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Intravitreal Gas (C_3F_8)

The vitreoretinal surgery has greatly been benefited from the use of select vitreous substitutes, substances that are injected into the vitreous intraoperatively to facilitate a given surgical procedure and later providing prolonged internal tamponade. A wide range of liquid and gaseous vitreous substitutes are available. At the end of the surgery, silicone oil or a gas (sulphur hexafluoride) (SF_6) or perfluoropropane (C_3F_8) is injected into the eye as a temporary vitreous substitute.

These agents temporarily prevent fluid from vitreous from gaining access to retinal tears and holes which could lead to recurrent retinal detachment. Silicone oil may be removed weeks to months later (sometimes left indefinitely) in the operating room; gases resorb ("evaporate") by themselves over a period of two to six weeks.

Physical characteristics (based on 1ml of pure gas)[1]

	Mol wt	Expansion	Longevity	Non expanding concentration
Air	29	0	5-7 days	-
SF_6	146	1.9-2.0	10-14 days	18%
C_2F_6	138	3.3	30-35 days	16%
C_3F_8	188	4	55-65 days	14%

Gas Dynamics

Gases are only slightly soluble in vitreous, have the highest surface tension and as a result create an interface[2]. Bubble expansion: Gases less soluble than nitrogen and water expand when injected in to the eye and the bubble enlarges as gases diffuse from the surrounding tissue fluid into the expanding gas bubble until partial pressure equilibrate between two compartments.

Maximum expansion of C_3F_8 occurs between 72-96 hrs. In an eye with normal outflow facility, 1.0-1.2 ml of expanding gas can be injected. Also, IOP should be monitored 10-30 minutes after any inhalational

anaethesia like N_2O used in a patient for general anaesthasia with intraocular gas. If intraocular gas is to be injected at end of surgery, N_2O should be discontinued 15 minutes before gas injection. Rapid decompression of atmospheric pressure during air travel can also cause elevation of IOP.

Nitrogen equilibration: The partial pressure of nitrogen in gas bubble equilibrates with nitrogen in surrounding tissue environment. For C_3F_8 it lasts 2-3 days.

Bubble dissolution: The concentration of all gases within the the bubble remains constant and the size of the bubble decreases as all gases diffuse out [3].

As gas bubble occupying 50% of vitreous volume is desirable for therapeutic tamponade, the ideal therapeutic size is available only during 25 % of longevity time of any gas.

Gas bubble geometry:

The two things in surgeon control are gas bubble size and duration. In a globe of average size (21mm) 0.3ml of gas would tamponade 90 degrees of arc and 1ml, 126 degrees of arc.

Clinical application of gases

Giant retina tear(GRT), large breaks with fish mouth phenomenon, posterior breaks or macular holes, restoration of intraocular volume after sub retinal fluid drainage, total retinal detachment with multiple breaks and large meridonial folds[4].

Choice of gases:

In retinal detachment(RD) surgery, air and SF_6 are used for scleral buckle surgery. For complicated detachments like GRT and posterior holes, perfloropropane is preferred for its longevity and greater expansion property. The Silicon study concluded that C_3F_8 is more effective than SF_6 for intraocular tamponade after vitrectomy for complicated RD with proliferative vitreo retinopathy(PVR).

Pneumatic retinopexy: This consists of an intravitral gas injection with transconjunctival cryopexy or laser photocoagulation followed by appropriate head positioning. The typical dose injected of pure gas (air-0.8ml; SF_6-0.5ml; C_3F_8-0.3ml). [5]

Complications of gases:

Rise in IOP(26-59%)
Lens opacities(feathery posterior sub capsular opacities)
Bulous keratopathy
Sub retinal gas
New or enlarged retinal breaks
Dislocated intraocular lens implant
Visual field loss[6,7]

Silicon oil:

Silicon oil is clear inert hydrophobic polymer compound based on siloxane repeating units of varying viscosities. The length of polymer determines its viscosity(1000-12500 cSt). The higher viscosity oil usually emulsify late. The refractive index of the silicone oil is slightly higher than vitreous. The interfacial tension is also high but less than gas water interface. Silicon oil is utilized as an extended intraocular tamponade as well surgical instrument due to its high interfacial tension and hydraulic capabilities[8].

Indications:[9,10,11,12,13,14]

- Prolonged tamponade: In RD surgery complicated by severe PVR, the silicon oil study had shown that silicon oil is superior to Sf_6 and roughly equivalent to C_3F_8 gas. Despite overall equivalence certain eyes appeared to do better with silicon oil. Relative indications include travel to higher altitude, difficulty with post operative prone positioning(children and mentally ill),eyes with severe anterior PVR., eyes undergoing relaxing retinotomies.

- Post operative positioning. It provides a more complete and consistent fill so no need for prone position post op.

- Complications of severe proliferative diabetic retinopathy. (severe diabetic traction, recurrent vitreous haemorrhage following vitrectomy, severe anterior segment neovascularisation, anterior hyaloidal fibro vascular proliferation). The use of silicon oil in these eyes causes potential reduction in postoperative haemorrhage impeding access of vasoproliferative factors from posterior to anterior segment., preventing diffusion of oxygen –enriched aqueous to posterior segment, rapid recovery of visual potential in one-eyed patients. and reduced postoperative positioning requirement.

- Selected case of macular holes(resurgery or complicated by RD)
- Giant retinal tear
- RD associated with choroidal colobomas
- Chronic uveitis with profound hypotony
- Trauma(severe penetrating injury with RD)
- Infectious Retinitis (RD in patients with Acute retinal necrosis, CMV retinitis, HIV retinopathy)
- Complicated paediatric retinal detachment:
- Endophthalmitis: Select case of endophthalmitis might benefit as it leads to increased concentration of intravitreal antibiotics, innate bactericidal properties, stabilization of atrophic retina

Complications: [15,16,17]

- Suprchoroidal silicone oil with incomplete penetration of choroids with silicone infusion line.
- Sub retinal silicone oil due to unrelieved traction and excessive manipulation of retina under silicone oil.
- Intraocular bleeding from relaxing retinotomy site, sclerotomy site or manipulation of retina
- Intraoperative optical problems: Pupillary miosis in aphakic eyes, oil in anterior chamber, silicone oil droplets adhering to silicone IOL
- Post operative anterior chamber silicone oil: due to blockage of inferior iridectomy or inadequate lens or intraocular lens-iris diaphragm
- Recurrent RD
- Glaucoma (pupilary block, overfill, emulsification of oil)
- Hypotony
- Macular epiretinal membranes

- Refractive changes: On an average the silicone filled phakic eyes will produce a 6D hyperopic shift. As silicone oil forms a concave surface behind the lens and acts as a minus lens inside the eye.
- In aphakic eyes refractive shift from + 12.5 to + 5.6 D as produces a convex surface acts as plus lens inside the eye.
- Cataract: Impaired metabolic exchange and direct toxicity.
- Difficulty in axial length calculation in silicone filled eyes due to a difference of speed of sound in oil.
- Late visual loss

Silicone oil removal:

The oil removal is normally recommended after 6wks to 6months .

2 port cannula systems for infusion of saline and passive efflux or active aspiration of silicone oil are used.

It may be left longer if eye is chronically hypotonus, predisposed to recurrent detachments, post trauma cases, detachments following infectious retinitis [18].

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Intubation in lacrimal surgery

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Intubation of the lacrimal system is essential in some congenital and acquired cases especially as a sequel to trauma. We hereby present various implants available and our technique for floor fracture repair, facial palsy and intubation of the lacrimal system.

Intubation in DCR

Intubation of the lacrimal drainage system is useful to treat epiphora in selected group of patients especially in children and as an alternative to DCR. Knowledge of the lacrimal drainage system and nasal anatomy is necessary to achieve best results.

Indications

1. Congenital dacryocystitis
2. Partial nasolacrimal duct obstruction
3. Failed DCR
4. Post traumatic dacryocystitis
5. Canalicular obstruction
6. Conjunctival DCR with Jones tube
7. Canalicular laceration

Congenital dacryocystitis

Indications

1. Failed multiple probings
2. Child older than 1 yr

Various type of intubation sets available are Riteling, Jed-med, Crawford, Quickert-Dryden etc*(Fig VI, A)*. The author prefers Crawford intubation set.

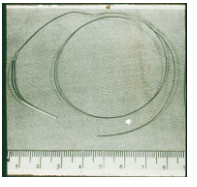

Fig IV,A- Silicone tube

Nasolacrimal duct intubation for Functional Obstruction

Silicone stent intubation is an alternative to DCR for functional obstruction. Stent may be left in position for 3 to 12 months which presumably dilates a stenotic duct.

DCR with Jones tube intubation (conjunctivo-Dacryocystorhinostomy)

Conjunctivo-dacryocystorhinostomy (C-DCR) with Jones tube intubation is required in cases with canalicular obstruction due to any aetiology. Jones tube is placed in the conjunctival cul-de-sac which carries the tears from conjunctival sac into the nose. It can be combined with external or endonasal DCR.

It can be performed under general anesthesia in children and local anesthesia with or without sedation in adults. Various materials including Pyrex glass*(Fig VI,B)*, polyethylene and silicon*(Fig VI,C)*. have been used for the purpose. Glass tubes have been found to offer the best capillary action nd least clogging with mucous. However glass tubes are difficult to obtain, need to be imported and a large inventory needs to be maintained. To overcome the difficulty, authors got Borosil glass tubes prepared by a glass blower*(Fig VI,D)*.

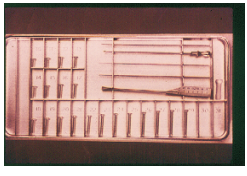

Fig VI,B- Pyrex glass tube

Fig VI,C-Silicone tube for C-DCR

Fig VI,D- Borosil tubes

Intubation for canalicular laceration

The lacrimal injuries may occur due to direct or indirect trauma medial to inner canthus. Direct trauma includes severing the lacrimal portion of the lid with objects, such as glass, hangers, dog bites, fingernails, or other sharp objects. Indirect trauma results from blunt injury to the ocular adnexa from such mechanisms as blows to the face , blunt weapons.

Facial fractures, especially naso-ethmoidal fractures, are associated with these injuries. The fractures result in displacement of bony fragments in addition to injury to the soft tissue of the medial canthal region, affecting the sac and naso lacrimal duct thus resulting in dacryocystitis and epiphora.

The goal is to reanastomose the mucosa of the canaliculi so that anatomical and physiological functions can be restored.

Stents:

The stents are used to maintain the proper alignment of an anastomoses and to prevent scarring. The various types of materials have evolved from the past starting from the use of organic materials like thick hairs (Wagenmarn, 1913), catgut, metal probes, metal rod with 4'0 Braided silk (Veirs), Synthetic materials like nylon, polyethylene and silicone. Silicone tubing was first used in the late 1960's and revolutionized the repair of canaliculus due to its softness, flexibility and tolerance by the canaliculus and conjunctiva.

Bi-canalicular stent

This places a stent in both the traumatized canalicular system as well as the normal. One disadvantage of this technique is the potential damage to the normal canalicular system.

Mono-canalicular stent

This procedure has the advantage of placing a stent in the traumatized canalicular system and thus avoids potential damage to the "good" canalicular system. Stents like mini-Monoka, Riteling monocanalicular stent are used.

Monocanalicular Intubation:

The authors prefer to use monocanalicular stents in unilateral canalicular injuries. The medial portion of the stent extends into the lacrimal sac or the nose via nasolacrimal duct. The lateral portion is situated within the canaliculus, punctum or deeper eyelid tissue and is fixed to the conjunctiva, lid margin or skin.

In case of associated medial canthal injury it is repaired with 4-0 chromic catgut after positioning the stent.

The stent is maintained in position for 3 months. The fixation sutures enable the tube to retain in position for desired duration.

Fig VI,E & F showing the preoperative and postoperative photograph.

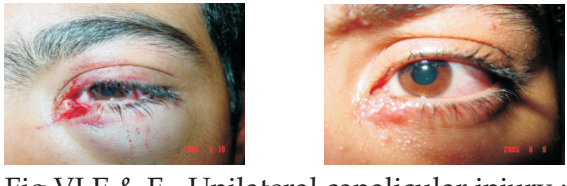

Fig VI,E & F - Unilateral canalicular injury :
Pre & Postoperative photographs

Annular monocanalicular intubation

The stent is passed through the canaliculus into the lacrimal sac. The stent is then drawn out of the skin through the wall of the lacrimal sac and the medial end is tied to the lateral end of the sling.

Sac and Nasolacrimal Duct

Facial trauma involving the nasal bones leads to sac and NLD injuries. The primary management includes the repair of the lids and face. Depending on the extent of injury to the sac- conventional DCR, canalicular or conjunctival DCR can be done at a secondary stage.

DCR in Traumatic NLD Obstruction

The landmarks are altered because of bony trauma and structures are more difficult to identify. Thick bone is often encountered. The DCR can be combined with bicanalicular nasal intubation.

Gold weight implants

It is indicated in patients with eyelid retraction due to facial nerve palsy with significant lagophthalmos *(Fig VI,G)*.

Fig VI, G- Gold weight implant
sutured to the tarsal plate

Counselling of the patient is necessary to explain to him that the aim of the procedure is to provide adequate closure but it will not improve the blinking.

The procedure is contraindicated in patients with

- Pale thin skin
- Atrophic Orbicularis
- Suprasulcus deformity

Implants for orbital floor fracture

Orbital fractures secondary to blunt trauma are not uncommon. The most common orbital walls to be affected by trauma are the floor and the medial wall, the thinnest bone in the body or may be associated with other facial trauma like zygomatic fractures. Clinical indications for repair of a fracture include diplopia or extraocular muscle

entrapment, a large fracture (greater than 50% of the wall), and enophthalmos greater than 2mm. Goal of repair is to cover the bony defect and prevention of prolapse of orbital tissues into the sinuses.

Implants

The ideal implant should be easy to insert and manipulate, inert, not prone to infection or extrusion, easily anchored to surrounding structures, and reasonably priced, and it should not rouse fibrous tissue formation. Most orbital floor defects can be repaired with synthetic implants composed of porous polyethylene, silicone, metallic rigid miniplates, Vicryl mesh, resorbable materials, or metallic mesh. Autogenous bone from the maxillary wall or the calvarium can be used, as can nasal septum or conchal cartilage.

Implants used are

1. Alloplastic implant such as Porous polythelene, silastic, Teflon, silicone,PMMA,Tantalum,ePTFE, Hydroxyapatite
2. Autologous materials like bone or cartilage(fig 26)
3. Dissolvable alloplastic material such as Gelfilm, Lactosorb
4. Allogenic material such as banked bone or lypholized cartiage.

Alloplastic implants

Advantage

- Inert
- No additional surgical site
- Can be cut into desired size

Silicone Blocks/Sheets

Advantage

- Inexpensive
- Easily available
- Inert and stable
- Block implants help in volume replacement in enophthalmos
- Long life

Disadvantage

- Cause recurrent inflammation and lid retraction

e-PTFE/Porous Polyethylene/Hydroxyapatite*(Fig VI,H)*

- Non-antigenic
- Biologically, chemically inert
- Stable and durable
- Resistant to infection
- Easily incorporated in host tissue

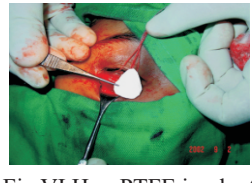

Fig VI,H - ePTFE implant

Autologous implants
Cancellous Bone/Cartilage

- Non-antigenic
- Biologically, chemically inert
- Resistant to infection
- Easily incorporated in host tissue
- Can be used to replace volume in enophthalmos as larger blocks can be used
- Inexpensive

Disadvantge

- Requires knowledge of special harvesting methods
- More Time consuming
- Resorption of graft possible over time

Dissolvable alloplastic material - Gelfilm and Lactosorb

They are used in cases of small fractures. Gelfilm is less rigid when in contact with moist tissue .Lactosorb is more rigid.

According to our experience complication rates were relatively more with silicone blocks / sheets. Bio-comptible implants like Medpor / e-PTFE have been giving satisfactory results. Cancellous bone is often used whenever surgery is performed in conjunction with neuro-surgeons / orthopedics surgeons. No Long term encapsulation / fibrosis / acquired strabismus / extrusion has been seen with any of the alloplastic implants used in the past two decade.

Timing of surgery

It is advisable to wait for 1-2 weeks to allow

- Decrease in haemorrhage / oedema
- Spontaneous improvement in movements

Approaches

- Orbital
- Caldwell's Approach
- Bi-coronal Scalp Approach

Oculoplastic surgeon prefers orbital approach due to the advantage of

- Direct Visualization of Fracture
- Release of entrapment possible
- Placement of prosthesis possible

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