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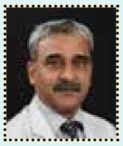
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Current Concepts in Cataract Management

Dr. (Prof.) Subhash C. Dadeya

Dear colleagues and friends!!

The Delhi Ophthalmological Society is one of the oldest ophthalmic societies in India successfully running DOS Times as its publication since years. The aim of this journal is to provide a platform to authors as well as residents to publish scientific papers of a rich and diverse academic content. Me along with my present editorial board promised to give you thematic dedicated issues focussed on as single sub speciality throughout the year. Since the last few issues of this journal have been based on a sub-speciality; this one is no less. We have chosen our basic and the most common sub-speciality i.e. cataract.

Cataract surgery has been the bread and butter of most ophthalmologists since many years. Refractive surgery on the other hand has been the new glamour in this area over the last decade. The present issue focuses on high quality research articles as well as reviews from well-known cataract surgeons, new techniques; clinical cases and well-designed essays. Burning topics like post refractive surgery IOL power calculation are also discussed. With these revamped series of DOS times; we include view points from luminaries in this field. We have encouraged residents too providing them a knowledge transfer platform through this rapidly evolving journal.

We aim to lay emphasis on new knowledge and innovations pertinent to our contemporary practice in cataract and refractive surgery. We hope that this issue also appeals to a substantial readership across India; with newer developments in the field of cataract and refractive surgeries.

Thanks

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Cataract Surgery in Uveitic Patients

Dr. Sudarshan Kumar Khokhar

Dr. Arun K. Jain

Dr. Krishna Prasad

Dr. Nikhil Rishikeshi

Cataract formation is one of the commonest complication in uveitic patients especially chronic cases. Primary aim of the surgery is restoration of good visual acuity taking into account all the associated problems including band shaped keratopathy, posterior synechaie, intense inflammation, glaucoma, cystoid macular edema etc. Various special considerations are required before, during and after surgery in these cases.
We therefore asked a panel of eminent cataract surgeons from around the country about their opinion and views on various aspects of management approach and treatment options through this questionnaire.

(SK) Dr. Sudarshan Kumar Khokhar: MBBS (AIIMS), MD (AIIMS), FRCS (Edin). He is currently working as Professor and Head of unit at Rajendra Prasad Centre, All India Institute of Medical Sciences New Delhi, India. He has expertise in Pediatric cataracts and complicated adult cataracts. He has authored over 80 indexed publications in peer-reviewed journals and has six chapters in Textbooks. He is the designer of "Khokhar's capsular painting cannula" and pioneered use of Plasma blade in PFV eyes. He was honored by Achievement awards by international bodies like APAO (2016) and AAO (2017).

(AJ) Dr. Arun K Jain: MD, DNB, FIACLE. He is currently working as Professor, Cornea, Cataract and Refractive Surgery, Advanced Eye Centre, PGIMER, Chandigarh. He has done his MD Ophthalmology from Dr. RP Center, AIIMS, New Delhi. Fellowship in Cornea & Anterior Segment, Madison, Wisconsin, USA. Fellow of International Association of Contact Lens Educators [FIACLE, Australia]. He has more than 70 Publications in peer reviewed national and international journals. Has presented more than hundred papers and guest lectures at various national and international conferences. He has worked as Reviewer for the various Journals.

(KP) Dr. Krishna Prasad: He is currently working as professor and head of Pediatric Opthalmology, M.M. Joshi Eye Institute, Hubli.

(NR) Dr. Nikhil Rishikeshi: He is working currently as Head of Department, Pediatric Ophthalmology, H.V. Desai Eye Hospital, Pune, India. He is also Consulting eye Surgeon, Sahyadri Speciality Hospitals, Pune, India.

The questions have been prepared by **(CD) Dr. Chirakshi Dhull:** MD(AIIMS), DNB: She is currently working as Senior Resident at Rajendra Prasad Centre, All India Institute of Medical Sciences New Delhi, India.

CD: What are the common causes of uveitic cataract you have encountered in your practice?

SK: Commonly we encounter Juvenile Idiopathic Athritis in children and Tuberculosis, sarcoidosis, Behchet's disease in adults.

AJ: 1. FHU; 2. JIA uveitis; 3. Pars planitis; 4. Granulomatous inflammation: VKH, Sympathetic ophthalmia, TB uveitis; 5. Behchets disease.

KP: Idiopathic variety of Uveitis happens to be the most common entity in practice but Cataracts associated with Uveitis are usually found in Fuchs uveitis syndrome, Juvenile Idiopathic arthritis associated uveitis, Behcet's disease, Vogt–Koyanagi–Harada syndrome and Presumed ocular tuberculosis.

NR: JRA, HLA B 27 associated spondyloarthropathies, Intermediate uveitis.

CD: What are the prerequisites before taking uveitic patients for cataract surgery?

SK: Proper counseling of the patient is the foremost prerequisite as the disease process continues despite cataract surgery. Prognosis also has to be explained based on posterior segment pathology, glaucoma, presence of chorio-retinal thickening.

Preoperative evaluation for planning of surgery is necessary as any other cataract surgery.

Adequate control of inflammation in the form of no activity over three months (off steroids- both topical and systemic).

AJ: The first and foremost prerequisite is control of inflammation. The eye should be quiet for at least 3 months. In Behçet's disease, we tend to wait for longer period of time as it has even been recommended that surgery be postponed until at least 6 months of quiescence to reduce the chance of postoperative inflammation.

The only exceptions are cases of phacoantigenic uveitis and intumescent cataract, where surgery is done on urgent basis. There should be no or occasional cells in anterior chamber. Minimal flare in anterior chamber is acceptable as these eye are never free of flare because of altered blood aqueous barrier. If patient has active inflammation, uveitis service consult is sought for control of inflammation. If patient is on any immunomodulatory drugs [mycophenolate, azathioprine and methotrexate], they are to be continued. Secondly IOP and secondary glaucoma evaluation has to be done. If IOP is high it has to be controlled. But more important in uveitic patient is to rule out low IOP [especially below 6 mm of Hg] as these eye are prone to go into phthisis bulbi. One has to rule out retinal detachment, choroidal effusion, ciliary body atrophy or cilio-choroidal detachment because of cyclitic membranes. The surgical management depends upon all these findings. Look for posterior synechiae [PS] and peripheral anterior synechiae [PAS] because these have to be separated as far as possible at the time of surgery. Third, dilatation of pupil is checked as most of these patients have poorly dilating pupil or posterior syneichiae. In event of poorly dilating pupil preoperative planning for use of iris hooks has to be thought of. Fourth, endothelium should be screened carefully and visual prognosis explained accordingly. Fifth patients with FHU usually have high corneal astigmatism so preoperative planning of spherical or toric IOL is contemplated.

KP: Primarily the Surgeon should assess the cause of poor vision in the particular case and should be sure of the need for cataract surgery. The Cataract surgery should be able to improve the visual acuity atleast to some extent or it could be even be undertaken to facilitate the evaluation and/or management of posterior segment disease.

As timing of cataract surgery is concerned, preferably the Eye needs to be quiet for at least 3 months prior to surgery.

Thorough counseling the patient for guarded visual prognosis and the need of prolonged medications in the post-operative period is mandatory.

NR: Quiet eye for at least 3 months before surgery, Peri operative steroids (systemic and topical) in large doses, Etiology of the cataract established.

CD: What is your preferred preoperative regimen for these patients?

SK: Treatment has to be individualized as it depends on type of uveitis, severity of disease, frequency of recurrences and associated systemic condition. As a routine all patients are started on topical steroids 3 days before surgery in addition to cycloplegic which helps in pupillary dilation as well as reducing inflammation and ciliary spasm. Systemic steroids or immunosuppressant's may be needed knowing the severity and course of the disease.

AJ: Ensure a quiet eye for at least 3 months prior to surgery, especially those with aggressive disease such as JIA-associated uveitis and Behçet's disease. In infectious uveitis, such as recurrent herpetic uveitis or ocular toxoplasmosis, start prophylactic antiviral [acivir 400 mg BD or Valcivir 500 mg OD] or antiprotozoal therapy [trimethoprim-sulfamethoxazole (160/800 mg b.i.d.] 3-7 days in advance of surgery to prevent recurrence of the disease.

Preoperative management specifically depends on the type of uveitis. In anterior non granulomatous uveitis and in Fuchs heterochromic iridocyclitis, topical administration of prednisolone acetate 1%/ dexamethasone 0.1% (1 drop every 6 h) starting three to seven days prior to surgery may be enough. Patients with uveitis associated with juvenile idiopathic arthritis, granulomatous anterior uveitis, intermediate uveitis including pars plants, posterior uveitis, panuveitis, or in patients with history of cystoid macular edema, topical therapy should be complemented with systemic corticosteroids.

For these cases, administration of prednisone (0.5 to 1.0 mg/kg/day), starting three to seven days before surgery should be added to the actual regimen of classical immunosuppressive therapy and/ or biologic agents that the patient may be already receiving for long-term control of inflammation. Topical non-steroidal anti-inflammatory drugs (NSAIDs) like, nepafenac 0.1%, ketorolac tromethamine 0.4%, or bromfenac 0.9% starting at least three days before surgery, and extending at least six to eight weeks after surgery are usually administered to all uveitis patients. Topical NSAIDs help to prevent cystoid macular edema secondary to surgery and maintain pupillary mydriasis during the procedure.

Associated uveitic glaucoma can be managed separately after cataract surgery. Band shaped keratopathy is treated before cataract surgery.

KP: Topical steroids one week prior to surgery like Prednisolone acetate QID and Oral prednisolone 1 mg/kg once daily for 3 days prior to the surgery helps in controlling Post Operative Inflammation.

NR: Tablet Wysolone 1mg / kg 3 days before surgery Prednisolone acetate eyedrops 1 % 1 week before surgery 4 times a day with an antibiotic eyedrop cover.

Nepafenac eyedrops 1 week before surgery 3 times a day, continued immediately post operative till 15th day.

CD: What are preoperative investigation you would suggest for these patients?

SK: Just like any other cataract surgery, preoperative biometry has to be done for planning of IOL. If fundus is not visible USG should be done to rule out posterior segment pathology. If fundus is visible and there are clinical features of vasculitis or choroiditis FFA may be done to rule out peripheral CNP areas, neovascularization, macular edema (OCT can also be done for this) or macular ischemia. Macular function tests should be performed to estimate visual potential.

AJ: In addition to recording visual acuity, pupillary responses to light, perception of light [PL] and projection of light rays [PR] , preoperatively optical biometry is done whenever possible or USG [A scan or B scan] guided axial length is calculated. In patients with significant cataract where there is no fundus view Ultrasound B scan is done to rule out any retinal detachment, vitreous hemorrhage, choroidal thickening. We also do Laser Flare metre to see if there is any AC flare. UBM is indicated to rule out ciliary body atrophy, ciliochoroidal detachment or cyclitic membranes [cases with low intraocular pressure]. Fluorescein angiography is done to rule out macular ischemia or edema, retinal ischemia or active posteriorsegment disease. OCT should be attempted whenever possible to rule out macular edema, atrophy or hole, choroidal neovascularization, opticnerve headeavaluation and neovascularization etc. Last but not the least potential visual acuity meter assessment for potential post-operative visual acuity is done to explain visual prognosis to the patient.

KP: Maximum pharmacological pupillary dilatation possible should be noted and pupil expansion methods should be planned preoperatively. Diurnal Variation of Intraocular pressure should be noted to document the preoperative values and to detect the high/ borderline intraocular pressure (which are often associated with Uveitis) which can help in planning Combined procedure considering other parameters.

Optical coherence tomography to rule out Macular edema or Epiretinal membranes, Fundus fluorescein angiogram to assess macular ischemia or edema or any other posterior segment disease is necessary.

NR: ANA; HLA B 27; TORCH titre; VDRL (if suggestive); SD OCT to rule out macular edema; B scan if posterior segment not visualized; CBC; HIV; Urine Routine and Microscopy.

CD: What are the common intraoperative difficulties encountered?

SK: 1. Shallow anterior chamber, PAS- can be dealt with viscocohesive devices

2. Band shaped keratopathy- may require EDTA chelation in center involving cases

3. Small pupil, filiform pupil, posterior synechiae- can be released, iris hooks may be needed

4. Hyphaema- NVI, friable vessels may bleed, there may be bleed from angle as in fuch's hetrochromia iridis

5. Pupillary membrane- can be peeled, leading to opening of pupil

6. Anterior capsule plaque/ thickening- capsulorexis can be performed using microincision scissors and forceps

7. Posterior capsule plaque- if thick can be removed intraoperatively or Yag Capsulotomy can be done postoperatively. In children as chances of VAO are high in uveitic patients, better to perform PCCC.

AJ: Many intraoperative difficulties are encountered. In some cases due to Band shaped keratopathy [BSK] there is poor view so BSK removal with help of EDTA is done and cataract surgery is taken up at later setting. Hyphaema, floppy iris, peripheral anterior synechiae [PAS], poorly dilating pupil, posterior synechiae, occlusio pupillae, seclusio pupillae, poor red reflex, white cataract, weak zonules are common problems encountered and should be dealt accordingly. PAS are dealt first of all by using viscodissection. Then I separate posterior synechiae with combination of sweeping with viscocanula and viscodisection with cohesivedispersive viscoelastic. In case of white cataract I stain the capsule with trypan blue.

In case of zonular dialysis CTR is injected and if needed Cionnis' ring is injected in the capsular bag to fix the CTR.

KP: The small pupil, shallow anterior chamber, posterior synechiae, peripheral anterior synechiae and pupillary membranes are to be expected in most cases. Other Complications may arise from problems like undersized or incomplete capsulorhexis, iris prolapse, increased risk of posterior capsular rent, increased risk of intraoperative zonular dehiscence.

NR: Non dilating pupil
Posterior synechiae
Zonular weakness, bag instability
Poor visualization (if BSK present)
Risk of increase of IOP (in cases with associated glaucoma).

CD: What is your preferred technique to achieve pupillary dilatation in patients with posterior synechiae?

SK: Preoperatively start homide or atropine. Intraoperatively, if pupillary membrane is there, it can be peeled with microincision forceps. If posterior synechiae are there, release with visco cannula or sinsky hook. After this if upto 4-4.5 mm pupillary dilatation is achieved, surgery can be performed using viscodilatation. If not, iris hooks, sphicterotomies, malyugian ring etc can be used.

AJ: First I break the posterior synechiae with sweeping movement with visco cannula and simultaneous injection of cohesive dispersive viscoelastic.. Then stretching of the pupil is done with two Kuglen or Behcert hooks in direction perpendicular to each other..

Care is taken not to tear the sphincter pupillae muscle of the iris. If pupillary membranes are there I remove it with a pair Kelman-Mcpherson forceps. Visco is injected further to viscodilate the pupil. Multiple sphincterotomies can be done to further dilate the pupil. If the pupillary diameter is greater than 5 I go ahead with surgery otherwise I use iris hooks to mechanically dilate the pupil. I have hardly felt the need to use Beehler two or three pronged pupillay dilator, Malyugin or Bhattacharjee rings.

KP: Pupillary dilatation should be attempted using various methods as it reduces intraoperative difficulties as well as it provides a larger pupil in the postoperative period which helps in further diagnosis and management of posterior segment disease.

Iris hooks are easy to use, cheap, and easily available option. Other devices like Malyugin ring, B Hex, Gupta ring & Beehler pupil dilators can also be used depending upon the surgeon's comfort and preference.

Pupil Expansion should be considered even when the Surgeon can finish the Surgery with the small Pupil as this Surgery provides an opportunity to enlarge the Pupil to optimum size which helps in post operative Posterior Segment Evaluation.

NR: Releasing the synechiae with dilatation using viscoelastic. If dilatation insufficient then iris hooks can be used.

CD: What size of capsulorhexis do you recommend?

SK: 5mm ideally, should be covering IOL 360 degree and should not be too small as it can cause anterior capsular phimosis.

AJ: Between 4.5- 5mm well centred capsulorhexis. Anterior capsule should cover the optic of the IOL optic 360 degree. Smaller capsulorhexis often lead to capsular contraction, phimosis, and increased possibility of IOL displacement, decentration, and posterior synechiae. On the other hand, very large capsulorrhexis lead to instability of the IOL.

KP: Usually 5 to 5.5 mm well centered circular capsulorhexis is recommended. Capsulorhexis should cover the IOL optic to decrease the early occurrence of posterior capsular opacification in these patients.

NR: 4-5 mm is ideal but may not be achieved every time (owing to the pathology).

CD: What is your IOL of choice in these patients?

SK: Hydrophobic acrylic UV blocking IOLs are preffered. Heparin coated IOLs may have advantage.

AJ: Hydrophobic acrylic heparin coated IOL is preferred. Second choice is hydrophobic acrylic. These IOLs prevent PCO which is common in uveitis patients. Though hydrophilic acrylic IOL are more uveal tissue biocompatible, risk of PCO is more with these IOLs as compared with hydrophobic acrylic IOLs. Silicon, plate haptics or multifocal IOLs are to avoided.

KP: A single-piece, square-edged acrylic hydrophobic in the bag IOL is most preferred. ACIOL and Iris claw lenses should be avoided in cases of lack of posterior capsular support as they increase the postoperative inflammation and pigment dispersion. Scleral fixated IOL can be performed in such cases.

NR: IOL implantation with primary surgery done only if inflammation is well controlled pre operative with no recent spikes of inflammation.

IOL preferred – Foldable acrylic hydrophobic in the bag / 3 piece Alcon if in the sulcus

In case inflammation is not well controlled pre operatively, intermediate uveitis present, other eye had increased inflammation after IOL implantation then, IOL implantation deferred and patient is left aphakic. Extended wear contact lenses are preferred in such patients.

CD: Any comments on use of intra cameral triamcinolone?

SK: Not as a routine. Risk of IOP rise is significant. If needed postoperatvely steroids can be given oral, topical, subtenon or intravitreal strictly as per need.

AJ: Though many people use it, I personally don't use it just for the reason of lack of availability of quality preservative free triamcinolone. I use systemic dexamethasone at the time of surgery.

KP: Intracameral preservative free steroids can be used as it significantly reduces postoperative anterior segment inflammation with less pigment deposits on the IOL surface while affording enhanced visualization of vitreous during the surgery.

Risk of post-operative IOP rise should be kept in mind. Intracameral dexamethasone can be preferred as it causes less IOP rise compared to triamcinolone.

Anterior subtenon's steroid injection can also be considered in non-complaint patients and in pediatric age group.

NR: None.

CD: What post operative regimen do you follow for such cases?

SK: All patients should receive topical cycloplegic and topical +/- systemic steroid. Subconjunctival atropine and dexamethasone is also used. Intravenous dexamethasone can be given immediately after surgery. Tropicamide cycles with phenylephrine can help in preventing synechiae formation.

AJ: Tab prednisolone is given 1mg/ kg body weight, topical prenisone acetate 1.0%/ dexamethasone 0.1% 8 times per day. Gatifloxacin 0.5 % qid on 1st day then Bd for two weeks, nepafenac 0.1%TDS for 6-8 weeks, tropicamide 0.8% phenylephrine 5% to keep pupil mobile and prevent synechiae. During night dexamethasone ointment is used. Steroids are tapered slowly. After a month I switch to topical loteptrednol 0.5%.

KP: Postoperatively, the patient should be treated with intensive topical prednisolone 1% hourly, night time mydriatics should be added to keep the pupil mobile and to avoid formation of synechiae, topical nepafenac 0.1% t.i.d can be added to reduce the post-operative cystoid macular edema and can be Continued for 8-10 weeks. Oral steroids should be tapered slowly over a prolonged period.

NR: Controlling inflammation for good surgical outcome is required.

Tab Wysolone 1 mg / kg continued post operatively then tapered weekly.

Prednisolone acetate eyedrops 1% 8 times a day, tapered weekly.

Moxifloxacin eyedrops 6 times a day tapered after 15 days.

Homide eyedrops 2 times a day.

Antiglaucoma medications if indicated.

CD: What are the common problems in postoperative period, any suggestions to avoid them?

SK: Adequate control of inflammation will take care of most of the post operative complications.

Fibrinous reaction especially after iris manipulation is common in severe cases. It is usually controlled by steroids (topical) or subconjuctivally.

PCO may form after surgery which is usually amenable to Yag capsulotomy, if not membranectomy can be done.

Patients have to be kept on close watch as such.

AJ: The risk of ocular complications after cataract surgery in patients with uveitis depends on the type, etiology, previous clinical course, degree of previous ocular damage, and therapeutic compliance of the patient. Despite the preventive measures mentioned above, the most common complication is postoperative intraocular inflammation.

Early post-operative period increased anterior chamber inflammation [high dose of oral and topical steroids], rise of IOP(total removal of viscoelastic, good perioperative IOP control using anti-glaucoma medications), low IOP [rule out anterior chamber leak, if no leak rule out choroidal effusion, ciliochoridal detachment, cyclitic membrane if nothing is there hike dose of topical and systemic steroids for long term], formation of posterior synechiae (use atropine ointment at end of surgery, perioperative mydriatic- cycloplegic combination), Pupillary membranes are common in conditions such as juvenile idiopathic arthritis and Vogt-Koyanagi-Harads disease[membranes may have to be removes surgically], deposits on IOL surface (adequate control of inflammation , YAG polishing of IOL), PCO (heparin surface modified IOL, YAG capsulotomy later on), recurrence of inflammation [adequate control with steroids], macular edema [NSAIDS for 6-8 weeks, oral acetazolamide, intravitreal steroids, becacizumab, if epiretinal membranes are producing macular traction, then its surgical removal is advocated] . Vitreous haze or membranes or hemorrhage [Viterctomy].

KP: Excessive postoperative inflammation and cystoid macular edema:The dose of oral steroid prophylaxis should be increased to combat any excessive inflammation.

If no prophylactic oral steroids had been given, a pulse of oral steroids or periocular steroid injection should be administered.

Raised intraocular pressure: Topical anti glaucoma medication,Systemic carbonic anhydrase inhibitors may be administered depending on the urgency of IOP lowering required. Prostaglandin analogues should be avoided.

Delayed complications include Posterior capsular opacification which can be tackled by Nd:YAG laser capsulotomy.

NR: Persistent inflammation – controlled with oral, periocular or topical steroids, immunomodulators if required.

Increased IOP – antiglaucoma medications with regular follow up. Oral acetazolamide to be added if necessary.

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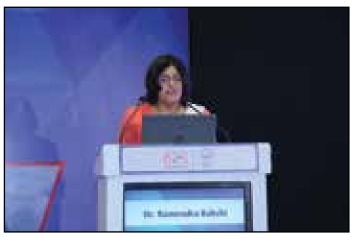

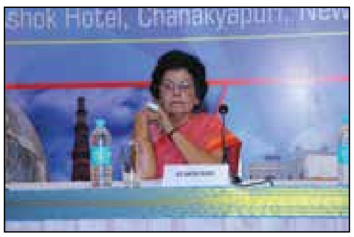

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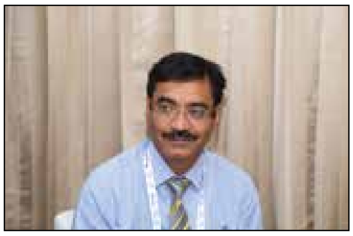













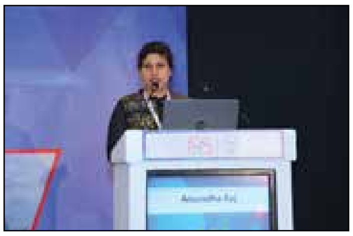
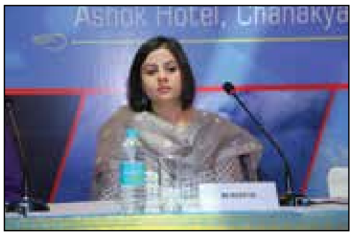



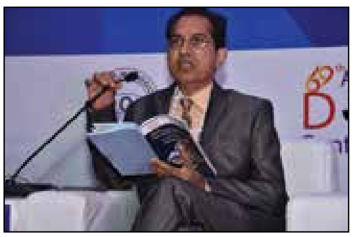


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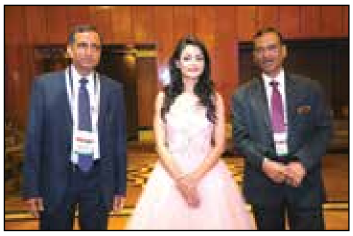




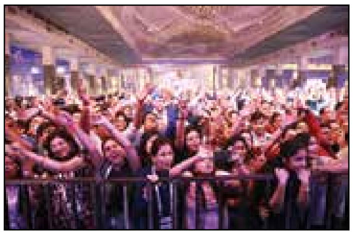



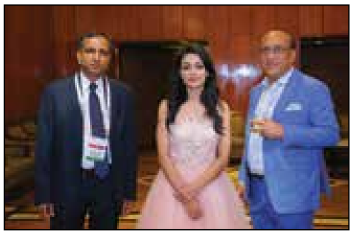











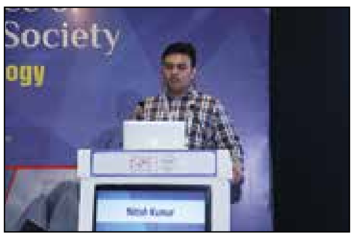

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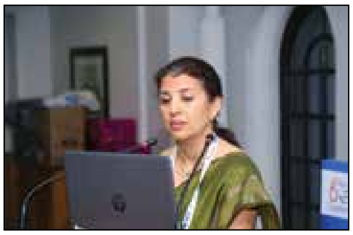






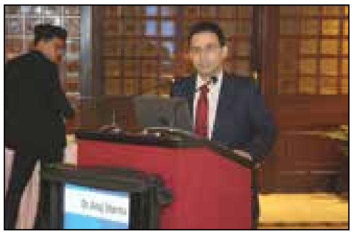












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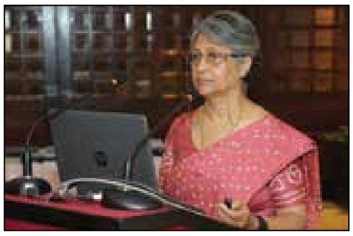






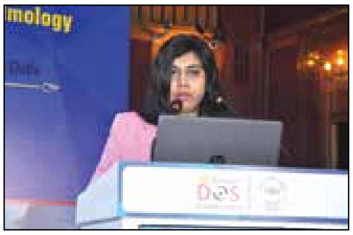




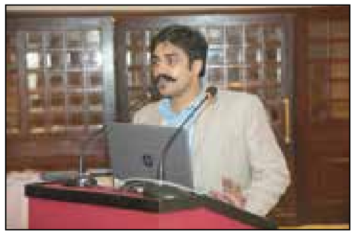











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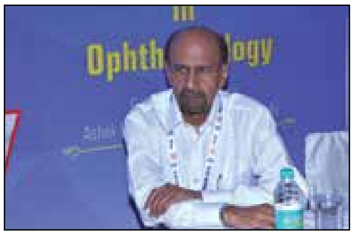















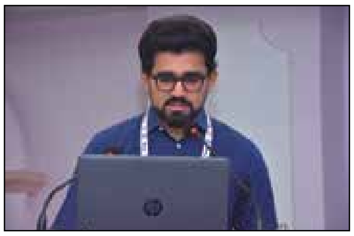



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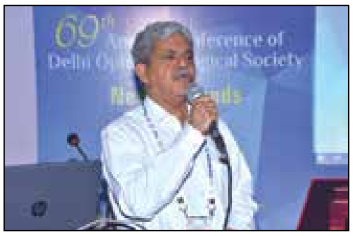








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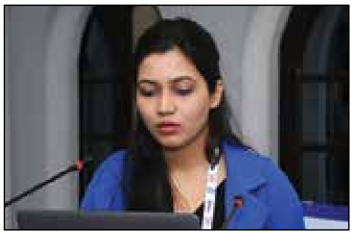








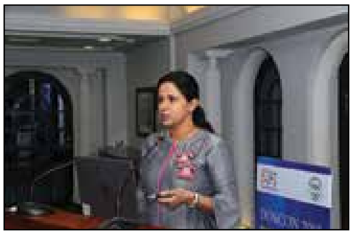

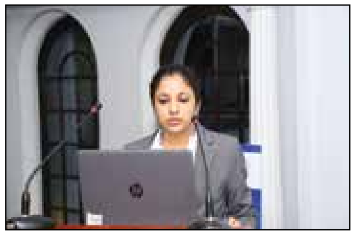











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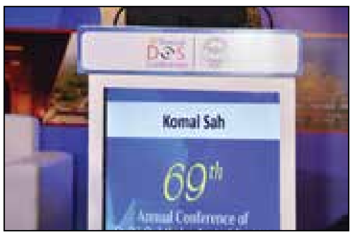



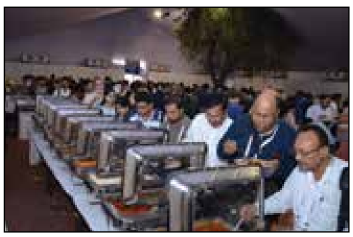

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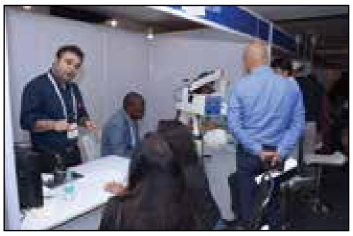









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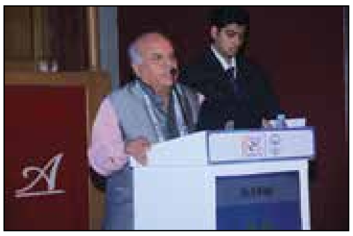










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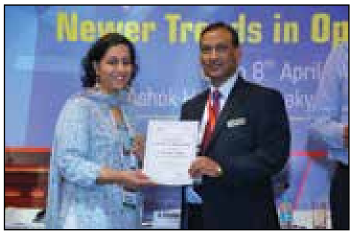












Blue Blocking IOLs

Dr. Yogita Gupta MD, **Dr. Chirakshi Dhull** MD, **Dr. Manish Mahabir** MD, **Prof. Sudarshan Khokhar** MD

Dr. Rajendra Prasad Centre for Ophthalmic Sciences, AIIMS, New Delhi, India

Abstract: *Intraocular lenses (IOLs) blocking the blue component of light were introduced in 1990s. Since studies demonstrated the increased risk of age-related macular degeneration (ARMD) and retinal damage after exposure to short wavelengths of light, their use was supported to prevent these wavelengths of light from reaching the retina. Since then, there have been great concerns on the effect of these blue-blocking IOLs on visual performance, color vision and circadian rhythm. The reported effects on scotopic vision and sleep pattern appear to be clinically irrelevant. They should be used only after careful evaluation of an individual's requirements.*

Keywords: *Blue-blocking, yellow IOLs, yellow-tinted IOLs, light blocking IOL, circadian rhythm.*

Large-scale epidemiological studies demonstrated the phototoxic effect of short-wavelength blue light on the retina[1,2,3]. The natural human lens turns yellow with age due to oxidation products of tryptophan and glycosylation of lens proteins. This is beneficial as, with the formation of cataract, the absorbance of blue spectrum of light increases by lens, thus protecting the retinal pigment epithelial (RPE) cells, laden with the lipofuscin fluorophore A2E from damage caused by the blue light. This may result in a reduction of the risk for development or progression of age-related macular degeneration (ARMD)[4]. However, after cataract surgery with the implantation of a clear intraocular lens (IOL), the retina is now exposed to short-wavelength light. Cataract extraction may, thus, accelerate ARMD[5].

Certain fish species possess occlusable yellow corneas and can vary the corneal colour in response to the level of illumination to regulate the amount of short-wavelength light reaching the retina[6]. It was further proposed that this phenomenon might also have a positive influence on visual quality by reducing longitudinal chromatic aberrations[7].

Yellow-tinted IOLs, which have a blue light–filtering chromophore, were introduced in the early 1990s[8] after convincing evidence emerged about damaging effects of short wavelength light on the retina[9]. The HUMAN cornea absorbs light with a wavelength below 295 nm and the crystalline lens absorbs light with a wavelength below 400 nm. Therefore, the human retina is normally protected from short-wavelength light. An ideal IOL should be similar to that of the adult crystalline lens.

ADVANTAGES OF BLUE-BLOCKING IOLS

Blue light-filtering IOLs show transmittance curves similar to that of a 53-year-old person's natural crystalline lens to help reduce the potential damage from blue light reaching the retina[10]. Acrysof SN60AT IOL model uses a proprietary, integrated polymer containing blue light filtering chromophore ImprUV and shows variable filtration from 200-550 nm ultraviolet (UV) and visible blue spectrum of light. Blue-light filtering IOLs have been found to be more protective against A2E-induced photochemical damage and inhibit more light-induced vascular endothelial growth factor (VEGF) production than a conventional UV-absorbing IOL. However, there is no definitive evidence that blue-blocking IOLs have any effect on ARMD. Also, better clarity and less postoperative photophobia and cyanopsia has been demonstrated with these IOLs[11].

CONCERNS ABOUT BLUE-BLOCKING IOLS

Henderson et al[12] reviewed the literature regarding blue-light filtering IOLs. It was concluded that there is no evidence to suggest any negative effects on visual acuity, contrast sensitivity or colour vision. However, despite the potential benefits of blue-light filtering IOLs there has been some suggestion that they can disrupt the circadian rhythm, cause problems with colour discrimination and negatively affect scotopic vision.

Effect on Scotopic Vision, Color Vision and Contrast Sensitivity

Blue light is responsible for 7% of photopic vision, but 35% of aphakic scotopic vision[13]. Hence, by blocking a significant portion of light used for scotopic vision, the blue blocking IOLs selectively decrease the ability to see in dark conditions. Mainster et al reported a 14-21% decrease in scotopic sensitivity by blue-blocking lenses when compared to a UV-only blocking lens[14]. A recent meta-analysis comparing the visual performance of these two IOLs showed no statistical differences in postoperative best corrected visual acuity, contrast sensitivity and overall color vision[15]. However, some compromise was noted with blue-filtering IOLs under mesopic light conditions. Despite initial concerns, there exists convincing body of evidence now that blue-blocking IOLs do not negatively affect contrast sensitivity and color perception[16–21]. In fact, they have been found to reduce glare and photophobia.

Effects on circadian rhythm

Photoreception plays important role in the regulation of circadian rhythm with external light-dark cycle. Photosensitive retinal ganglion cells in inner retina, through release of melanopsin, cause inhibition of melatonin release from pineal gland and, thus, increasing alertness and waking hours. This light-triggered melatonin suppression is sensitive to blue light and therefore short-wavelengths of light is important in maintaining sleep-wake cycle. A concern was raised about potential derangement of circadian rhythm predisposing to insomnia, depression and cognitive impairment with implantation of blue-blocking IOLs. However, Landers et al demonstrated in a survey-based study that there were no effects on sleep quality of patients implanted with blue-blocking IOLs as compared to conventional UV-blocking IOLs, indicating that these IOLs might serve as an alternative to conventional IOLs without detrimental effect on circadian rhythm[22].

Implications in Ophthalmic Investigations and Procedures

A lower transmittance ratio has been demonstrated when laser beam were passed through yellow-tinted IOLs. Thus, power of laser beam is often required to be raised while performing photocoagulation[23]. Other ophthalmic investigations like, retinal nerve fibre layer (RNFL) photography,[24] frequency doubling technology (FDT) perimetry,[25] short-wavelength automated perimetry,[26] show no differences in their interpretation after implantation of yellow tinted IOLs. Also, no significant reduction in visualization during vitreoretinal surgery has been noted with these IOLs[27].

SMART YELLOW IOL

The concerns of yellow-tinted IOLs affecting night vision led to the development of a photochromic IOL that turns yellow only on exposure to UV light. It has a UV-near blue absorption curve similar to SN60AT in photopic conditions, while it behaves like a clear lens in mesopic and scotopic conditions. It is a three piece lens with hydrophobic acrylic material optic with blue polyvinyliedene haptics with square optic edge.

VIOLET-LIGHT FILTERING INTRAOCULAR LENSES

Recent advancements have led to the availability of violet-light filtering IOLs. These filter wavelengths below 440 nm and therefore avoid potential effects on melanopsin, melatonin secretion and scotopic photosensitivity. Violet-light filtering IOLs attenuate wavelengths that are known to excite lipofuscin and therefore the formation of reactive oxidative species and free radicals should be reduced and phototoxic damage of the photoreceptors and RPE avoided. Thus, its use balances well between photoprotection and photoreception.

CONCLUSION

There exist a debate over use of blue-blocking IOLs. Though, the published literature prove no clinically harmful effects on visual performance or sleep habit, yet individual risks and benefits should be considered while recommending their use. There is also a great potential advantage of prevention of phototoxic effects of blue light with these IOLs. Though scientifically plausible, definite evidence is still required to prove their beneficial effect in ARMD.

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Pediatric Refractive Surgery Options and Perspectives: A Review

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Refractive surgery in children as been performed and reported in the medical literature for more than a decade now, with good functional outcomes[1,2,3,4,5]. Majority of adults undergo treatment for low to moderate myopia and astigmatism, and the most common intervention in this group is LASIK. In children with anisometropic amblyopia, the refractive error rarely falls into the "moderate" category but rather the -8.00 to -15.00 D range. It has also become an option of managing amblyopic children with higher refractive errors. However, it has been emphasized multiple times that refractive surgery is only appropriate for very specific circumstances in children. This type of surgery may improve the visual acuity, quality of vision and reduce refractive error.

Children having very high uncorrected refractive error develop suppression amblyopia (amblyopia ex anopsia) and lead a secluded life concentrating on near objects as they grow into adulthood. Spectacle correction and contact lenses may offer rehabilitation to such children, however severe degrees of unilateral anisometropia or bilateral ametropia may lead to aniseikonia and aberrations, potentiating amblyopia in such eyes. Amblyopic children on being unnecessarily pushed to lead isolated lives may develop components of depression and antisocial behaviour, with a lack of interest in their surroundings, which has been found to improve on proper refractive rehabilitation via laser refractive surgery[6]. Von Noorden in 1985 described a condition called idiopathic amblyopia, in which patients were not found to have any cause of visual deprivation, strabismus, media opacities or other organic cause which could have led to amblyopia[7]. An abnormality in binocular interaction also has been postulated to be responsible for such amblyopia. Studies have evaluated structural differences between amblyopic and non-amblyopic eyes in anisometropic children using Scheimpflug photography and found no significant difference in both anterior and posterior segments of the eyes[8]. However, Brunette et al in 2003 described how a disordered regression of higher order aberrations (HOA) in a growing eye (similar to disruption of emmetropisation) may be responsible for difference of HOA between the two eyes, thereby leading to HOA associated amblyopia[9]. It has been seen that wavefront-guided refractive surgery reduces HOA in adults. Hence, such a reduction is theoretically possible in children also, and may be another contributory factor towards managing amblyopia[10].

INDICATIONS

Conventional methods of treatment of amblyopia consist of:

a. Treatment of cause of visual deprivation by removing ocular media opacities, eg, corneal opacity, cataract, etc.
b. Full correction of refractive error with spectacles or contact lenses.
c. Occlusion therapy.
d. Pharmacologic/ optical penalisation.

However, these modalities may not suffice the requirement of certain groups of children as follows:

- Children with high ametropia along with neurobehavioral abnormalities who are

Non-compliant for spectacles usage

- Children with high degree of anisometropia who are noncompliant to spectacle and contact lens wear.
- Children with high ametropia with skeletal malformations like craniofacial anomalies, ear deformities, or neck hypotonia that prevent the use of refractive correction.
- Accommodative esotropia
- Refractory amblyopia

SURGICAL TECHNIQUES

Today refractive surgery offers us a myriad of options. The evolution of refractive surgery started with incisional surgeries like radial keratotomy and epikeratophakia which are now of historical importance. The boom in this industry came with the description of photorefractive keratotomy (PRK) in mid 1980s followed by Laser assisted in situ keratomileusis (LASIK) in 1990. Phakic intraocular lenses (IOLs) were approved by the USFDA in 2004. LASIK as of now is approved for myopia and hyperopia and astigmatism. Phakic IOLs are indicated for similar indications with a higher range of spherical equivalent correction. The choices of procedures in children would be discussed below.

Laser refractive surgeries

A PRK or Laser epithelial keratomileusis (LASEK) procedure has been commonly performed over the years and is preferred in children over LASIK. General anesthesia is required for such excimer laser procedures. A biometry examination is performed under anesthesia and the desired refractive correction is programmed into the excimer laser machine after which the procedure is performed. Postoperatively, topical antibiotic, steroid and NSAID is prescribed. Oral Vitamin C 500 mg once daily is also prescribed. Amblyopia therapy is continued in the postoperative period. Table 1 shows the results of multiple studies of laser refractive surgeries in anisometropic and ametropic amblyopic children. Most of

Table 1: Studies of laser refractive surgeries and their outcomes								
Year	Procedure	Indication	No of patients	Age (years)	Pre-op SE (D)	Post-op SE (D)	Pre-op VA	Pre-op VA
1999[11]	LASIK	Myopic anisometropia	14	7-12	-7.9	-0.6	20/50	20/25
2001[12]	PRK/LASIK	Myopic anisometropia	14	9-14	-8	-0.07	20/125	20/121
2002[13]	PRK	Bilateral myopia	10	1-6	-10.7	-1.4	20/70	NA
2002	PRK	Myopic anisometropia	27	1-6	-10.7	-1.4	20/70	20/40
2004[14]	LASIK	Myopic anisometropia	6	2-12	-10.2	-3	20/142	20/63
2004[15]	LASEK	Bilateral myopia	11	1-17	-8	-1.2	20/80	NA
2006[16]	LASEK	Bilateral myopia	9	3-16	-3.8 to -11.5	-1	20/133	20/60
2007[17]	LASIK	Myopic anisometropia	32	6-14	-10.1	-2.2	20/50	20/33
2007[18]	LASEK	Myopic anisometropia	298	0.8-19	-6 to -14.9	-0.6 to -3.3	20/30 to 20/400	20/30 to 20/400

them have reported an improvement in vision up to the best corrected visual acuity (BCVA) and a substantial number of studies reported improvement beyond previous BCVA, indicating a reversal of amblyopia. With LASIK surgery, the advantages are decreased healing time and increased comfort. However, in pediatric population PRK is preferred over LASIK. The reasons include a lower potential for flap-related complications of LASIK, greater biomechanical stability, and a thicker residual bed. Hence there are lesser chances of keratectasia in contrast to a large dose LASIK. Severe corneal haze in children have been reported rarely, and only with tapering of steroids. Steroids need to be used 6 months or longer. Topical mitomycin also promises good results like in adults. Another issue with laser procedures is regression over first 6 to 12 months, which although stabilises afterwards.

Phakic IOL

In the array of refractive surgery options, phakic IOLs are comfortably placed in between corneal refractive surgeries and refractive lens exchange. They have been used for patients with a much higher range of refractive errors than corneal surgeries without the associated risk of post-surgery corneal ectasia and post-PRK corneal haze[14]. There is lesser risk of complications associated with clear lens exchange like posterior capsular rupture, vitreous loss, retinal detachments, endophthalmitis, etc. A big advantage these phakic IOLs offer is the preservation of accommodation in children. LASIK/PRK is technically difficult in children and especially with LASIK, children would be at a risk of post-traumatic flap displacement. Both anterior chamber and posterior chamber phakic IOLs have been studied in children. Iris-fixated polymethyl methacrylate (PMMA) IOLs (Artisan) need to be inserted through a larger incision with corneal sutures to close the wound and the hooks used to fixate to the iris, but the Artisan model is available in foldable form to be inserted through a smaller incision. The advantage of anterior chamber phakic IOLs is that they are placed at an adequate distance from the crystalline lens and there is effectively very less chances of lens touch and cataract formation. Also, unlike angle supported anterior chamber IOLs, the lenses avoid angle crowding and glaucoma in the long term. However, there is a risk of accidental de-enclavation of the iris-hooked IOL due to mechanical trauma. Contrary to this, posterior chamber phakic IOLs are placed in the sulcus with a risk of future lens touch on possible reduction of IOL vault. Table 2 shows that both the types of PIOLs are effective options for rehabilitation of anisometropic and ametropic patients with and without amblyopia. Reports show that the visual acuities improved to pre-operative levels and there may have been gain in Snellen's lines of visual acuity. Apart from improving visual acuity, vision quality, stereopsis and quality of life also improved. Another long-term concern with all of these IOLs is endothelial cell loss keeping the long life expectancy and chances of eye rubbing. According to a study the rate of endothelial cell loss was 6.5% to 15.2% over 3-5 years[19]. Contraindication for phakic IOLs is a small anterior chamber depth, hence a proper case selection must be done before implantation. Phakic IOL surgery is reversible, unlike corneal procedures, and in situations like de-enclavations and increased endothelial cell loss a prompt IOL explantation can be planned. There is no fixed guideline regarding the range of refractive error for phakic IOL usage, but the studies have included children having errors ranging from -3D to -17D[24]. Till date the exact timing of phakic IOL implantation in anisometropic children is not clear with ages of implantation tried ranging from 3 years to 20 years in studies. However, it has become quite evident that earlier the surgery is done, better is the impact on amblyopia prevention.

Refractive Lens Exchange (RLE)/ cataract surgery and aphakic rehabilitation

A RLE may be required in ametropia of more than 20D and shallow anterior chamber depth precluding usage of phakic IOLs. Developmental cataract is another common indication for a lens aspiration. A pediatric lens aspiration combined with posterior capsulotomy and anterior vitrectomy are performed and a foldable acrylic IOL is implanted after performing biometry. The choice of the IOL depends largely on the surgeon and patient factors. Unanimously it can be said that pediatric aphakia is a very

Table 2: Outcomes of studies involving phakic IOLs in children				
Year	**Procedure**	**Indication**	**Number of patients**	**Remarks**
1999[20]	PC-PIOL	Anisometropic amblyopia	5	Gain of vision seen
2000[21]	PC-PIOL	Anisometropic amblyopia	3	Gain of vision seen
2002[22]	PC-PIOL	Anisometropic amblyopia	12	No gain of vision
2008[23]	AC-PIOL	Bilateral myopia	20	73% gain of vision
2010[24]	AC-PIOL	Anisometropic amblyopia	7	6 lines of Snellen's vision increase
2012[25]	AC-PIOL	Bilateral myopia	11	Gain of vision seen

PC-PIOL: Posterior chamber phakic IOL
AC-PIOL: Anterior chamber phakic IOL

difficult condition to treat as putting an IOL inside the eye is just the beginning of a life-long cooperation between the physician and the patient. After IOL implantation patients need to be followed for long term to observe for amblyopia and occlusion therapy to be started at the onset of signs of the same.

Post cataract surgery aphakics who have a preserved capsular bag can undergo a 'in-the-bag' intraocular lens implantation. Monofocal, bifocal and trifocal IOLs are available, with monofocals being the commonest in use. However, loss of accommodation in children is a big cost of cataract surgery, and multifocal IOLs are being looked at as viable options for amblyopes or children at higher risk of amblyopia post-RLE because of loss of accommodation. With the multifocal IOL design, the brain is presented with a sharp image along with other blurred images. The theoretical advantage with multifocal IOLs is the elimination of the need for bifocals, stimulation of good near, intermediate and distant vision, higher chances of developing binocularity and stereopsis, and reduced risk of developing amblyopia from accommodative excess. However, the early generation multifocal IOLs led to a significant number of complaints related to glare, halos, and loss of contrast sensitivity. The multifocal IOL requires precise biometry and excellent centration which must be carefully considered before considering a patient as a good candidate for multifocal IOL implantation. A young child might not be a good candidate as precise biometry and centration are difficult to achieve. Proponents of both schools are there and the debate gets stronger day by day as to whether multifocals are here to stay in pediatric refractive surgery or not.

Toric IOLs for tackling pre-existing astigmatism are also becoming popular both after clear lens surgeries and post cataract surgeries performed in children[26]. In a first of its kind study, Ram et al showed that single piece toric IOL may be an effective option of correcting corneal astigmatism in children 8 years and above undergoing cataract surgery[27]. Gwiazda et al have reported that most of the change in corneal astigmatism occurs from birth up to age of 2 years, after which astigmatism stabilises by age 6[28].

Angle-supported anterior chamber lenses and iris-enclavated lenses are commonly used options for rehabilitation[29]. Angle supported ACIOLs have been reported to be associated with corneal endothelial cell loss, peripheral anterior synechiae (PAS) formation and glaucoma due to chronic anterior chamber irritation and modern users may have become sceptical of its use in younger population[30].

Malbran et al first reported transscleral sulcus fixation of posterior chamber IOLs after intracapsular cataract extraction (ICCE) in aphakic eyes in 1986. There has also been a concern regarding SFIOL use in pediatric patients as the sclera is elastic and less rigid compared to adults. SFIOL haptics have to be buried under the conjunctiva or scleral flaps with polypropylene sutures. Although polypropylene (Prolene) is theoretically non-absorbable, there is a possibility of late decentration caused by deterioration of the sutures after several years, and this is of concern for the pediatric patient[31]. However compared to ACIOLs, SFIOL has enjoyed being a preferred option by many ophthalmologists across the world because of the lack of the angle and endothelial concerns.

Femtosecond laser assisted cataract surgery

A posterior capsulotomy of the right size is very important till at least 6 years of age for prevention of posterior capsular opacification. The pediatric capsules being highly elastic, anterior and posterior capsulorhexis are quite challenging to perform and frequently leads to oversizing or decentration. Hence, femtosecond laser offers an alternative with optimum circularity of capsulorhexis of adequate strength. In cases of children planned for toric or multifocal IOLs which need to be put inside the capsular bag and require the rhexis to be uniformly circular and centered on the pupillary axis, femtosecond may be a good option. However, the biggest disadvantage of this procedure in the young age group is the need for the femtosecond device to be removed everytime following rhexis, for surgery and a re-docking is required later for posterior capsulorhexis. Though there are divided opinions regarding manual versus femto rhexis, it can be said that only the future research holds the way to achieve the perfect rhexis in the pediatric ages.

Visual and quality of life improvement

A metaanalysis from 2011 showed that post refractive surgery, there was a significant gain in logMAR uncorrected visual acuity and best corrected visual acuity in the amblyopic eyes. Moreover, the change in best corrected visual acuity after surgery was significantly better if the age of the child treated was less. As regards the modality used, PRK had significant better outcomes than LASIK. The main complication reported was corneal haze, more in the PRK group[32]. A systemic review from 2014 has reported that with corneal procedures and phakic IOLs, the spherical equivalent of refractive error was fully corrected in all eyes, and there was no significant difference in final refraction in each group. Morever, more than 50% children have shown improved binocular fusion and stereopsis in all cases[33].

Challenges and risks

Pediatric refractive surgery has more dissimilarities than similarities to adult refractive surgery and the main differences between adult and pediatric surgery is the indication of performing the procedures. Most young children undergoing laser or intraocular refractive surgery require general anesthesia. Pediatric ophthalmologists advise that children should be treated in centers where pediatric anesthesia is regularly practised. In older children topical anesthesia may be used, however it requires a high level of cooperation from the patient's part. Decentration has been reported with laser procedures under general anesthesia, as fixation by the patient to ensure optical centre is not possible.

Corneal changes

A special concern for the cornea exists towards the development of haze, regression and keratectasia in pediatric patients. Also, pediatric eyes have a greater propensity toward the development of postoperative inflammation. The haze may be treated with use of steroids or mitomycin effectively.

Axial length change

Outcome of surgery performed in children depends on precise biometry performed during examination under anesthesia. However, in a growing eye these parameters hardly remain constant and these changes affect the long-term outcomes of early refractive surgery including change in axial length, change in lens thickness and overall growth of the eye. In the phakic IOL group, the position of the lens placed in the ciliary sulcus may shift over time.

Refractive shifts

In adults and children with very high refractive error, the desired postoperative refraction is plano. In cases of anisometropia, the goal is to match the refraction in the fellow eye. For growing children undergoing refractive surgery, the target refraction may be left slightly hyperopic, as the growing eye will overcome this much over the years and adjust for the axial length changes and other structural changes of the eye. No lower limit has been set for performing refractive surgery in refractive myopic patients, however it is preferable that the refraction has been stable for a year before considering for surgery. This will effectively eliminate all such high myopes, as myopia progression is seen even in the 30s.

Conclusion and Indian perspective

Pediatric refractive surgery may not become as universal as in adults as it targets only a specific segment of the pediatric population. However, it holds promise in patients who have failed conventional treatment modalities and is an effective option for reversal and treatment of amblyopia. In spite of a number of complications that may occur postoperatively, with improved technology and expertise of the operating surgeons, the outcomes of surgery have been good, with minimal complications. Lastly, they may help increase social functioning in amblyopes and in the developmentally challenged section of children, who cannot be effectively rehabilitated using spectacles and contact lenses. There have been no studies from India till date using refractive surgery in children. The major reason behind this is the huge cost behind refractive surgery which very few young Indian parents are able to afford. Moreover, there is a huge amount of heterogeneity regarding the choice of patients and the general acceptance to conventional amblyopia therapies is also low. Pediatric ophthalmological surgery as a whole is in an infant stage in the country and refractive surgery may play an additive role in the years to come with further development of surgical strategies to tackle the needs of a growing population of the world's largest democracy.

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Lenticular Subluxation

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Abstract: *Subluxated lens is a common entity seen across various age groups due to different causes ranging from hereditary systemic conditions to isolated ocular abnormality. This ocular feature along with systemic findings help in syndromic diagnosis and early referral for systemic management. The ocular management of these cases depends on multiple factors including the age of the patient, visual symptoms, severity of symptoms, improvement with refraction, progression of the disease and the degree of subluxation. Surgical management requires good surgical technique with fine control at each step. The endocapsular support devices have allowed phacoemusification in subluxated lens, centration of the capsular bag-IOL complex and prevent the post-operative capsular contraction. However, severely subluxated lenses may require lensectomy with anterior chamber intraocular lens (ACIOL) or scleral-fixated intraocular lens (SFIOL) implantation. The use of femtosecond laser in cases with subluxated lens have opened new areas for exploration but its use in pediatric cases is still distant.*

Keywords: *Subluxation, lenticular subluxation, Cionni, CTR, Marfan's syndrome.*

Subluxated lens is partial displacement or malposition of the natural crystalline lens from its normal position in the patellar fossa. Though subluxated lens and ectopia lentis are used interchangeably, it is preferable to use latter for lens subluxation due to hereditary causes. It signifies compromised zonular fibers and is caused by different congenital, developmental, metabolic or systemic disorders. Acquired subluxation may occur with trauma or intraocular surgery[1,2] (Table 1).

SYMPTOMS AND SIGNS

Subluxation of lens can occur at any age. Even congenital cases may manifest later in life due to progressive changes associated with the disease. Patient may present with decreased or fluctuating vision due to lenticular astigmatism or refractive error, monocular diplopia, impaired accommodation, photophobia or glare. Complications like pupillary block and angle closure may develop due to dislocation into the anterior chamber or pupil. These patients may present with pain, redness, watering, nausea, vomiting, blurred vision and colored haloes. Obvious signs include phacodonesis, vitreous prolapse, iridodonesis and lens subluxation. An undiagnosed subluxated lens may create problems during surgery especially for the beginners. Thus, it is important to detect subtle signs such as the visibility of lens equator during eccentric gaze, decentred nucleus in primary position, iridolenticular gap, changes in contour of lens periphery and focal iridodonesis. However, these subtle signs may still a missed. Few intraoperative signs such as radial folds when puncturing anterior capsule, excessive movement of lens during capsulorhexis and hydrodissection, difficulty in nuclear rotation, posterior displacement of lens on starting phacoemusification, vitreous prolapse or lucid interval between margin of lens and iris allows the detection of subluxated lens intraoperatively.

WORKUP

History: Appropriate history should include the onset and severity of visual symptoms, relevant trauma and treatment received. Due to association of many metabolic and systemic syndromes with ectopia lentis, it is crucial to assess the family history and perform complete physical examination to detect other associated anomalies.

Systemic evaluation: A detailed systemic examination of skeletal, cardiovascular, neurological, respiratory and genitourinary system helps us to identify the syndromic diagnosis and also allows early referral to pediatrician or physician to prevent morbidity and mortality due to disease. Cases of Marfan syndrome are diagnosed based on modified Ghent's criteria and have features such as increased arm span, arachnodactyly, high arched palate, aortic root dilation, mitral valve prolapse, etc.[3,4] Weill-Marchesani syndrome cases show features such as short stature, brachydactyly and joint stiffness[5]. Serum homocysteine level helps in diagnosing homocysteinemia and also assessment of the steps to be taken to prevent thrombophilia[6,7]. Genetic testing is done in cases where family history is present.

Ophthalmic examination: Visual acuity (both distant and near), an external ocular examination, a slit lamp examination, retinoscopic refraction (through phakic and aphakic areas), intraocular pressure and a dilated fundus examination must be done in all cases. The slit lamp examination must be performed under maximum mydriasis and attention given to following details:

- Direction of subluxation (tends to be superotemporal in Marfan syndrome and inferotemporal in homocystinuria).
- Number of clock hours involved.
- Status of zonules: stretched or absent (eg. stretched and elongated zonules are seen in Marfan syndrome while homocystinuria cases shows stretched zonules)[8] .
- Transparency of lens.
- Degree of phacodonesis.
- Presence or absence of any vitreous in anterior chamber.
- Presence of any lens coloboma.
- Examination for other signs of trauma (corneal/scleral injury, iris hole, iridodialysis, lens capsule integrity,

Table 1: Etiology of subluxated lens				
Isolated ocular abnormality	**Associated with systemic syndromes**	**Associated with metabolic syndromes**	**Associated with other ocular conditions**	**Other**
• Simple ectopia lens	• Marfan's Syndrome	• Homocystinuria	• Congenital aniridia	• Traumatic
• Simple Microspherophakia	• Weil Marchesani syndrome	• Hyperlysinemia	• Ectopia lentis et pupillae	• Surgical trauma
	• Ehler Danlos syndrome	• Sulfite oxidase deficiency	• High myopia	
	• Reiger's syndrome	• Lysyl hydroxyl deficiency	• Hypermature cataract	
	• Sturge Weber syndrome		• Pseudoexfoliation syndrome	
	• Pflander's syndrome		• Congenital glaucoma	
	• Crouzon's syndrome		• Buphthalmos	
	• Chondrodysplastic dwarfism		• Megalocornea	
	• Oxycephaly		• Staphyloma	
			• Perforation of large central and	
			• Uveal coloboma	
			• Cornea plana	
			• Uveitis	
			• Retinitis pigmentosa	

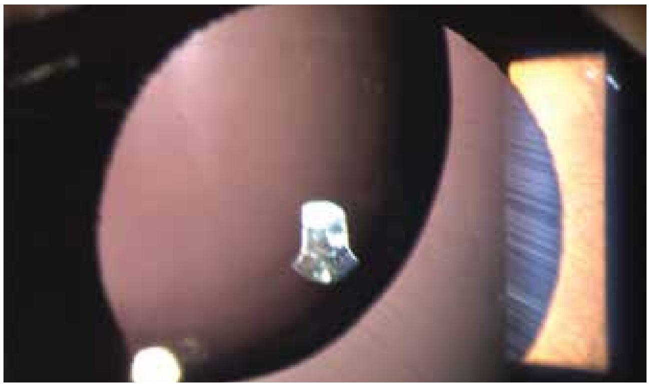

Figure 1: *Superonasal lenticular subluxation in the left eye of a patient showing stretched intact zonules with almost nine clock hours subluxation*

Figure 2: *Ultrasound biomicroscopy image showing stretched zonules and subluxated lens.*

capsular fibrosis), pseudoexfoliation syndrome (fleck like material on iris, angle, lens capsule).

- Gonioscopy for angle recession, fleck like material in angle.

INVESTIGATIONS

In case of non-visualisation of fundus, ultrasonography should be performed to assess the posterior segment status. Ultrasound biomicroscopy (UBM) can detect the area and extent of zonular dehiscence or stretching (Figure 2).

Further increased lenticular sphericity, ciliary body flattening and increased lens–ciliary body distance are indirect signs of zonular defects. Also, it allows the assessment of the lens in the supine position which is also the surgical position as subluxated lens is known to show variation with posture[9]. The endothelial count is documented as cases like pseudoexfoliation or aniridia may have preoperative low endothelial count and these surgeries are known to be difficult further lowering the endothelial count. With knowledge of these extra precautions can be taken to avoid the endothelial loss.

GRADING

The grading system would allow a consistent classification to be followed by various ophthalmologists and in different studies. A classification proposed based on the lens displacement in relation to the undilated pupil also allowed post-operative outcome prediction[10]. Using red field illumination, subluxated lens was graded as: grade 1- lens seen on the pupillary area, grade 2 - lens seen on 2/3 of the pupillary area, grade 3 - lens seen on 1/2 of the pupillary area or grade 4 - lens absent from the pupillary area. Another classification grades the degree of lens subluxation as: Minimal to mild - lens edge uncovers 0% to 25% of the dilated pupil, moderate - lens edge uncovers 25% to 50% of the dilated pupil or severe - lens edge uncovers greater than 50% of the pupil[11]. However, no classification is widely accepted for grading of subluxated lens.

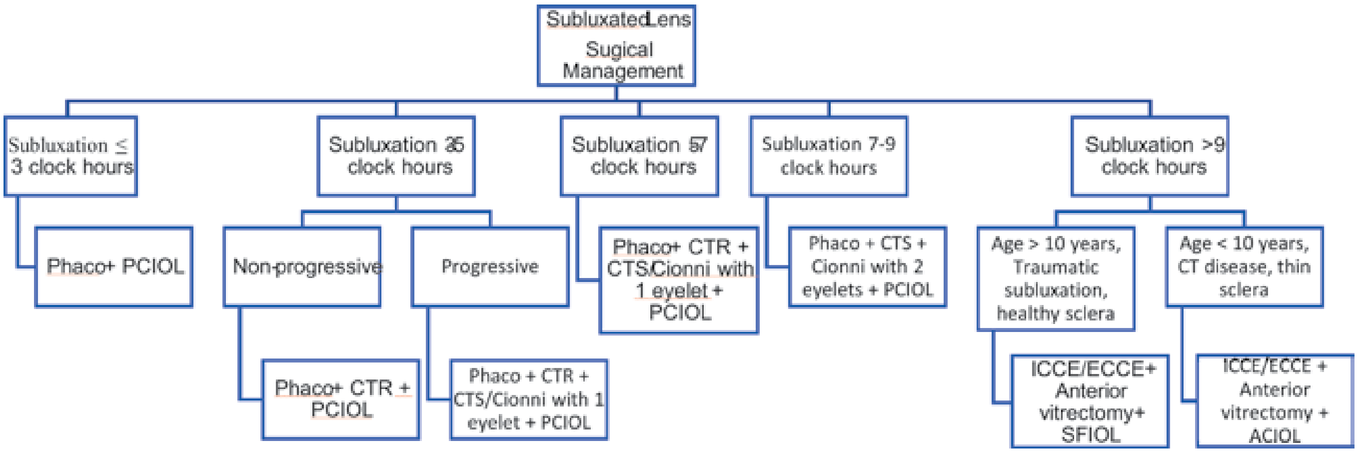

Figure 3: *Surgical management in subluxated lens.*

MANAGEMENT

Conservative management

The management of subluxated lens depends on multiple factors including age of the patient, uncorrected and best corrected visual acuity, correction of refractive error achieved, visual discomfort to the patient and the degree of lens subluxation. Optimal correction of refractive error with glasses or contact lens should be the first line of management[12]. In mildly subluxated lens with lens in the pupillary axis or markedly subluxated lens with clear pupillary axis, patient may benefit with phakic or aphakic refractive correction respectively. Other conservative methods like minimising diplopia with the use of miotics or enlarging the phakic zone with use of mydriatics are rarely used nowadays.

Surgical Treatment

Surgery is indicated in following conditions:

- Significant refractive error in older children and adults, not corrected by conventional means like glasses or contact lens or patient unable to wear glasses and contact lens intolerant.
- Significant risk of amblyopia or amblyopia progression in younger children where no improvement is observed with optimal refractive correction and patching.
- Significant diplopia caused by subluxated lens bisecting the pupillary axis.
- Significant progressive subluxation of lens or lens threatening to dislocate anterior or posteriorly.
- Significant cataract and angle closure glaucoma.
- Secondary glaucoma related to lens subluxation.

Route of surgery

The route of lensectomy depends upon the comfort of the surgeon and case requirement. Anterior route can be used when limited anterior vitrectomy is planned along with IOL implantation. Pars plana route can be used for more extensive vitrectomy especially when IOL implantation is not to be done, or in cases with severe lens subluxation posteriorly into the vitreous cavity in the supine position[13].

Surgical techniques

Cataract surgery in subluxated lenses requires good technique. The type of surgery and the requirement of use of endocapsular support devices depends on the nature of disease and degree of subluxation (Figure 3). General anesthesia for children and peribulbar block for adults is required for surgery. It is safer to make incision opposite to the direction of subluxation as it allows for counteraction against the strongest zonular area and prevent any sudden loss of viscoelastic to cause vitreous prolapse in the wound area. Vitreous in the anterior chamber is first taken care of by limited vitrectomy. The vitreous can be identified by triamcinolone acetonide use[14]. However, care should be taken to avoid its excessive use. The exposed posterior hyaloid phase can be covered with dispersive ophthalmic viscosurgical device (OVD) which prevents further vitreous prolapse and avoids posterior migration of the lens fragments. The anterior chamber should be maintained with OVD repeatedly during the entire surgery. The loss of OVD during surgery can cause progressive shallowing of the anterior chamber and increased lens movement which can complicate the surgery.

Capsulorhexis is a crucial step to allow phacoemulsification and bag preservation during surgery. The zonular compromise and elasticity present challenges to create a continuous circular centred capsulorhexis. The capsulorhexis must be centred on the crystalline lens and not on the pupil or corneal apex. Also, 2 mm edge must be maintained between the capsulorhexis edge and the equator. Staining with few drops of trypan blue dye across the anterior capsule in an OVD-filled anterior chamber prevents minimal entry of dye in the vitreous to cause red reflex loss. A standard cystitome, a microvitreoretinal blade or a straight 25-gauge needle can be used to penetrate the capsule. Vitreoretinal forceps can be used to complete capsulorhexis and allows entry through a smaller wound with decrease risk of loss of OVD from the anterior chamber as compared to capsulorhexis forceps. To support the bag, flexible iris retractors can be used to hook the capsulorhexis edge after capsulorhexis is made. Capsule hooks on contrary support the bag at its equator keeping it distended.

Hydrodissection and viscodissection are important steps as when inadequately performed they can create excessive stress on the zonule during phacoemulsification and cortical aspiration. Soft lens in younger children allows for aspiration of lens matter with irrigation/aspiration (I/A) handpieces or a cannula. A modified technique of endocapsular lens aspiration by the limbal route in severely subluxated lens has been recently described[15,16] (Figure 4). Phacoemulsification is performed cautiously with lower aspiration and flow parameters to reduce the turbulence and maintain greater control over fragmentation of the lens[17]. Direct phaco-chop is the preferred technique

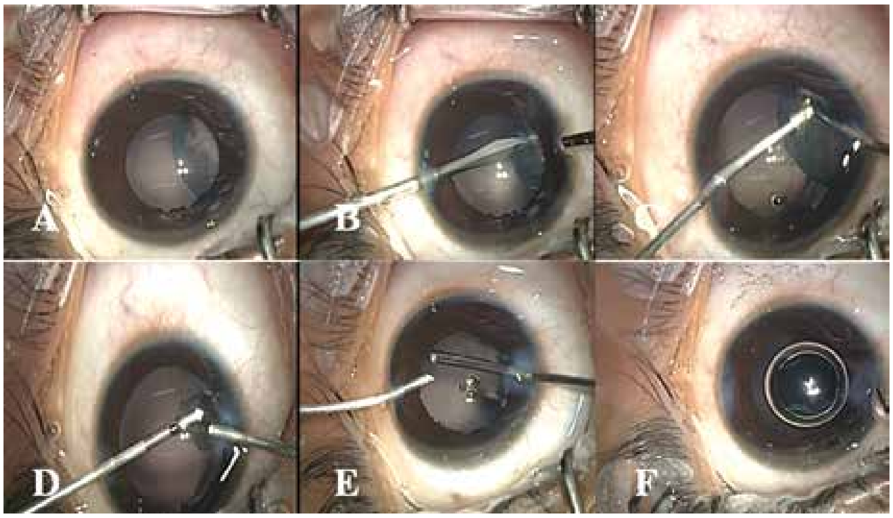

Figure 4: *Intalenticular aspiration done in a severely subluxated lens in a 8 month old child.* ***A:*** *Severe temporal subluxation of lens in the right eye (8 clock hours);* ***B:*** *mivcrovitreoretinal (MVR) blade used to create initial puncture in anterior capsule;* ***C:*** *Intralenticular apsiration of lens matter;* ***D:*** *Aspiration of capsular bag;* ***E:*** *Anterior vitrectomy; F: closure of wound with air bubble in anterior chamber, patient left aphakic.*

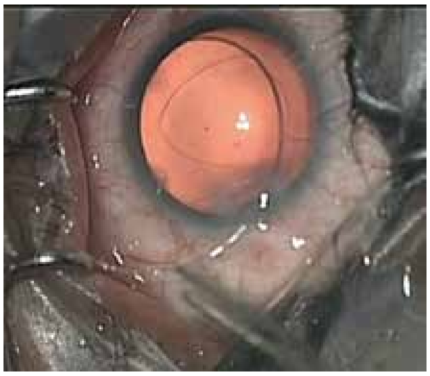

Figure 5: *Capsular tension ring (CTR) being inserted in the capsular bag in a case of mild lens subluxation.*

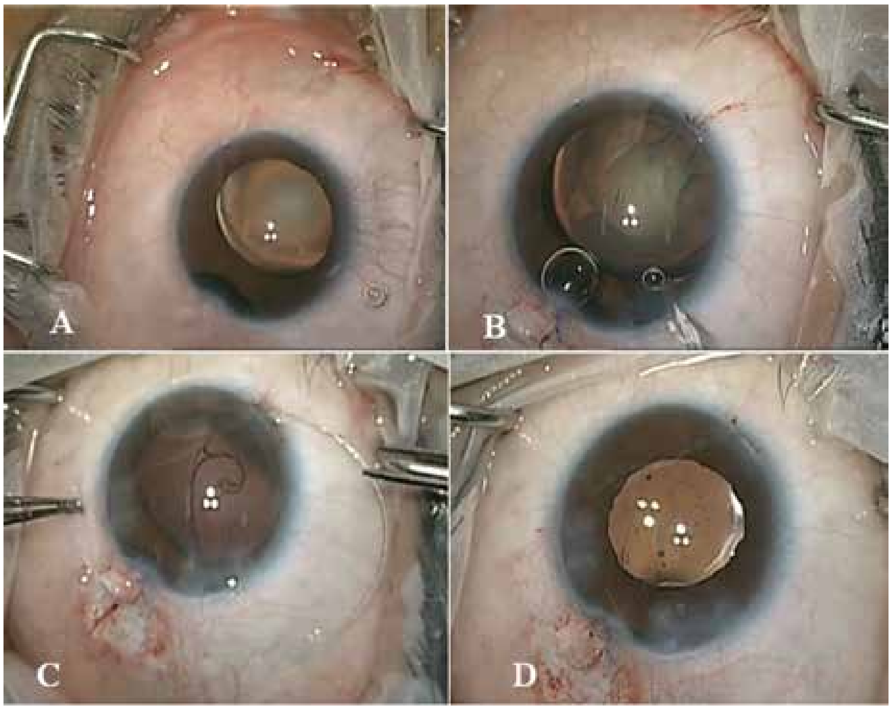

Figure 6 – A: *Post traumatic subluxated lens with iridodialysis.* ***B:*** *A continuous circular capsulorhexis centred at lens.* ***C:*** *Cionni ring with single eyelet being placed in the capsular bag after phacoemulsification and cortical matter removal. The scleral flap made for suture placement is also seen.* ***D:*** *A centred intraocular lens with Cionni and repaired iridodialysis is seen.*

as it decreases stress on the zonules and capsule. Minimum movements should be performed in the bag to avoid undue traction on zonules. Cortical aspiration can be done by an automated coaxial device or bimanual aspiration. Stripping of the fibers centripetally maximises the tension on zonules and thus avoided.

ENDOCAPSULAR SUPPORT DEVICES

The endocapsular support devices like capsular tension ring (CTR), Ahmed capsular tension segments (CTS) or Cionni are helpful in improving intraoperative safety and providing long-term stability of the IOL-capsule system. It also prevents post-operative capsular contraction and subsequent IOL decentration[18–20]. A CTR is a PMMA open ring device with blunt tipped eyelets at ends and can be inserted during any step of the surgery following capsulorrhexis (Figure 5).

By creating an equally distributed centrifugal force to the equator of the bag, the CTR recruits tension from stronger zonules to support the areas of weak or absent zonules. This stabilises the entire IOL-capsule complex in mild subluxated cases but difficult to achieve recentration in severe cases[21]. In these situations, a Cionni or a CTS provides a stable long-term solution through scleral-fixation[22] (Figure 6).

A CTS is a partial PMMA ring segment of 120-degree arc with an anteriorly positioned fixation eyelet. Also, cases with a progressive pathology, zonular problems are expected to worsen over time and thus CTR/CTS/Cionni should be placed in these patients even if subluxation is mild. Presence of anterior or posterior capsular tear is considered as a contraindication to the use of CTR as the centrifugal force generated by the ring may cause an extension of the tear with risk of loss of the CTR to the posterior segment. A CTS can be possibly used in such cases with discontinuous rhexis, anterior or posterior capsular tear as it does not create a 360 degree expansile force. The size of the CTR selected depends on the capsular bag dimension which correlates with the axial length and corneal diameter. Thus, horizontal white to white and axial length are used as a guide to select the size[23]. Also, the time of placement has been debatable and depends on the capsular stability, device preferred and choice of surgeon. Early placement provides capsular stability but may cause increased manipulations and zonular stress compared with placement after cataract removal[24–27].

Intraocular lens (IOL)

In cases with an intact posterior capsule, a single piece IOL is implanted in the bag. However in cases with inadequate capsular support, ACIOL or SFIOL can be opted for[28–30]. Scleral suture-fixated IOLs and glued IOLs are being used in cases with subluxated lenses especially in individuals > 10 years, those with healthy sclera, absence of connective tissue disorders and normal anterior chamber angle[31,32]. Multifocal and toric IOL have been used in some cases but due to requirement of appropriate centration and alignment, they are not preferred in cases of subluxated lens[33].

Femtosecond laser in subluxated lens

Recently femtosecond lasers have been tried successfully in subluxated lens but are limited to cases where the lens is not excessively tilted, pupil is fully dilated or do not have a severe subluxation with increased mobility of lens. The gas bubbles created in and around nucleus during nuclear fragmentation facilitates gentle nuclear rotation with little or no hydrodissection[34,35]. However, use of this technique in pediatric age group is limited by the need to shift the patient to femtosecond laser suite and requirement of associated general anesthesia facilities.

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Intraocular Lens Power Calculations

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Abstract: *The postoperative refractive outcomes of modern day cataract surgery depend to a large extent on choosing the correct intraocular lens (IOL) power and the accuracy of ocular biometry performed. Optical biometry is the current standard in IOL power calculations. With the introduction of partial coherence interferometry based biometry, measurements have become more precise. Optical biometry might replace the ultrasonic methods in near future. This article provides an overview of methods and various formulae used for calculating a precise IOL power.*

Cataract surgery is the most common surgery performed in ophthalmology. There have been major advances in this area which have led to cataract surgery being a refractive surgery now days. For accurate post operative results and minimum residual refractive errors, it is imperative that power of the Intra ocular lens (IOL) to be calculated with utmost precaution and for that the biometry plays the most important role. So, the aim is to achieve the benchmark criteria with proposed targets of post operative residual refraction within +0.5D in > 55% cataract surgeries and within +1D in > 85% cases[1]. But with improved methods of biometry more than 90% surgeries in patients with no other ocular pathology or prior refractive surgery achieve a post operative refraction within 1D.

BIOMETRY

It refers to the mathematics applied to the biology. In ocular perspective it refers to the measurement of axial length, keratometry and other ocular parameters. Optical biometry using either partial coherence interferometry (PCI) or optical low coherence reflectometry (OLCR) has now become the gold standard in IOL power calculation and gives accurate results with good predictability.

Maximum errors in IOL power calculation are due to axial length (54%), followed by ACD (38%) and lastly by keratometry (8%)[2].

AXIAL LENGTH

Accurate measurement of axial length is very important as minor errors may also lead to large differences in IOL power calculated. A 1-mm error in AL measurement results in an error of approximately 2.35 D in IOL power in an average eye of 23.5 mm and may translate to an error of 3.75D in a 20 mm eye and much more in the very short eye[3].

Axial length can be calculated using ultrasound method (applanation or immersion) or optical method using laser interferometry.

Ultrasound method has largely been replaced by optical method as the latter is user independent, non contact, takes measurement from the fixation point (especially helpful in cases of staphyloma), fast, accurate and predictable. The disadvantages are that it cannot be taken in eyes with total cataract, dense PSC, nystagmus, corneal opacity, paediatric age group and in patients not fixing. But these cases are only 10% of the population presenting in ophthalmology OPD.

Second best method to determine axial length is the immersion A-scan method in which a scleral cup filled with normal saline is used to measure the axial length. It is a user dependent method but has an advantage over the contact method in that the probe doesn't touch the cornea. Thus, there is no indentation of the cornea which prevents reduced axial length measurement. For all practical purposes axial length measured using immersion A-scan is as accurate as optical biometry.

Good A scan graph is characterized by- tall single echo from cornea, tall echoes from anterior capsule and posterior capsule, tall echo from retinal layer with no staircasing and there should be no intervening spikes from aqueous and vitreous chamber. Mean of 8-10 readings should be taken to give the most accurate value. Care should be taken not to indent the cornea. Lastly, if the difference between the two eyes is more than 0.3mm, the measurement should be repeated. Also A scan having the largest ACD should be taken.

KERATOMETRY

Keratometry is yet another measurement that is necessary to the IOL formulas. It depends on the steepness of the cornea. Generally radii of the anterior corneal surfaces are measured and translated into the corneal power using manual (now obsolete) or automated keratometers. Modern topographers using scheimpflug principle, slit imaging technique or the optical coherence tomography, can give you the posterior corneal curvature as well, thus, giving you the net vertex power. But Shammas[4] and Lam[5] has showed in their published studies that keratometry using scheimpflug imaging may not improve the IOL power prediction to a great extent and that the results using automated keratometers were comparable.

Also, the optical biometers (IOL master, Lens star) can measure keratometry along with the axial length and hence preventing the unnecessary hassle of a separate machine.

In cases of irregular corneas or variability of multiple readings video keratography (VKG) can be done and that can be taken as a final value.

Comparison between IOL master (Figure 1) and Lens star (Figure 2)		
	IOL master	**Lens star**
1)	Introduced earlier	later
2)	Zeiss	Haag streit
3)	Uses partial coherence interferometry (PCI)	Uses optical low coherence reflectometry (OLCR)
4)	Uses multi modal light emission diode laser	Uses super luminescent diode laser
5)	Uses a laser of wavelength 780 nm	820nm
6)	Easier and takes lesser time	Takes longer time
7)	Does not measure central corneal thickness CCT and lens thickness (LT)	Measures central corneal thickness CCT and lens thickness (LT)
8)	AL measurement range 14-40mm	14-32mm

Figure 1: *IOL Master*

Figure 2: *Lens Star*

As can be seen from above comparison that central corneal thickness (CCT) and lens thickness (LT) can be measured in Lens star. Thus newer formulas like Olsen's formula, Barret's formula and Holladay 2 can be used in Lens star machine and not in the IOL master.

IOL POWER CALCULATION

In early days regression formulas were popular. But with advancement in cataract surgery, better understanding of the subject and better techniques of biometry, it has been found that the regression formulas work well in the average axial length group (22-24.5 mm) with greater prediction errors in other groups. Thus, the third and the fourth generation formulas (theoretical formulas) came into being (Table 1). These formulas have the advantage that they try and predict the effective lens position of the IOL, hence increasing the accuracy of IOL power prediction. General guideline for the formula use (Table 2).

Recently, in a database study of 8,108 eyes undergoing cataract surgery, the Hoffer Q formula was found to provide the best refractive outcomes in eyes shorter than 21.00 mm and the Holladay 1 and Hoffer Q formulas were equally reliable for eyes with an AL between 21.00 mm and 21.49 mm. This same study also concluded that the Holladay 1 formula may perform marginally better for eyes between 23.50 mm and 25.99 mm, although the Hoffer Q, Holladay I and SRK-T formulas gave comparable refractive outcomes. Finally, these authors found that the SRK/T formula performed significantly better for eyes with an AL of 27.00 mm or longer[14].

Table 1: Various generations of IOL formulae		
Generation	**Formula**	**Features**
First	SRK[6]	P= A-2.5(Axial length)-0.9(mean of keratometry)
Second	SRK II[7]	Above with correction. AL<20mm-> +3 add to the A constant, 20.00-20.99mm-> +2 add, 21.00-21.99mm-> +1 add and -0.50 add if the axial length is more than 24.5mm
Third	SRK/T[8]	Al, Km and IOL constant
	Hoffer Q[9]	Al, Km and IOL constant(pACD)
	Holladay I[10]	Al, Km and IOL constant(surgeon's factor)
Fourth	Hagis[11]	Al, Km, Preop ACD and 3 IOL constants(a0, a1, a2)
	Holladay II[12]	Al, Km, Preop ACD, pre operative refraction, lens thickness, age, WTW and one IOL constant
	Barret's	Uses a theoretical model eye in which anterior chamber depth (ACD) is related to axial length (AL) and keratometry. A relationship between the A-constant and a "lens factor" is also used to determine ACD. It is available online for calculation of IOL power.
	Olsen[13]	Al, Km, Preop ACD, pre operative refraction, lens thickness and one IOL constant

There are number of reports describing MAE (mean absolute error) using different formulas. It has been established beyond doubt that Hoffer Q is the most accurate formula in eyes with AL less than 22mm[15]. Hagis formula is more accurate than Hoffer Q in these eyes if the ACD is less than 2.40mm[16].

For the medium length eyes, all the formulas had comparable results.

For medium long axial lengths (24.5-26mm) Holladay 1 has better prediction accuracy than other formulas.

In long axial length eyes (>26mm) SRK/T has better prediction accuracy.

Many studies have shown that Barrett II formula may outperform other IOL formulas in highly myopic eyes[17].

Olsen formula may have been shown to perform better across the axial length spectrum if OLCR measurements were used. But if PCI measurements were used, it failed to perform as the latter does not measure lens thickness.

Holladay 2 is theoretically the most accurate formula. It is the only formula

Table 2: General guidelines for the use of formulae	
<22mm	**Hoffer Q**
<22mm(ACD<2.40mm)	Hagis
22-24.5mm	Holladay1, SRK/T, Hagis, Hoffer Q
24.5-26mm	Holladay 1
>26mm(<6D)	SRK/T, Hagis
>26mm(>6D)	Barret's formula, SRK/T

that uses pre operative refraction in its calculation. But number of studies have shown that its prediction accuracy improves when the pre operative refraction is excluded from the calculation.

EFFECTIVE LENS POSITION

Accuracy of axial length and keratometry measurement has been widely demonstrated. But one thing that can't be predicted certainly is the final position of the IOL where it is going to settle down. So, considering IOL to be very thin ELP is the distance between the anterior corneal plane and the plane of IOL. Third and fourth generation formulas try to predict the ELP using constants, ACD, Lens thickness etc. Thus, they have more accurate IOL power prediction. As ELP depends on many factors, personalized optimization of constants can be done according to the surgeon to give more predicatble results.

PERSONALIZED OPTIMIZATION OF IOL CONSTANTS

The term IOL constant is a misnomer and refers to systematic errors arising from the entire clinical environment, including those arising from the biometry measurement devices (and combinations thereof), patient population, and surgical technique. Constant optimisation is the process by which the IOL constant is adjusted to minimise the systematic errors listed above, as indicated by a ME of zero.

The IOL constant is typically provided for contact ultrasound biometry. But recently, developers have started providing constants for immersion and optical biometry as well. If IOL constant for contact biometry is used with other methods, it will result in more hyperopic outcomes as contact biometry gives smaller axial lengths due to indentation.

If an IOL constant specific for immersion or optical biometry is not available, then a suitable value may be listed at the User group for Laser Interference Biometry (ULIB). But caution needs to be exercised as different populations may need different IOL constants.

IOL constant optimisation has been shown to improve substantially prediction accuracy for contact ultrasound (from 79.7 to 82.5% within ±1D), immersion ultrasound (from 60% to 65% within ±0.5 D)[18], and with optical biometry.

IOL constant optimisation may be performed by entering refractive outcome data into the IOL master, or by using one of the online services provided by Dr Haigis or Dr Hill. Haigis recommends using data from more than 50 eyes, and Hill more than 200. Aristodemou et al evaluated the clinical significance of different degrees of error in the IOL constant and estimated that a minimum of 86 eyes is required to optimise the pACD for the Hoffer Q formula and around 250 for the SRK/T A constant and Holladay 1 Surgeon Factor.

All eyes included for optimisation should have a stable refractive error and best-corrected visual acuity of 6/12 or better, and as wide a range of axial length as possible, and preferably all eyes should have been measured using the same devices for keratometry and axial length.

Studies have shown that surgeon variations need not be used for IOL constant optimization. But if the variations are too much between surgeons, then personalized constants may be developed according to the data of their patients.

IOL POWER CALCULATION POST REFRACTIVE SURGERY

Refractive surgery alters the relation between anterior and posterior corneal curvature. Corneal Refractive surgeries alter the basic assumptions on which the biometry for IOL calculations is based – namely the perfectly spherical nature of cornea. The refractive surgeries mainly affect the central cornea, as well as alter the posterior corneal curvature, which is not routinely measured. Instrument errors occur due to the inability of keratometers to measure the central zone of effective corneal power. Flatter the cornea, greater the measurement zone hence greater the error.

Methods to measure IOL post-Refractive surgery can be divided as "Indirect" or "Direct" based on the measurement of the corneal power after surgery (direct involves actual measurement, while indirect makes assumptions based on historical data or theoretical analysis.)

Indirect- they are so named as they use other information apart from keratometric power.

1) Clinical history method or calculation method
2) Contact lens (CL) over-refraction
3) Vertexed IOL power
4) Intraoperative autorefraction measurement
5) DBR method

Direct-it directly uses post refractive keratometric power or other methods to predict ELP.

1) Modern theoretical formulae with modifications (Hagis, Holladay), Gaussian optics and regression formulae.
2) Aramberri "double K"
3) Topographical methods
4) Camellin and colossi method
5) Rosa method
6) Direct measurements

Clinical history method or calculation method is the most accurate among these. It uses pre operative keratometry, pre operative refraction and stabilized post refractive surgery refraction. As the pre operative data is accurate upto +/- 0.25D, more predictable results can be obtained[19].

Although many methods have been described, IOL power calculation after refractive surgery is still in its nascent stages and much understanding is yet to be obtained.

INTRAOPERATIVE ABERROMETRY

Intraoperative refractive biometry (IRB) using Talbot-Moiré wavefront aberrometry is based on the idea first put forward by Ianchulev et al[20] in 2005 using hand held auto retinoscopy. In this method IOL power is measured intra operatively with eye being in the aphakic mode (Figure 3). Cataract is removed, and anterior chamber is filled with viscoelastic. Adequate intra ocular pressure is needed for the accurate measurement. Eye tracker is provided so that the biometry measures the

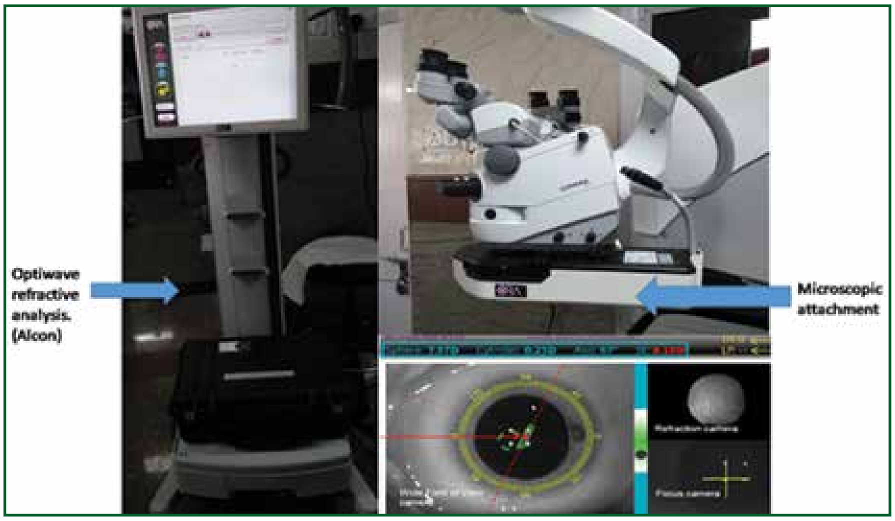

Figure 3: *Intraoperative aberrometry with optiwave refractive analysis (ORA) system*

functional axial length and provides better results. The aphakic refraction is an optical measurement obtained directly from the infrared laser reflection off the retina. Instead of relying on the estimated corneal power, it therefore automatically accounts for the refractive state of the entire optical media, including the aqueous and vitreous. Second, the IOL power calculation relies more on refractive optical biometry and much less on the corneal power as extrapolated from K. IOL power is calculated using the vergence formula.

Studies have reported better predictability of IOL power using IRB. It is especially useful in cases with previously operated refractive surgery where the conventional methods of IOL power calculation have reported only 55-60% of the eyes coming within +/-0.5D of target refraction post operatively. Using IRB the figure goes up to 70% achieving the same[21].

Optiwave refractive analysis (ORA, Alcon) is a device which provides with intraoperative biometry and IOL power. It also assists the surgeon in implantation of Toric IOLs. It prompts the amount of rotation that is to be done for accurate cylindrical correction.

Although, it seems to be a lucrative option for IOL power estimation, it has its own fallacies. The patient is in supine position which may lead to myopic shift and cyclotorsion, eye is not in the physiological condition with deep AC, hydrated vitreous, corneal wounds, aphakia and lastly hydration of wounds may change the corneal curvature and hence the IOL power.

So, better formulas incorporating IRB are needed for improved prediction accuracy.

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Recent Trends in Refractive Investigations

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Summary: *Refractive surgery is ever evolving. Novel surgical techniques led to the emergence of more sophisticated corneal imaging devices. A good refractive outcome in cataract and refractive surgery relies on accurate and precise understanding of corneal topography and tomography. The current discussion details the various corneal imaging modalities for refractive surgery and their recent advances.*

Corneal topography is the study of the anterior surface of the cornea while tomography is the study of the entire cross-section of the cornea, the anterior and the posterior corneal surfaces and its pachymetry[1].

These devices in general appear to comprise of three main parts:

- A projection device
- An acquisition device
- An analytical device that is a computer with various software and normative database to analyze the data that is obtained.

CLASSIFICATION

Corneal topography can be based on

- Placido disc images;
- Corneal elevation;
- Optical coherence tomography based corneal data;
- Combined corneal topography and wavefront sensing Placido based systems;
- Reflection based: Keratometer;
- Projection based: Photokeratoscope, Videokeratoscope.

In the keratometer, an object is projected onto a central corneal zone of known diameter and distance from the light source and a virtual upright image is produced. The relationship between the image and object size is used to estimate the radius of curvature along a particular meridian.

Drawbacks with the keratometer are

- Only four data points are generated.
- It is not very useful for irregular surfaces or corneas.

Projection based devices include photokeratoscope and computerized videokeratoscopes[2]. The reflective mires appear closer together on steeper parts of the cornea and farther apart in flatter areas. These devices can measure much larger areas than the keratometer and use axial, tangential or refractive power maps to calculate radius of curvature. Currently available videokeratoscopes include Eye MapEH -290 (Alcon), EMS (Zeiss) and Keraton videokeratoscope (Optikon).

Drawbacks with Placido devices are

- Inability to acquire data points within the central 2 mm of the cornea.
- Difficulty in imaging objects with sudden slope transitions, alignment, focusing or centration errors.

Currently available devices utilizing placido disk technology include.

- Atlas 9000 Corneal Topographer.
- Tomey TMS Corneal Topographer.
- Magellan Mapper.
- EyeSys 3000 and EyeSys Vista.
- Galilea Dual Scheimpflug Analyzer.
- Oculus Keratograph.
- Wavelight Topolyzer and Topolyzer Vario.

Corneal tomography can be based on one of the various principle, as follows:[3]

Scanning slit system

- Orbscan.
- Orbscan II and IIz Anterior Segment Analysis System. Orbscan is the prototype of this system[4]. It uses the projection of a slit of light at various positions on the vertical meridian on the cornea and takes images at pre-specified positions with a video camera. The entire cornea is covered with 40 vertical slits, 20 on each side normal to the surface at each position of acquisition within 1.5 seconds. Each of the slits has 240 data points and the curvature at these positions is calculated using triangulation.
- Orbscan II incorporates a Placido-disk and has the benefits of both Placido-disc and slit scanning approaches of corneal topography. It measures 9000 data points per scan in 1.5 seconds.
- The latest upgrade is the Orbscan IIz (Figure 1) which is equipped with a Shack-Hartmann aberrometer on Zyoptix workstation[5].

Scheimpflug technology

In this technology, a higher depth of focus is achieved by placing the subject plane, lens plane and the image plane in such a way that they intersect each other (Figure 2).

- Pentacam and Pentacam HR (Oculus).
- Galilei Dual Scheimpflug Analyzer (includes placido disk topography).
- Sirius (Tomey corp).
- Wave Light Oculyzer and Oculyzer II.
- Preciso (CSO).

PENTACAM

The Pentacam system (Oculus) uses a rotating Scheimpflug camera and a monochromatic slit-light source, blue light-

Figure 1: Orbscan II z topographer

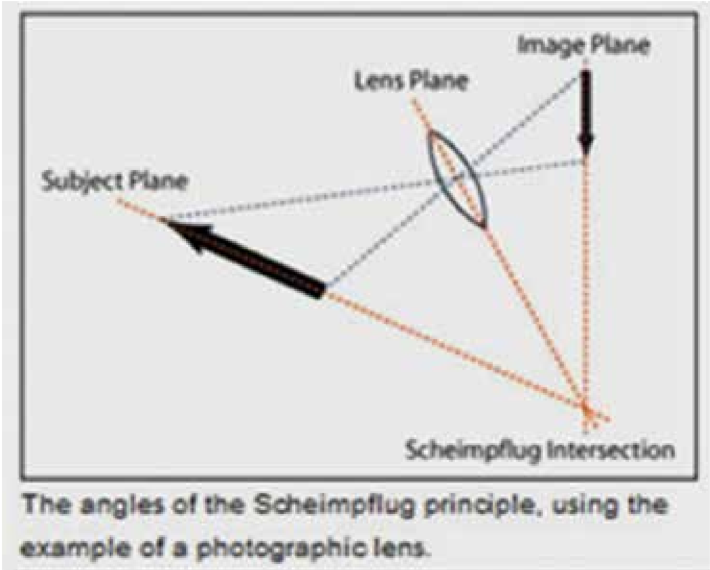

Figure 2: Principle of Schiempflug photography

emitting diode [LED] at a wavelength of 475 nm. The camera rotates around the optical axis of the eye to calculate a 3-dimensional model of the anterior segment. Overall, 138,000 true elevation points are recorded.

PENTACAM HR

The Pentacam HR tomographer is a high resolution system with five times the image resolution of the basic, classic model. It has an improved optic design and fixation options with enhanced precision. There are several scanning options available including a 25-picture (1 second) scan, a 50-picture (two seconds) scan, and a cornea fine (50 pictures in 1 second) scan. Using data from these pictures, the system calculates a 3D model of the anterior segment from up to 138,000 true elevation points. Any eye movement is detected by a second camera and corrected for in the process.

PENTACAM AXL

The most recent addition to this technology is the Pentacam AXL (Figure 3) which has an integrated axial length measurement[7].

ADVANTAGES

- Fast screening Report.
- Includes triple IOL constant optimization algorithm and customized IOL calculation formulas developed specifically for the post-refractive cases.
- Easier and accurate toric IOL calculations.
- Includes an overview image and keratometry overlay for toric IOL positioning.
- 3-D phakic IOL simulation and ageing prediction Various models of pentacam (Table 1).

Figure 3: Pentacam AXL

Table 1: Various models of Pentacam

Pentacam (Basic)	Pentacam Classic	Pentacam HR
Qualitative analysis of cornea	All features of basic plus various software package	All features of classic plus various software package
Screening of glaucoma- Pachymetry based corrected IOP, anterior chamber angle, depth and volume measurement	Refractive- Calculation of corneal thickness progression for early keratoconus detection	Sharp Schiempflug images for precise representation of implants, corneal rings, opacities of lens and cornea
Topography-based keratoconus detection and classification	Cataract- Comprehensive cataract analysis (3D densitometry) and Pentacam nuclear staging	Precise imaging for determining positions of Intraocular lenses, tilting and centering
Additional software upgrade module can be used to upgrade basic to classic model	Zernike polynomials and corneal wavefront analysis	Belin/ Ambrosio enhanced ectasia Holladay report and Holladay Equivalent Keratometer readings for IOL power calculation in post-refractive eyes

OCT-based systems

These systems typically combine Placido disk topography and OCT pachymetry and anterior segment details.

- Optovue Anterior Segment OCT .
- Visante Omni (Zeiss).
- SS-1000 CASIA.

Combined topography/ tomography and wavefront analysis systems.

These systems typically combine wavefront aberrometry, topography, refraction, pupillometry and keratometry.

- iTrace Combination Topography and Wavefront System (Tracey Technologies).
- Nidek OPD Scan II – based on optical path difference technology.

- Topcon KR-1W .
- Topo-Aberrometry (Keratron Onda, Optikon).

Arc scanning with high-frequency ultrasound:

- Artemis (Arcscan).

Colored LED topographer:

- Cassini.

Using Corneal Topography in Corneal Refractive Surgery.

Basic guidelines to using corneal topography in corneal refractive surgery were provided by Randleman. Various patterns in the cornea have been described representing the steepest part of the cornea[6].

- Round.
- Oval.
- Symmetric bow-tie.
- Asymmetric bow-tie.
- No readily describable irregular pattern.

For keratoconus and ectasia screening,

- Rule out contact lens warpage and ocular surface dryness.
- Calculate the I-S ratio.
- Look for skewed radial axes (SRA).
- Determine the steepest K-reading.
- Look for topographic changes over time.

SIRIUS

Sirius topographer device (Figure 4) combines a three-dimensional rotating Scheimpflug camera with a Placido disc topographer. It analyses more than 100,000 data points to give a high resolution of up to one micrometre. This system gives data on corneal pachymetry, anterior chamber depth, aqueous depth, lens thickness, keratometry, white to white, pupillography, anterior and posterior corneal topography and corneal wavefront analysis.

Corneal thickness and anterior chamber depth measured by Sirius and ultrasound methods showed comparable results with repeatability with either instrument. However, they should not be used interchangeably[8].

Advantages

- Analysis of both the entire cornea and the anterior segment in one step.
- Faster image acquisition and processing in less than 10 seconds.
- Pupillography can be done under photopic, scotopic, mesopic and dynamic conditions.

Figure 4: *Sirius topographer*

Figure 5: *Galilei dual Schiempflug photographer*

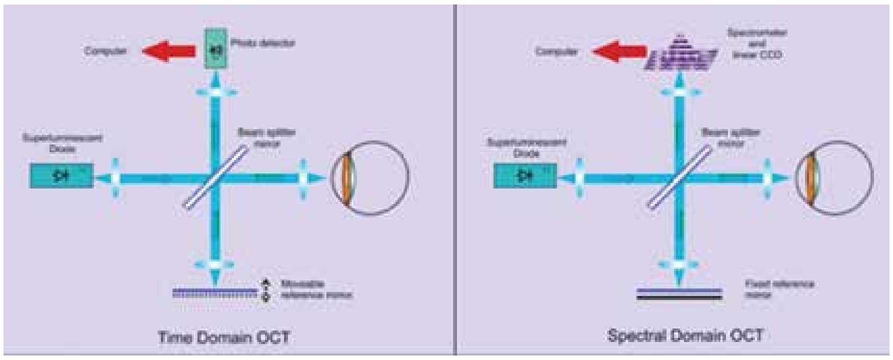

Figure 6: *Principle of OCT*

GALILEI

The Galilei analyzer (Figure 5) system uses the principle of rotating dual Scheimpflug technology combined with a Placido disk to improve the accuracy of corneal power and pachymetric measurements. The flash illumination is emitted from a 475 nm wavelength blue ultraviolet free LED and it measures more than 122,000 data points per scan[9].

It provides accurate

- High-resolution Scheimpflug images.
- Pachymetry.
- Corneal and lens topography.
- 3-dimensional anterior chamber analysis.
- Crystalline Lens thickness.
- Corneal and lens densitometry.
- Pupillometry.

Advantages

- Dual technology – Placido system provides accurate central anterior corneal curvature while Scheimpflug images furnish precise elevation data of the cornea.
- Comprehensive single data set.
- Near/ far adjustable fixation target which allows examining the anterior chamber, crystalline lens, and any implants under near and far accommodation.
- Corresponding corneal thickness data from each view can simply be averaged to compensate for unintentional misalignment.
- Eye motion correction by tracking based on iris pattern recognition and corrected for to prevent motion artifacts.

Anterior segment optical coherence tomography (ASOCT).

Optical coherence tomography (OCT) is a non-contact imaging technology that provides detailed cross-sectional images (tomography) of internal structures in biological tissues.

- Imaging of corneal and anterior segment.
- Angle evaluation to diagnose narrow-angle glaucoma.
- Anterior chamber biometry for intraocular lens placement.

The principle of OCT is to measure the delay of infrared light of wavelength 131 nm reflected from tissue structures[10,11]. It makes use of low-coherence interferometry to compare the delay of tissue reflections against a reference reflection (Figure 6). The device scans a light beam laterally, creating a series of axial scans (A-scans), after which it combines these A-scans into a composite image. Each A-scan contains information on the strength of the reflected signal as a function of depth.

Currently available OCT platforms are (Table 2):

- Time-domain based - Visante OCT (Carl Zeiss Meditec) and slit-lamp OCT (Heidelberg Engineering GmbH, Heidelberg, Germany).
- Spectral domain based - Spectralis (Heidelberg Engineering GmbH, Heidelberg, Germany), RTVue (Optovue, Inc., CA, USA), and Cirrus OCT (Carl Zeiss Meditec) - Interference between the sample and reference reflection is detected as a spectrum which is detected by a spectrometer.
- Swept-source OCT (SS-OCT) - Casia SS-1000 OCT (Tomey, Nagoya, Japan).
- Ultrahigh-resolution OCT (UHR-OCT) - Bioptigen Envisu (Bioptigen Inc.) and the SOCT Copernicus HR (Optopol Technologies). It employs a spectrometer that can detect the fringes reflected from both reference and sample arms. It can also be used for differentiation among various corneal and ocular surface pathologies, including ocular surface squamous neoplasia (OSSN), lymphoma, pterygium, melanosis, and Salzmann nodular degeneration[14].

Uses of OCT in refractive surgeries[12,13] are:

- To enable the precise measurement laser in situ keratomileusis (LASIK) flap thickness and the residual stromal bed thickness before LASIK enhancement to avoid a post-LASIK ectasia.
- Evaluation of the flap and stromal bed after femtosecond lenticule extraction[15].
- For the diagnosis and management of the complications after keratorefractive surgery.
- Quantitative assessment of the infiltration in the eye with post-LASIK corneal inflammation.
- Accurate AC biometry also allows the clinician to select the appropriate-sized IOL, in order to avoid complications.
- Intraoperative examination using hand-held SD-OCT system (Bioptigen) allows more accurate evaluation of the flap characteristic before flap edema and stromal bed hydration changes accuracy[16].

Aberrometry

Ocular aberrations are deviations of the wavefront exiting the eye from a chosen unaberrrated reference wavefront (Figure 7). The overall visual performance post refractive procedures also depends on the residual ocular aberrations. These are described in Zernike as their notation is specific to the aberrations they are classifying and can be expressed using either a single or double indexing method system[17].

Table 2: Various available OCT platforms

Time domain OCT	Fourier/Spectral domain OCT	Swept source OCT	Ultra high-resolution OCT
Varying position of the reference mirror	Stationary reference mirror		Light source with a broad bandwidth
Wavelength of 1310 nm	Wavelength of 830 nm	Wavelength of 1310 nm (CASIA-SS)	Wavelength of 840 nm
Axial resolution of 15-20 microns	Axial resolution of 4-7 microns	Axial resolution of 10 microns	Axial resolution of 1-4 microns
Scan width of 16 mm and depth of 6 mm	Scan width of 3-6 mm	Scan width of 16 mm	Scan width of 5-12 mm
2000 scans per second	27000 scans per second	1,00,000 scans per second	24,000 scans per second
Can penetrate and visualize deeper structures	Improved resolution and reduced motion artefacts		

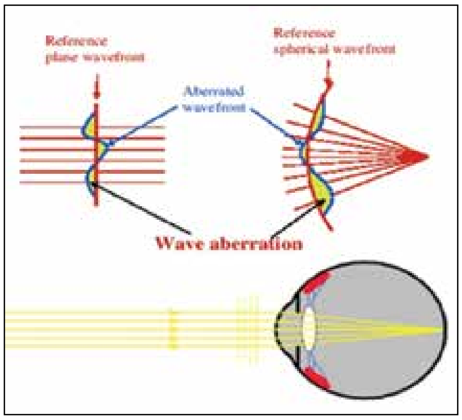

Figure 7: *Wave aberration*

Figure 8: *iTrace aberrometer*

Wavefront aberrations can be further classified based on their Zernike notation as

- Lower order aberrations - zero, first and second order - myopia, hyperopia and regular astigmatism.
- Higher order aberrations- third order and above- spherical and chromatic aberrations, coma, trefoil.

i-TRACE

Aberrometers using various principles such as Hartmann-Shack, Tscherning, Ray Tracing and automatic retinoscopy have been developed to quantify these ocular aberrations. The iTrace System (Tracey Technologies) (Figure 8) is a unique design with combined Placido corneal topography, pupillography, autorefractometer and an aberrometer based on the principle of ray tracing[18].

Concept of ray tracing

A sequential series of infrared beams of 785 nm wavelength is projected into the entrance pupil parallel to the eye's line of sight. Each of these points represents the entrance of parallel light rays into the eye, which become refracted by the eye's optical power and eventually focuses on the retina. The local aberrations at the beam's entry point on the cornea or the lens cause a shift in the location on the retina with respect to a position of reference thus ultimately affecting the visual outcome.

When analyzing I trace data, we come across the following types of graphs.

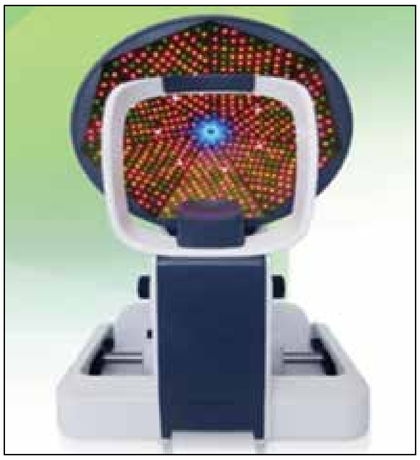

Figure 9: Cassini LED topographer

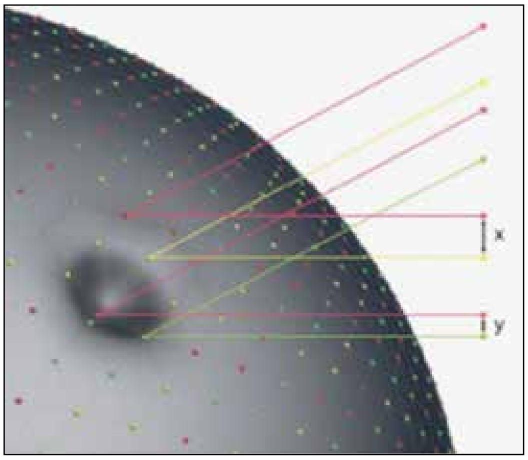

Figure 10: Point to point ray tracing

Figure 11: Corvis ST

- Total wavefront graph and higher order aberrations graph. These are color-coded graphs based on the location of the wavefront in front or back of the reference plane.
- Root mean square.
- Total refractive and higher order aberrations graph.
- Point spread function total and HOA maps.
- Snellen letter total and HOA.
- Zernike polynomials.
- Aberrations of internal optics analysis.

Optical aberrations after refractive surgery

- Though there is a correction of astigmatism and defocus post-refractive surgery, there is an increase in higher order corneal aberrations which correlate well with a decrease in contrast sensitivity.
- Refinement of ablation algorithms and a better understanding of the corneal biomechanical changes are needed to avoid induction of high order aberrations.
- Prior precision planning and counselling are essential to avoid postoperative disappointments in visual quality.

Artemis

It consists of a high-frequency (50 MHz) broadband transducer (Panametrics, Inc) transducer to sweep an arc segment of the cornea which follows the corneal contour. This enables ultrasonic data to be acquired over an area 8 to 10 mm diameter in 0.5 seconds[19]. It provides high-resolution imaging and high-precision three-dimensional thickness mapping of the cornea.

Studies done by Reinstein et al showed that B-scans and 3D thickness maps after LASIK demonstrated resolution of epithelial, stromal component of the flap, and residual stromal layers[20].

Cassini

Cassini topographer (i-Optics) uses the principle specular reflection of multicolored light emitting diodes (Figure 9). Six seventy-nine red, green and yellow coloured LEDs take instantaneous measurements of the cornea[21,22]. It analyzes the information using point to point ray tracing combined with second Purkinje image technology (Figure 10). This unique principle produces accurate measurements of keratometry and lower and higher order aberrations using Zernike polynomials.

Advantages

- Ease of use.
- Predictability.
- Comparable results to other commonly used devices.
- Increased repeatability of cylinder measurements which is more useful when using toric intraocular lenses.

Corvis ST

Corvis ST is a non-contact tonometer which also provides data of corneal biomechanical properties. The cornea is applanated with an air puff and a Scheimpflug camera is used to capture 4330 images per second (Figure 11). The velocity of corneal deformation at the first and second applanations and the maximum depth of corneal deformation due to the air jet are recorded by this camera.

Intraocular pressure is measured by taking into account biomechanical properties of the cornea. Central corneal thickness obtained by this device showed good accuracy and repeatability when compared to standard ultrasound pachymetry.

IMPLICATIONS IN REFRACTIVE SURGERY

Both small-incision lenticule extraction and femtosecond laser-assisted LASIK can cause biomechanical changes in the cornea. However, changes in the cornea's viscoelastic properties were less after lenticule extraction than after LASIK[26].

Both microincision lenticule extraction and small incision lenticule extraction procedures significantly altered the biomechanical characteristics of the cornea[27,28]. The smaller 2mm incision was associated with less reduction in ORA parameters during the early postoperative period.

Ideal refractive surgery ?

Refractive surgery includes a wide variety of options from laser in situ keratomileusis, epi LASIK, laser-assisted subepithelial keratectomy, Refractive lens exchange, PRK, pIOL implantation, intracorneal rings limbal relaxing incisions to small-incision lenticule extraction and its variants, multifocal IOLs, corneal crosslinking (CXL), and femtosecond and topography-guided lasers. SMILE and femtosecond-LASIK are safe, effective, and predictable surgical procedures to treat myopia but there is a lesser chance of induction of higher-order aberrations and spherical aberration with SMILE than with femtosecond-LASIK[29]. Having close-to-ideal ablation profiles should improve the clinical results, decreasing the need for nomograms, and reducing the induced aberrations after surgery[30]. Wave front guided and topography guided ablations are customized as per requirement. SMILE and Femtosecond-LASIK are comparable in terms of both safety and efficacy with SMILE having fewer dry eye symptoms and greater corneal sensitivity than femtosecond-LASIK[31].

The bottom line

Concept of corneal warpage should be kept in mind prior to any corneal imaging. A minimum contact lens free period of at least 2 weeks for soft lenses and 3 weeks for rigid gas permeable lens should be observed. Cases of dry eyes should be evaluated and treated prior to imaging. A detailed fundus examination to rule out retinal pathology is mandatory prior to any refractive procedure. Clear guidelines and an efficient protocol will make refractive surgery rewarding for the surgeon as well as the patient.

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Hyperopic Refractive Surgery

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Abstract: *Hyperopia or farsightedness is often associated with short axial length or weak focusing mechanism like a flat cornea or a combination of the two factors. Refractive surgical options, such as laser-assisted in-situ keratomilieusis (LASIK), are being explored to address these anatomic factors in hyperopic eyes. For low degrees of hyperopia, these procedures show good efficacy and predictability. However, regression and lower predictability is reported with higher amounts of hyperopia. This article summarizes the current perspective on the treatment options for hyperopia.*

Keywords: *Hyperopia, hyperopic refractive surgery, hyperopic LASIK, hypermetropia, SMILE.*

Hyperopia is the optical term for farsightedness, a condition in which parallel light rays focus behind the retina, making near objects appear blurred. This refractive error has a reported prevalence of 25.2% to 31.8% in adults[1]. The age-adjusted prevalence of hyperopia in Asian adults is reported to be 35.9% (95% CI 33.7-38.3) in the Singapore Indian Eye Study (SINDI)[2].

This may be due to short axial length or weak focussing mechanisms for the given axial length of the eye, e.g. a flat cornea. Refractive surgical options have been designed with aim of increasing the overall focusing power of eye, either by altering corneal curvature or by placing an artificial lens in the eye. It can be categorized into low (≤ 3.00 D), moderate (3.00-5.00 D), and high (≥6.00 D). Various refractive surgical options for hyperopia have been listed below:

- Keratorefractive procedures –
  - Surface treatment techniques: Photorefractive keratectomy (PRK), laser subepithelial keratomileusis (LASEK), Epi-LASIK.
  - Lamellar treatment technique: Laser-assisted in situ keratomilieusis (LASIK) using micro-keratome or femtosecond laser.
  - Femtosecond laser alone techniques - Small incision lenticule extraction (SMILE), Femtosecond lenticule extraction (ReLEx FLEx).
- Lens-based procedures – Phakic intraocular lens, refractive lens exchange (RLE).
- Keratoplasty– Conductive keratoplasty, Laser thermal keratoplasty.

While the refractive surgical correction for myopia has evolved continuously since the introduction of 193 nm excimer laser, the refractive treatment of hyperopia has lagged behind due to regression and unpredictability. Refractive surgical treatment for hyperopia remains a challenge for a refractive surgeon and no single technique has been accepted as standard treatment for hyperopia[3]. Factors to consider when deciding between these options include the degree of hyperopia, the patient's age, lens opacification, accommodative ability, keratometry (K), corneal topography, and endothelial status[4].

PREOPERATIVE CONSIDERATIONS

After a thorough clinical history and ocular examination, a cycloplegic refraction must be performed to determine the exact amount of hyperopia to be corrected. Stability of refraction must be ensured for last one year. Contact lenses must be removed prior to the pre-op examination for a minimum of 7-14 days for soft contact lenses and 3 weeks for rigid gas permeable lenses. Any other past significant ocular or systemic history must be ruled out.

A post mydriatic test must then be performed after the effect of cylcloplegic agent wears off. Manifest and cycloplegic refraction both are recommended to select appropriate surgical treatment. Determination of pupil size, keratometry, pachymetry, white-to-white diameter and corneal endothelial cell counts (should be preferably >2000 cells/mm2) help in careful patient selection. Anterior chamber depth (ACD) from endothelium is an important consideration before planning intraocular surgery in hyperopes.

PRK

PRK uses excimer laser to reshape the cornea, but without requiring a lamellar flap. Aftering removing surface epithelium, the laser is applied directly to the anterior stromal surface. In hyperopic PRK, corneal tissue is removed from the anterior corneal stromal surface following removal of the corneal epithelium. It has been found to be of comparable efficacy as LASIK. However, a higher postoperative pain, and an initial myopic overshoot peaking postoperatively at one month has been reported with PRK[5]. In eyes after PRK, prolonged epithelial healing process may often contribute to high regression rates[6]. After hyperopic PRK, epithelial remodeling aims to compensate for the ablated corneal tissue. On the other hand, central epithelial hyperplasia would manifest as refraction overshoot over the first week to month, and after complete healing, a regression is seen after 3–4 months.

LASIK

LASIK is currently the most commonly performed surgery for hyperopia. Excimer laser is used for ablation of paracentral cornea to steepen the central cornea (Figure 1). For mild (<3 D) and moderate (3-5 D) hyperopia, the outcomes of LASIK surgery have been reported to be safe, predictable and effective in achieving very good to excellent uncorrected visual acuity, achieving postoperative refractions within 1 D of emmetropia, and is safe in terms of minimal loss of best-corrected spectacle vision[7,8]. However, for higher degrees of hyperopia (≥6 D), the results are less predictable and regression of effect is commonly seen[9].

Hyperopic LASIK tend to require larger optical zone and transition zone. Hence, when compared to LASIK for myopia, the errors related to position of excimer laser pulse and its fluence projection and reflection[10] become more relevant in hyperopic LASIK, where most ablation in peripheral. While considering LASIK for hyperopia, cycloplegic refraction and corneal keratometry must be carefully noted. Those patients with high latent hyperopia have high propensity for regression.

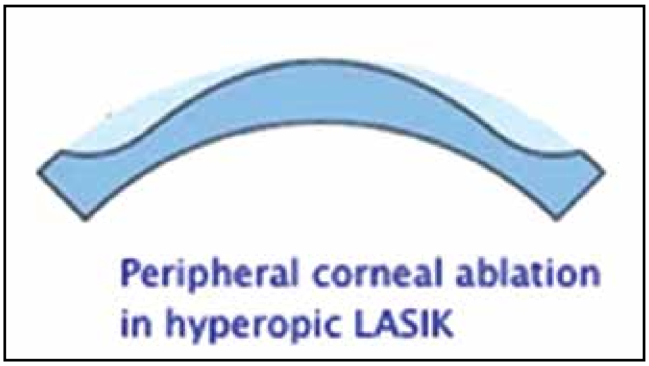

Figure 1: *Hyperopic LASIK involves peripheral corneal ablation and steepening of central corneal power*

Also, due to increase in corneal steepness after hyperopic LASIK, the anticipated corneal keratometry must be considered before proceeding for surgery. Too steep cornea postoperatively may lead to an abnormal tear film and poor vision quality. If preoperative mean keratometry is greater than 44D, an increased loss of best corrected visual acuity (BCVA) and lower patient satisfaction has been reported[11]. Thus, refractive surgeon must be cautious in eyes with high hyperopia and steep preoperative corneal keratometry.

SMILE

To offer the advantages of SMILE like maintenance of integrity of corneal nerve plexuses, the outcomes of hyperopic SMILE are being studied. SMILE eliminates the errors related to excimer laser fluence projection, which are well known to cause errors in LASIK treatment as SMILE uses femtosecond laser to delineate the lenticule. Since femtolaser cutting is accurate and does not depend upon the shape of the lenticule, there is no difference in between hyperopic and myopic SMILE, for low and high refractive errors[12,13]. The 'trough' of mid-peripheral tissue removed in hyperopic treatment is filled by epithelial remodelling[14]. Also, due to large optical zone in hyperopic treatments, regression is seen to be less when compared to myopic treatments[15]. However, no long term results exist for hyperopic SMILE. Reinstein et al described a doughnut shaped lenticule extraction with 6.3-6.7 mm optical zone, cap diameter 8.8 mm, a 2 mm transition zone, 30 µm minimum lenticule thickness and 90° side cut[16]. Reinstein et al compared the outcomes of hyperopic SMILE (mean optical programmed zone 6.37 mm) with hyperopic LASIK (two control groups of 6.5 and 7 mm optical zone). The mean achieved optical zone (OZ) diameter of hyperopic SMILE was found to be larger than the mean achieved OZ diameter of hyperopic LASIK. Spherical aberration induction was found to be similar for the two. Despite the fact that SMILE does not use an eye tracker, a study analyzing the optic zone centration of hyperopic SMILE demonstrated its OZ centration to be similar to eye-tracker-centered hyperopic LASIK.

RELEX FLEX

This method of refractive correction involves raising a flap followed by lenticule extraction. Blum et al first reported it to be a feasible and effective surgery for treating hyperopia[17]. Since then, ReLEx has been gaining popularity for refractive correction. Further research is needed to improve predictability and effectiveness of the procedure for the correction of hyperopia. Sekundo et al[18] conducted a pilot study with an improved lenticule shape with a large transition zone of at least 2 mm adjusted to the 5.75 mm optical zone and reported good centration and acceptable refractive outcomes using FLEx.

PHAKIC INTRAOCULAR LENS

Surgical placement of an implant can correct hyperopia with good efficacy and refractive predictibility[19,20]. However, a higher incidence of pupillary blocks has been reported in hyperopic eyes. Currently, no FDA-approved phakic intraocular lens available to treat hyperopia. Also, no ICL model with central hole is available for hyperopia, unlike the EVO Visian ICL (previously known as the Visian ICL V4c; STAAR Surgical) for myopia and myopic astigmatism. Thus, a surgical peripheral iridectomy (PI) is necessary with the currently available ICL models implanted for hyperopia. Also, a careful evaluation of ACD (from endothelium) is required before deciding for implanting ICL. STAAR ICL for myopia and myopic astigmatism is contraindicated in eyes with ACD <3 mm and anterior chamber angle < grade II[21–24]. However, for hyperopic eyes, if one selects a cutoff of ACD at least 2.8 mm, in order to avoid pupillary block-related complications, many hyperopic eyes will not fulfill the criteria, making ICL implantation a contraindication in them.

With hyperopia exceeding 4.00 diopters (D), the predictability of the refractive outcome and uncorrected visual acuity (UCVA) have reported to be better with phakic IOL rather than with refractive corneal surgery. A ten year follow-up study of eyes implanted with phakic implantable collamer lens (ICL) showed a quick restablization of refractive power and confirmed the safety, accuracy and predictability of ICL for hyperopia. The mean incidence of endothelial cell loss in hyperopic eyes is reported to be 4.7%.

For hyperopia correction, Horáková et al. compared 37 LASIK eyes of 20 patients with an average age of 36.3±11.8 years and followed up for 28.1±10.2 months with 21 ICL eyes of 13 patients with an average age of 28.6±6.1 years and followed up for 30.4±20.9 months.25 Better uncorrected visual acuity (UCVA) was obtained with the ICL, and best spectacle corrected visual acuity (BSCVA) improved only after ICL implantation. Post-operative refraction stability was also better with the ICL, while continuous regression was evident in the LASIK group[25]. Hyperopic ICLs have also been found to have good optical quality with clinically negligible wavefront aberrations[26].

RLE

It is a procedure identical to cataract surgery: removal of natural lens followed by implantation of artificial intraocular lens, but involves extraction of clear lens. Lyle et al described use of refractive lens extraction to treat hyperopia. Since there is an associated loss of accommodation in RLE, it may not be tolerated well by young hyperopes. Hence, it is offered to patient who are nearing presbyopic age or are

Table 1		
Procedure	**Advantages**	**Disadvantages**
LASIK	Safe, predictable and effective for low to moderate hyperopia.	Loess predictable and regression commonly seen in high hyperopia.
SMILE	Better preservation of corneal nerve plexuses and less incidence of dry eyes reported by some studies.	Long term outcomes regarding visual outcomes and safety are yet awaited.
ICL	Quick and better refractive stability than corneal procedures. Predictable, safe and effective for higher grades of hyperopia.	Higher reported incidence of pupillary block glaucoma in hyperopic eyes. Stringent criteria of ACD ≥ 2.8 mm might not be fulfilled by many hyperopic eyes.

presbyopic, with lower age suggested to be 35-39 years in the literature[27]. It has been reported to be safe, effective and predictable. In a study of 20 eyes in 12 patients, Lyle and Jin reported that 89% of eyes achieved a UCVA of 20/40 or better and that all eyes had 20/25 or better BCVA. Preetha and colleagues had 70% of patients within 0.50 D of the intended refraction, and three eyes gained lines of BCVA out of 20 eyes in the study[28].

CONCLUSION

Most of the treatment modalities discussed above remain ill-defined for treatment of hyperopia. Amongst the available surgical options, RLE has long been an established procedure. Each of these procedures have their merits and demerits (Table 1), thus, requiring a careful patient selection and good patient counselling.

Though we do have short term visual and refractive outcomes of keratorefractive surgeries (like SMILE and LASIK) and hyperopic ICLs, long-term results are still awaited for most of these surgical options for hyperopia.

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LASIK Vs SMILE

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Abstract: *Femtosecond laser in situ keratomileusis (FS-LASIK) has been the most common corneal refractive surgery and has been used for correction of wide range of refractive errors over the years. SMILE is a newer modality, which provides an alternate for LASIK for myopia and myopic astigmatism. It offers certain advantages over LASIK. Before choosing one over the other, various factors need to be taken into account.*
Keywords: *LASIK, SMILE, Refractive Surgery, Corneal Biomechanics.*

Femtosecond laser in situ keratomileusis (FS-LASIK) has been the most common and effective corneal refractive surgery and has proved to be safe and predictable for treating myopia[1]. Major problem with this surgery includes the risk of flap related complications and dry eye[2-3].

Small incision lenticule extraction (SMILE) is a newer modality for treatment of myopia without corneal flap production, by removing the corneal stroma lenticule from a minimized incision to reduce the complications of corneal flap and dry eye since 2011[4-5]. It has been shown in various studies that there is less impairment of the biomechanical effects and more corneal nerves are preserved when treated with SMILE compared with FS-LASIK which can reduce the incidence of dry eye[6-8].

SURGICAL TECHNIQUE

SMILE is a new single femtosecond laser procedure (Figure 1). It involves the creation of an intrastromal lenticule between two photo disruption planes. First step is docking with precise centration and suction is initiated. Patient cooperation is of utmost importance. Then, a posterior lenticule is cut followed by verticle edge incision, then the cap cut and finally one or two side cuts. We use two side cut where second side cut is used as rescue and is opened only in case of adhesions or difficult dissection. The anterior and the posterior layer are dissected and mechanically removed through a small corneal incision tunnel of 2 mm diameter.

On the other hand, LASIK procedure involves two distinct steps: the creation of the flap (corresponding to a lamellar cut typically 100–120 μm within the cornea) by either a mechanical microkeratome or a femtosecond laser (usually operating at 1,056 nm). This is followed by the refractive part, the ablative removal of stromal tissue from the exposed bed under the lifted flap using an excimer laser (usually operating at 193 nm).

LASIK is approved for myopia, hyperopia and astigmatism while SMILE is approved for only myopia and myopic astigmatism. LASIK may be applied for customized treatments where centration can be actively controlled and cyclorotation compensated and where wavefront and/or topographic data can be incorporated in the tissue pattern planned for removal.

INTRAOPERATIVE DIFFICULTY AND COMPLICATIONS

LASIK potentially has the benefit of vast surgical and research experience. The surgical technique is easy and has high reproducibility. Major complications are flap related which are overcome by SMILE. SMILE comes with its own set of difficulties. It has a learning curve. Difficulty in lenticule dissection, incorrect tissue planes and suction loss are major challenges. If suction loss occurs during lenticule cut after 10 percent of cut, it has to be converted to FS-LASIK. At any other time, procedure can be continued with set guidelines.

VISUAL OUTCOME

Most studies have demonstrated no significant difference between LASIK and SMILE uncorrected visual acuity (UCVA) of 20/20 or better[8-10]. Although faster visual recovery is noted with LASIK, postoperative mean refractive spherical equivalent and postoperative refraction within ±1.0 D of the target refraction have been found similar between the two.

CORNEAL ABERRATIONS

It has been observed that higher order aberrations (HOA) and spherical aberration are lower in the SMILE than that in FS-LASIK. No significant difference has been seen in either the horizontal coma or the vertical coma between the two groups[11,12,13,14]. The reason for this is not clear. There is no transition zone for the SMILE procedure which may reduce spherical aberration. Another possible explanation is that in SMILE the lenticule is created with femtosecond laser scanning at two depths of the stroma, which may avoid the ablation efficiency reduction in the periphery and therefore induce less increase in corneal asphericity whereas for an excimer laser, the ablation efficiency reduction in the periphery of cornea would increase corneal asphericity even when the exact Munnerlyn ablation profile is used. Epithelial remodeling may also play a role.

CONTRAST SENSITIVITY

The contrast sensitivity usually recovers to the preoperative level later in the SMILE group than that in FS-LASIK. It has also been shown that contrast sensitivity was better in the SMILE

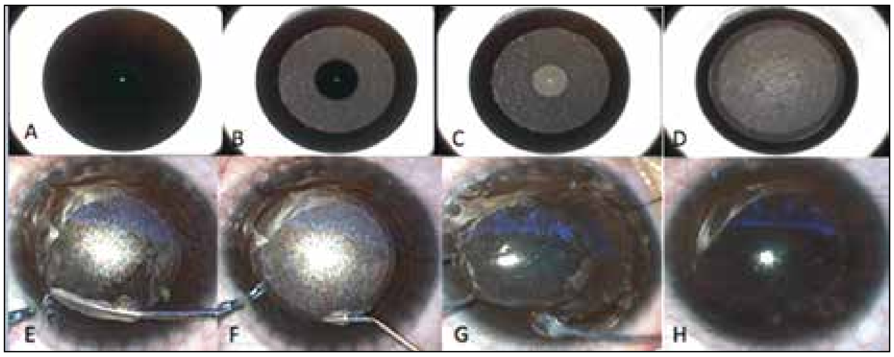

Figure 1: *Steps of SMILE surgery **A.** Docking of eye while maintaining centration. **B.** Posterior lenticule cut out to in. **C.** After peripheral verticle cut, anterior cap cut is made in to out. **D.** Side cuts are made. **E.** Anterior and posterior cuts are identified and seperated. **F.** Lenticule is dissected. **G.** Lenticule is extracted from the incision and checked for completeness. **H.** After completion of surgery.*

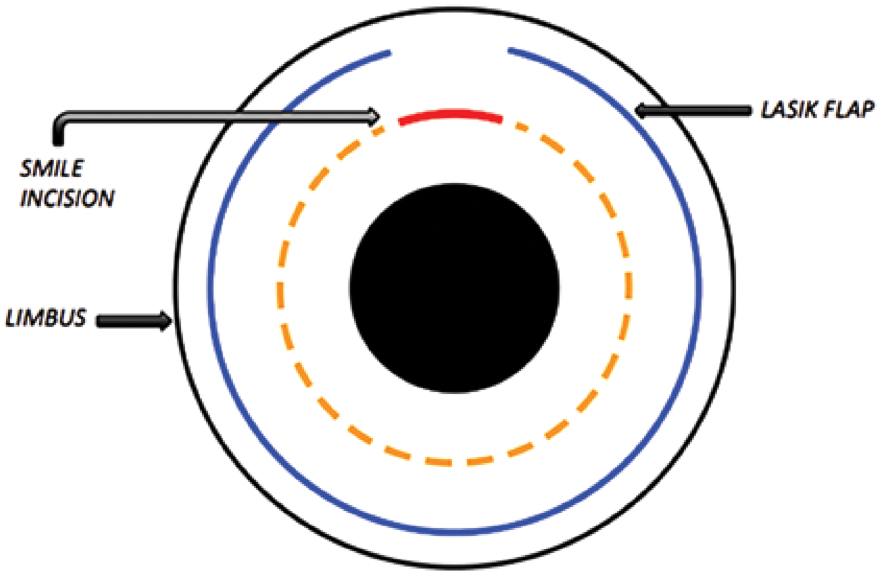

Figure 2: *Comparison of SMILE and LASIK incisions with respect to limbus*

Table 1

SMILE over LASIK

- Better patient comfort and reduced dry eye
- May have lesser tensile strength reduction, so may reduce incidence of ectasia
- Lower HOA and spherical aberration
- Better contrast sensitivity
- Lower dependence on environmental factors

LASIK over SMILE

- Tried and tested over years
- Greater range of refractive correction especially astigmatic correction
- Treatment of hyperopia is possible
- Wavefront and topography guided treatment available
- Faster visual recovery

group than in FS-LASIK, particularly at higher spatial frequencies. The decrease in contrast sensitivity is usually associated with the increase in HOAs.

BIOMECHANICAL PROPERTIES

The removal of corneal tissue by either procedure inevitably leads to reduction of corneal tensile strength[15,16]. Both procedures alter corneal biomechanical properties that are thought to play an important role in the development of post surgery ectasia, but the nature of each procedure may produce different biomechanical effects. First, it is known that vertical cuts have more biomechanical impact than horizontal cuts. In SMILE significantly less anterior cornea is subjected to transverse separation, since side cut diameter is 2–3 mm (50°) compared to LASIK where flap diameter is of 300°, that is, 360° minus only the hinge (Figure 2). Additionally, it is also known that anterior stromal lamellae are stronger than posterior stromal lamellae, and the anterior 40% of the central corneal stroma constitutes the strongest region of the cornea, whereas the posterior 60% of the stroma is at least 50% weaker. In SMILE, since the anterior stroma remains uncut and the tissue is removed from deeper stromal layers than in LASIK, the strongest part of the stroma continues to contribute to the strength of the cornea postoperatively.

OTHER FACTORS

SMILE is associated with lower induction of dry eye as very few corneal nerves are cut as compared to LASIK where almost 360 degree cut is made.

SMILE offers reduced dependence on environmental factors that may influence excimer stromal ablation, such as laser fluence variability and stromal hydration. Also there is probably reduced possibility for operating room airborne foreign-body interface contamination. However temperature and humidity are to be controlled for both LASIK and SMILE machine for optimal functioning.

Patient comfort during and immediately after surgery is much better in SMILE compared to LASIK.

CONCLUSION

Both SMILE and LASIK procedures have performed well in studies in measures of safety, efficacy, and predictability for myopia correction. SMILE, a relatively newer and evolving procedure, has been so far employed for the correction of myopia and/or myopic astigmatism. Both have their own advantages and disadvantages (Table 1). Proper patient selection and counseling can help in optimal use of both the entities.

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Scleral Fixated Intraocular Lens (SFIOL)

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Scleral fixation of the intraocular lens is an innovative technique which was initially used for centering the lens to avoid inferior subluxation or posterior migration to being used now as a method for correcting aphakia. In this era with the increase in cataract surgery and hence the associated complications leading to inadequate capsular support, the scleral fixated intraocular lens is being considered as an alternative to anterior chamber intraocular lens and iris fixated intraocular lens. There are various techniques which have emerged over the past three decades and has invariably made the procedure easier and reproducible with less number of complications.

INDICATIONS

Besides iatrogenic aphakia post ICCE, ECCE with inadequate capsular support, large Posterior capsular rupture or anterior rhexis extension posteriorly, the procedure is also being used in cases of traumatic dislocations of lens or IOL, Subluxated lens, Spherophakia and spontaneous dislocation of the lens in cases of pseudoexfoliation.

HISTORY

The contribution from the greats in the field cannot be ignored and surprisingly the lenses for scleral fixation were designed as early as 1961 by Strampelli with nylon loops that were long enough to extend under the scleral flap but unfortunately those dissolved with time[1]. Then in 1976, Pearce came up with a lightweight posterior chamber lens that was sutured to the iris[2]. Choycee modified and illustrated a translimbal fixation technique as well as a scleral trapdoor in 1979[3].

The 10-0 polypropylene suture for SFIOL first came into use in 1983 by Lowell A Gess, where he used Pearce and Omega lenses for scleral fixation and closed the scleral flap with 8-0 polyglactin suture. One of the techniques described by him in 1983 is similar to Yamane's currently popularized technique where he used cautery to heat the tip of polypropylene to form a ball that prevented it from being pulled back[4].

In 1984 Sanford described a suture fixation technique to sclera which was further modified by Lois Girard in 1988 to correct Sunset syndrome[5]. In 1991 Shapiro et al came up with direct visualization technique to limit damage to the ciliary body[6]. Meanwhile, polypropylene knot erosion, externalization, and endophthalmitis due to suture track was reported leading to a modification of burying knot by Lewis et al. in 1993[7]. People also started noticing tilt in the lens causing unwanted astigmatism, to address this issue four-point fixation was proposed using two sutures by Bergren et al. in 1994[8].

This technique was also used in pediatric cases with favorable outcomes. The first Multipiece IOL for scleral fixation was described by German ophthalmologist Szurman Petal in 2006[9]. The major shift in technique came with Agarwal et al. Glued sutureless Multipiece intraocular lens within scleral flap and haptics placed in scleral tunnel made parallel to limbus in 2008 to address the problem of broken suture and delayed IOL subluxation and dislocation[10]. Meanwhile another addition of anterior vitrectomy with few cases of complete pars plana vitrectomy was reported as safer technique to reduce the chances of retinal detachment[11].

Technique: The procedure is started with marking the 3'o clock and 9'0 clock position followed by limited conjunctival peritomy on either side. Two flaps of 3mm width are made on either side with help of crescent blade. Infusion is attached and started after confirming the tip at an intraocular pressure of 25 mm of hg. Two 25-gauge ports are introduced at 1.75 mm from limbus for doing anterior and port side vitrectomy. The ports are removed and a 3.2mm incision is made at 12'o clock along with 2 MVR incision at 10'o clock and 2'o clock. The IOL is injected and the leading haptic tip is grasped with end-grasping forceps and exteriorized from the 3'o clock. The trailing haptic is left outside the wound. The trailing haptic is grasped away from the tip and introduced into the anterior chamber from where it is grasped from the tip by another end-grasping forceps at 9'o clock and exteriorized. The exteriorized haptics are placed in a tunnel made by 26-gauge needle parallel to the limbus and scleral flap followed by conjunctiva is closed with fibrin glue. The final step is to inject pilocarpine and air in anterior chamber followed by hydration of wounds (Figure 1).

COMPLICATIONS

The newer techniques emerged because the suture fixated IOL had complications such as suture breakage in approximately 27.9% of cases with 10-0 polypropylene sutures hence newer material like Gortex and 9-0 polypropylene were proposed but even these are time-consuming, complex and invasive. Even the glued IOL technique has complications like corneal edema (5.7%), IOL drop, Retinal detachment, macular edema (1.9%) , IOL Tilt, Pigment dispersion or iris chaffing syndrome (1.9%) , vitreous haemorrhage (0.4%), slippage of haptic (7.7%), extrusion of haptics (1.9%), choroidal detachment and optic capture (4.3%)[12].

The first needle guided multipiece IOL with scleral pocket implantation was reported in 2010 by Inaki Rodriguez et al.[13] The endoscope was used in 2011 to guide scleral fixation but this had a long learning curve and increased operative time[14]. This brings us to the current technique which is being used for scleral fixation.

Flanged Intrascleral IOL with double needle technique

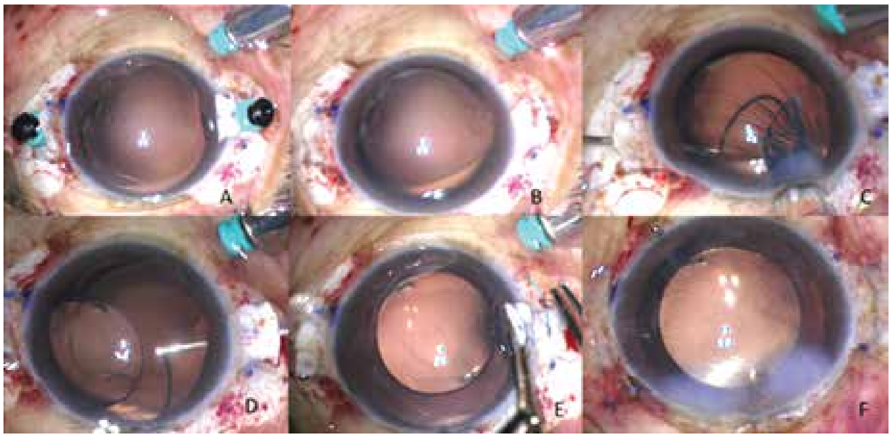

Figure1: A) *Infusion placed inferotemporally, 3mm Scleral flap made at 3'o clock and 9'o clock with 25-gauge ports at 1.75mm from limbus.* ***B)*** *Ports removed after anterior and port side vitrectomy.* ***C)*** *Tip of the leading haptic grasped with end-grasping forceps and exteriorized.* ***D)*** *Trailing haptic is introduced into anterior chamber and grasped from the tip.* ***E)*** *Exteriorised tip is introduced into a scleral tunnel made parallel to limbus with 26 gauge needle.* ***F)*** *Flaps and peritomy closed with fibrin glue, wound hydrated followed by pilocarpine and air injection in anterior chamber.*

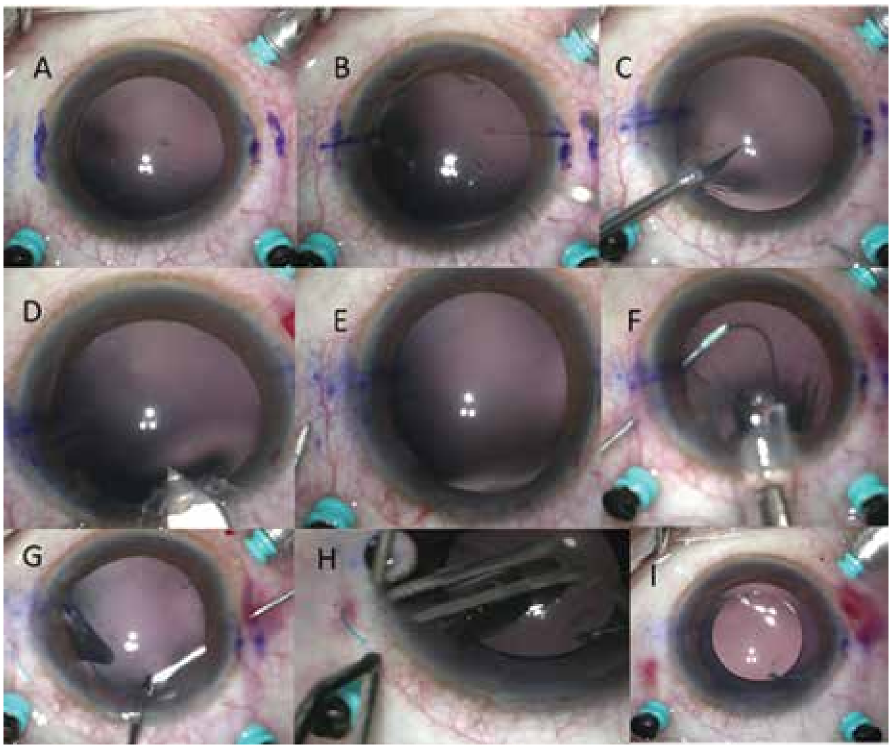

Figure 2: A) *1.75mm mark taken on either side of limbus.* ***B)*** *3'o clock and 9'o clock mark made using either toric marker or RK marker.* ***C)*** *Two MVR entry made at 10'o clock and 2'o clock.* ***D)*** *3.2mm valvular entry made at 12'oclock.* ***E)*** *27-gauge needle entry made at 30° angle.* ***F)*** *Leading haptic docked in needle directly.* ***G)*** *Trailing haptic docked in needle using end-grasping forceps.* ***H)*** *Tip of the haptic cauterized to make a flange.* ***I)*** *Tip of haptics is pushed back in sclera followed by pilocarpine, air injection and wound hydration. A Peripheral iridectomy is optional.*

by Shin Yamane et al.[15]: This technique was designed to be a minimally invasive procedure wherein two angled 30-gauge thin walled needle was used to dock the haptics and exteriorized simultaneously to avoid rotation of IOL followed by cauterization of haptic tips to make a flange. The haptic diameter of 3-piece IOL ranges from 0.14-0.17mm and can easily be docked in 30-gauge thin bore needle with a diameter of 0.20mm.

This procedure reported IOL dislocation in 3%, hypotony in 2%, increased intraocular pressure in 2% and Cystoid macular edema in 1% of cases. Interestingly iris capture of IOL was the most common complication in 8% along with vitreous hemorrhage in 5% of cases. The IOL tilt measured using Anterior segment OCT was on an average 3.4°.

The advantages of this procedure being a transconjunctival sutureless, flapless and a glueless technique which reduces the surgical time drastically along with patient's post-operative comfort. The disadvantage being the availability of thin bore 30-gauge needle, Polyvinylidene fluoride (PVDF) haptic IOL, the learning curve in docking of haptics, chance of slippage especially with bigger gauge needle and optic capture of IOL.

Modified Technique: The procedure is started by making three self-sealing 25-gauge pars plana ports. After completing the pars plana vitrectomy (anterior vitrectomy, port side vitrectomy and at 3'o clock and 9'o clock), 1.75 mm marking is done on either side of limbus using gentian violet. The toric marker or radial keratometry (RK) marker can be used to make the 3'o clock and 9'o clock marks. Two Microvitreoretinal blade entry is made at 10'o clock and 2'o clock which helps in haptic manipulation. A 3.2mm biplanar clear corneal incision is made for injecting the 3-piece IOL. In case of non-availability of thin bore 30-gauge needle, a 27-gauge needle can alternatively be used which has an outer diameter of 0.40 mm and an inner diameter of 0.22mm to make an entry at 30° angle parallel to the limbus. The leading haptic is docked in the needle while injecting the IOL and the trailing haptic is left outside. We prefer to exteriorize the haptic immediately. The trailing haptic is docked in the needle using end-grasping forceps. Once exteriorized both the tips of haptics are cauterized using a bipolar cautery to make a flange and pushed back to snuggly fit into the scleral tunnel. The only additional disadvantage of the 27-gauge needle being the need to make a bigger flange to avoid slippage (Figure 2) At the end of surgery all the ports are removed, pilocarpine is injected to make sure there is no vitreous tag and optic capture. This is followed by intracameral air injection and wound hydration. A Peripheral iridectomy is optional as we use 3-piece with a posterior angulation of 18°, optic capture seldom occurs. The wounds are always checked for leaks and if present we should not hesitate to put one vicryl suture. Postoperatively the air gets absorbed in a days' time and patient enjoys good vision from next day onwards. The antibiotic (moxifloxacin 0.5%) and Homatropine 2% are continued for 2 weeks along with tapering of topical steroid over 6 weeks.

CONCLUSION

The newer transconjunctival technique has made the procedure less invasive and will be practiced more often in future but newer innovation is bound to happen to make the procedure of scleral fixated intraocular lens even more safer.

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Recent Advances in Cataract Surgery

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Abstract: *Cataract is most common cause of visual impairment through out the world. Although the fundamental aim of cataract surgery is removal of the opacified natural lens to improve vision, has remained the same but the way of doing it have changed drastically over the years from large intracapsular extraction to small incision laser cataract surgery. This is because of revolution in technology as well as the increasing expectations of the people. Compared to the standard techniques of cataract extraction which were quite successful in the past, the newer techniques provide greater safety and better vision the patient. We have discussed the latest trends in the cataract surgery.*

ANTIBIOTIC PROPHYLAXIS. ESCRS endophthalmitis guidelines suggest single use preparation of povidine iodine solution could avoid the risk of post op endophthalmitis[1,2,3]. Since alcoholic solutions are potentially toxic to ocular surface as they cause lipid layer toxicity and postoperative foreign body sensation, so it is better to use alcohol-free solutions which also contain hyaluronic acid for extra protection .Results have shown more free iodine in 5% solution compared to 10% povidine iodine solution[4,5].

1.8 mm INCISION.Surgeons are aiming at smaller incisions in cataract surgeries to avoid complications like astigmatism. Traditional 2.5 mm incision gave way to sleeveless micro phaco which was associated corneal burns. Recently newer machines are compatible with 1.8 mm incision with regular phacoemulsification parameters. Problems like low vaccum and less inflow are not seen with advances in technology.

ZEPTO It is an advanced form of cataract surgery in which the most technically challenging step of the surgery capsulotomy is automated using disposable nanotechnology device independent of pupil size,corneal clarity and lens density (Figure 1). It can be inserted through 2.2 mm incision. It is a combination of calibrated suction and low-energy pulses which produces high quality capsulotomies.

BHATTACHARJEE RINGS: Disposable square and hexagonal pupil expansion rings made up of 5-0 nylon (Figure 2). It has flanges at the sides and notches at the corner with single 0.1 mm thin plate. Single use disposable ring. Inserted through 0.9mm incision when the flanges are held with 23 gauge forceps. Ring can be removed by disengaging the two notches and pulled out

Figure 1: *zepto capsulotomy.*

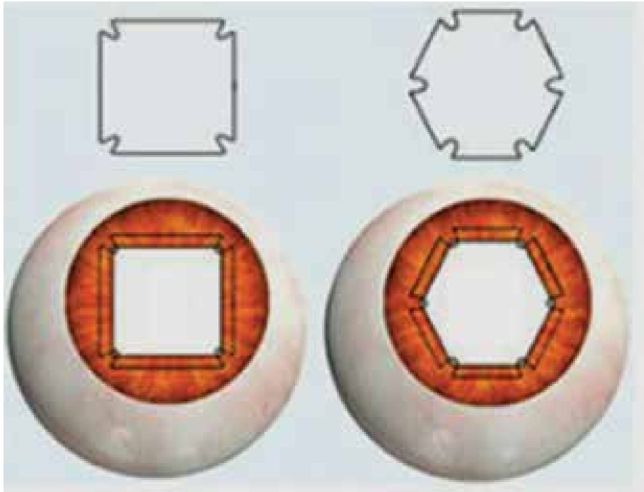

Figure 2: *Square, hexagonal bhattacharjee rings.*

through the incison. It does not require any injector. No sagging is seen at incision site.

PRECHOP is a technique where nuclear fracture is performed mechanically (Figure 3) under viscoelastics prior to phacoemulsification without using any ultasouund or femtosecond laser energy. This minimizes the risk of endothelium damage also reduces total surgical time. Takayuki

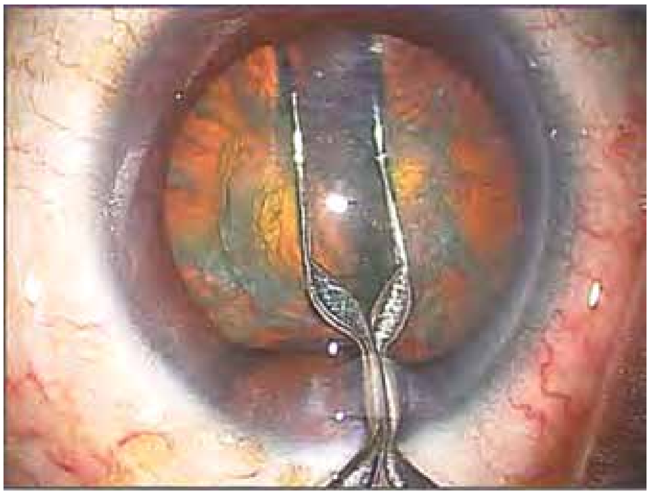

Figure 3: *Impale the closed prechopper blades directly down into the nucleus. Open the blades gradually while pushing the nucleus slightly downward.*

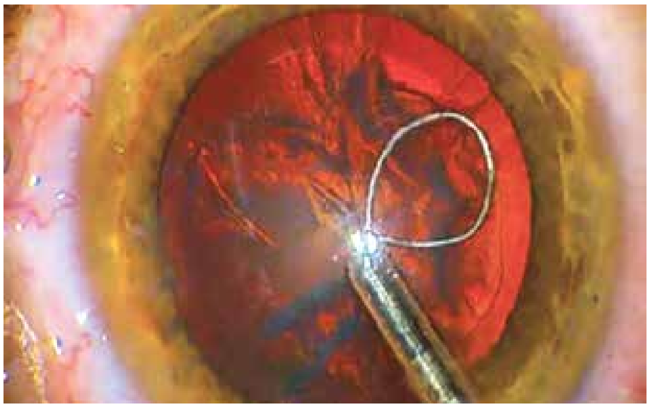

Figure 4: *MILOOP.*

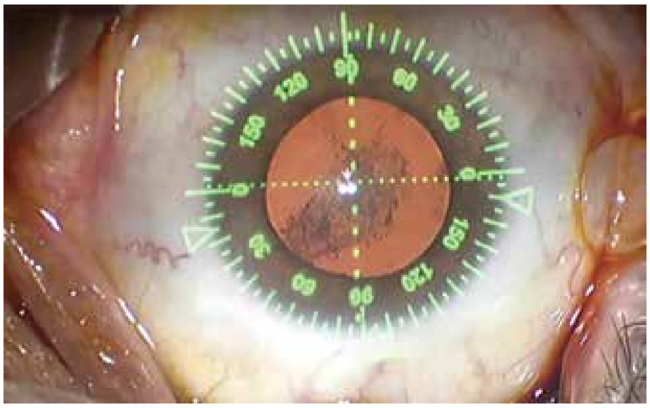

Figure 5: *Toric IOL alignment system.*

Akahoshi has defined two prechoppers and two methods: karate Prechop with the Akahoshi Combo II prechopper for soft cataracts and the Counter Prechop with Akahoshi Universal II prechopper for dense cataracts.

MILOOP. It is a single use disposable instrument (Figure 4). It is nitinol loop which is flexible and retractable. It is designed to be deployed within the capsular bag to encircle the catractous lens. Then the loop is retracted bisecting the lens. It can be used in relatively small pupil, works independent of nuclear density. Economical compared to femtolaser.

TORIC IOL AXIS ALIGNMENT: Intaoperative wavefront aberrometry provides continuous ,real time refractive feedback for astigmatic correction when surgeon is rotating toric IOL. Verion Reference Unit (Figure 5) is a modified keratometer. It captures a high resolution reference image ,measures corneal power and auto detects scleral vessels, limbus, pupil, and iris features thus locking k values to the image.

INTRACAMERAL ANTIBIOTICS Although the use of intracameral cefuroxime has become a standard of care in the European countries, it is far from fully recognized worldwide. Numerous studies have been reported regarding the safety of intracameral moxifloxacin in various concentrations (0.1mg/0.1ml, 0.5mg/0.1ml and 250ug/0.05ml). Intracameral moxifloxacin has been found to be safe and effective for prophylaxis of endophthalmitis with no significant adverse effects on corneal endothelium and retinal thickness[6,7,8].

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Glistenings of Intraocular Lens

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CASE: A 50 year old old man presented with painless, gradual diminuition of vision in the right eye since two months. He had undergone uneventfull cataract surgery one years back with good post op vision gain. His best corrected visual acuity was 6/36. On slit lamp examination, numerous micro cysts in optic of posterior chamber IOL were present along with diffuse haziness. Rest of anterior segment and posterior segment examination was normal. As patient lost all previous records ,no details about the type of IOL placed at time of surgery was present (Figure 1). As patient was facing difficulty in earning his livelihood an IOL exchange was performed and vision was restored to 6/6 (Figure 2).

Figure 1: *Glistenings of IOL.*

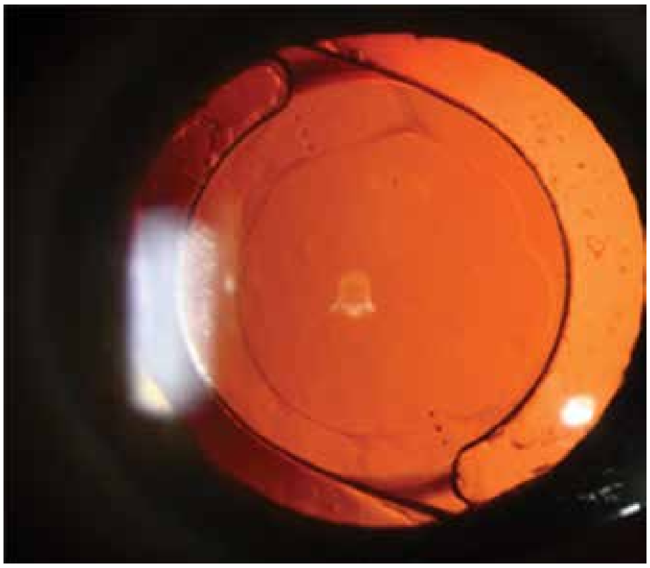

Figure 2: *After IOL exchange.*

Comments: The glistenings in IOLs can cause decrease in visual acuity, contrast sensitivity and loss of special function of premium lenses like multiofocalty. Microscopically glistenings appear as fluid filled opacities in IOL. Numerous instances have been found of glistenings in IOLs like Acrysof[1], phakic IOLs[2], Sensar[3], Tecnis and Hoya. Glistenings in acrylic IOLs are seen to be more visually significant. Small voids in IOL left during manufacturing are filled with fluid after implantation causing glistenings. This is facilitated by change from room temperature to higher temperature inside eye. In most situations, IOL exchange is the simple solution.

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Glistening- Does it Really Matter?

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Summary: *Glistening happens in all types of IOL but it is more evident in hydrophobic IOLs. It remain unnoticed being asympomatic or present with minimum signs and symptoms. Visual acuity is affected in very advance glistening i.e. grade 4 IOL glistening and need explantation. As per literature, only few lenses have been explanted because of diminution of vision due to glistening & our case is one of them. So glistening should be kept in mind as a adverse effect of high index lenses particularly in premium category of cataract surgery.*

A 63 year old male presented to our out patient department with complaints of blurring of vision in right eye since 8 years which is insidious in onset, gradually progressive and painless in nature. Patient had undergone cataract surgery in right eye and left eye 14 years and 12 years back respectively.

On examination, Patient was orthophoric with visual acuity of 6/24 (LogMAR 0.6) in right eye which was not improving with pinhole and 6/6 (LogMAR 1.0) in left eye. On slit lamp examination, Anterior segment of right eye showed multiple shiny pinhead sized structure visible in pupillary area (Figure 1,2,3). On dilatation, multipiece Intraocular Lens (IOL) was present in the bag and linear Posterior Capsular Rupture (PCR) was noted. Rest of anterior segment examination for right eye was within normal limits. Left eye was within normal limits.

Both eye applanation tonometry was 15mm Hg. Fundus examination of both eyes revealed no abnormality.

On the basis of examination, the provisional diagnosis of grade 4 IOL glistening was made. Pitting by Nd:YAG laser to the IOL was kept as a 2nd diagnosis in view of PCR. In view of substandard vision, explantation of this IOL (Figure 4) was decided and replaced with PMMA IOL in sulcus of 6.5mm optic diameter through sclerocorneal tunnel (to have minimum SIA) (Figure 5&6). Postoperatively patient attained 6/6 unaided vision.

Preoperative Photographs

Figure 1: *Torch Light Examination of RE Showing IOL Glistening.*

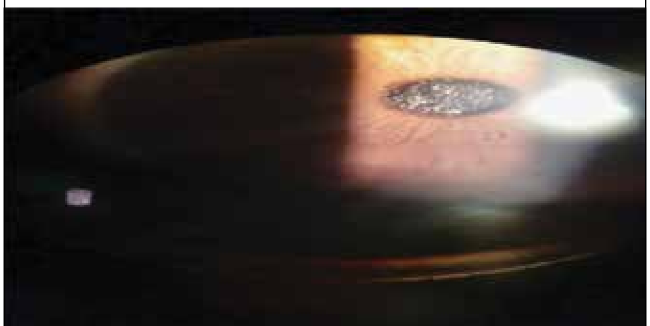

Figure 2: *Focal Illumination of RE Showing IOL Glistening.*

Figure 3: *Diffuse Illumination of Dilated RE Showing IOL Glistening.*

GLISTENING - DOES IT REALLY MATTER ???

Glistening is fluid filled Micro-vacuoles that form within the intraocular lens optic, in aqueous environment[1].

Glistening is more evident in hydrophobic lenses but it has been observed that glistening occurs in all type of lenses having different materials like hydrophilic acrylic, PMMA, and silicon. Some studies such as a prospective clinical trial by Miyata et al observed glistening in 50% of their cases within 6 months postoperatively[2]. It is still controversial that severity of glistening increases with time or it stabilizes after initial increase.

INCIDENCE

Mainly hydrophobic lenses were included in various studies and accordingly.

- At three month- 20% lenses shows glistening.
- At six months - 51% lenses shows glistening.
- At one year - 55% lenses shows glistening[3].

A pilot study in 2001, reviewed 254 eyes and concluded 62% eyes are having mild glistening, 16% moderate, 11% having marked and 1% having severe glistening. (Dr Richard Smith, Australia)[4].

GLISTENING IN DIFFERENT MATERIAL OF INTRAOCULAR LENS

Glistening happens because of difference in or refractive index in lens material and water microdroplets trapped into the polymer of lens material. The index of lens material varies from 1.43 to 1.55 and refractive index of water is 1.33. Higher the refractive index higher the incidence of glistening.

FORMATION OF GLISTENING

Microvacuoles results due to water absorption, vapourisation and subsequent condensation in polymer of lens material, influenced by temperature, inflammation and aqueous compositions and medications. Other theory explained the migration of hydrophilic impurities into the hydrophobic lens[5].

CLINICAL FEATURES

Symptom

1. Asymptomatic.
2. Visual acuity remains same even with 2+ or 3+ glistening[14]
3. Glare in majority of cases.

SIGNS

1. Contrast sensitivity at higher spatial frequency is affected with glistening while there was no change in contrast sensitivity of lower frequency[16].
2. Slit lamp examination – Grading of glistening density
   - With slitlamp beam set at 10mm by 2mm – Graded as trace= fewer than 10;
     1+ = 10 to 20; 2+ = 20 to 30; 3+ = 30 to 40; and 4+ => 40.
   - In study by miyata et al, the grades were 0= no glistenings; 1= up to 50/mm3;
     2= upto 100/mm3; and 3= upto 200/mm3.

EFFECT ON VISUAL FUNCTION

A. Glistening ranging from traces to 2+ has reduces the contrast sensitivity significantly[6].

Postoperative Photographs

Figure 4: *RE Explanted Multipiece IOL with Deposits.*

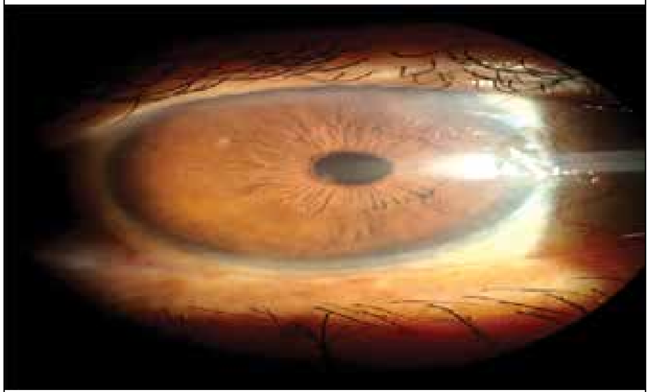

Figure 5: *Diffuse Illumination RE Pseudophakia.*

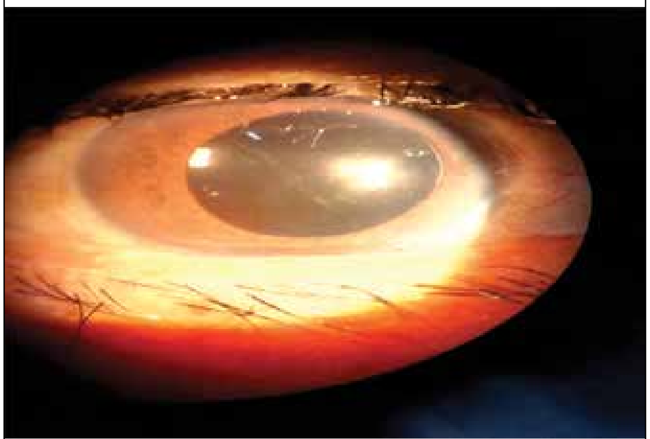

Figure 6: *Diffuse Illumination of RE in Dilated Pupiil, IOL in sulcus.*

B. Visual acuity is reduced significantly in 2+ or more glistening[7]

C. Few studies like Miyata et al conclude that glistening upto 2+ did not affect visual acuity significantly[15,17].

D. Scattering and glare are also associated with glistening.

FACTORS INFLUENCING GLISTENING FORMATION

Besides IOL material composition,

A. IOL manufacturing technique – cast moulding and lathe cut techniques. Glistening is seen more commonly in cast moulding technique because of molecular weight dispersion and heterogenous parts containing unreacted monomers if polymerisation is not complete[8].

B. IOL packaging – Acrypack and wagon wheel technique of packaging. Acrypack packaging is associated with more glistening as IOL and folder underwent terminal sterilization within this plastic case leading to change in microenvironment of IOL, facilitating glistening formation[9].

C. Associated conditions such as glaucoma or those leading to breakdown of blood aqueous barrier (postop inflammation)[10,11,12].

D. Concurrent Ocular medications and systemic condition like diabetes mellitus increase glistening formation[13].

INVESTIGATION

Schiempflug photography could be used to quantify glistenings, as different types of irregularities, damages, or disturbances in the transparency of IOL material could be identified by more or less intensive light scattering[18,19].

DIFFERENTIAL DIAGNOSIS

1. Posterior capsular Opacification.
2. IOL Pitting During Nd:YAG laser capsulotomy.
3. Cells and debris deposit in hydrophilic IOL.

TREATMENT

Most of the patients are asymptomatic and does not require any treatment. IOL explantation and exchange is recommended in patients complaining of glare and vision disturbance.

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SMILE COMPLICATION

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With increased prevalence of myopia, demand of refractive surgery has increased. And demand leads to innovation. LASIK is a well established technique for correction of refractive error. Making flap using microkeratome has largely given way to femtosecond technology. 10-15 pulses of energy are used to create a flap with little or no collateral damage. This technology gives you precise control, customization and reproducible results.

Sekundo et al[1] came up with their prospective study on femtosecond lenticule extraction (Flex) in which they used femtosecond laser to create a corneal flap as well as to created a lenticule in the corneal stroma and extracted it with appropriate instruments. This procedure had a good safety profile with good post operative results. This procedure obviated the need for eximer laser.

Then came small incision lenticule extraction (SMILE)[2]. Although the principle was same as described above, but instead of creating a flap, lenticule was extracted using a cap cut of 2-5 mm. Thus, it prevented flap related complications. It also has few other benefits like increased corneal biomechanical stability, decreased severity of dry eye due to better preservation of corneal nerves[3], early recovery, better post operative comfort etc.

But SMILE is also associated with its unique set of complications. We report a unique and an unexpected complication that can occur while lenticule extraction.

CASE REPORT

A 20-year-old male, third year graduate student with myopia since 11 years of age came to our center for refractive correction. He had been using glasses since 9 years and wanted to get rid of them as an eligibility criterion to some government services. He had never used contact lenses. His power of glasses had not changed for the last one and a half years. There was no history of past redness or discharge. No history of drug abuse. Patient was systemically fit.

We worked him up for refractive surgery. UCVA was 6/60 in OU. BCVA in OD was 20/30 in OD and 20/20 in OS with -4.25D sphere and -0.75D cylinder at 40 degrees in OD and -4.25D sphere and -0.50 D cylinder at 140 degrees in OS on post mydriatic testing. Keratometry measured under dilated pupils using automated keratometer was 45.50/46.75D at 42/132 degrees in OD and 45.25/46.00D at 131/41 degrees in OS. Thinnest pachymetry using oculus pentacam was 508 microns in OD and 499 in OS. There were no significant posterior elevations and BAD score was within normal range. Intraocular pressures were 12 mm Hg in OD and 14 mm Hg in OS, as measured by non contact tonometry. Fundus examination was done by indirect ophthalmoscopy. Disc and macula were healthy with no peripheral treatable lesions.

We planned the patient for SMILE surgery with informed consent using VISUMAX, ZEISS system. Patient was also made aware of the procedure. Data entry was done. Optical diameter was 6.3 mm in OU and cap diameter was 7.3 mm in OU. Transition zone was kept at 0.1 as there was cylindrical refractive error present. We used a two incision technique in which two cap cuts of 2mm each were preset at 120 degrees and 359 degrees. The cut at 359 degrees was kept as a rescue incision just in case the lenticular dissection was difficult from the other incision or to relieve the lenticule of some tight adhesions. Residual stromal thickness as determined by the machine was with in normal surgical limits.

Docking was performed in OD with lenticule cut, side cut, cap cut and cap opening incisions successfully completed. Lenticule was approached using the 120-degree incision. First the anterior plane was demarcated, then the posterior plane. Then the dissection of anterior plane was completed using blunt instrument and subsequently that of the posterior plane. Then the lenticule was extracted. Interface was washed and excess fluid was extruded from the interface by gently pressing on the cornea. Antibiotic was put. Procedure was uneventful.

OS was approached in a similar fashion. Docking and various cuts performed by the machine were uneventful. Few black spots were visible in the inferonasal portion of the lenticule. Anterior and posterior plane were dissected gently with difficulty in releasing adhesions in the inferonasal portion. Other incision at 359 degrees was also used but with no result and lenticule was attached in the inferonasal portion. So it was decided to use the lenticule holding forceps (Tan DSAEK forceps[4]) (Figure 1) to do a lenticulorrhexis and extract the lenticule. Lenticule was grasped and lenticulorrhexis was performed. Lenticule was re grasped and while pushing it in, it was noted that the margin of the cap side cut got stuck in the hinge between the sliding sleeve of the forceps and the hub of the forceps. So while extracting there was a tear in the cap at that localized area near the cap cut with tissue loss (Figure 2). Interface was washed and bandage contact lens was put to help

Figure 1

Figure 2

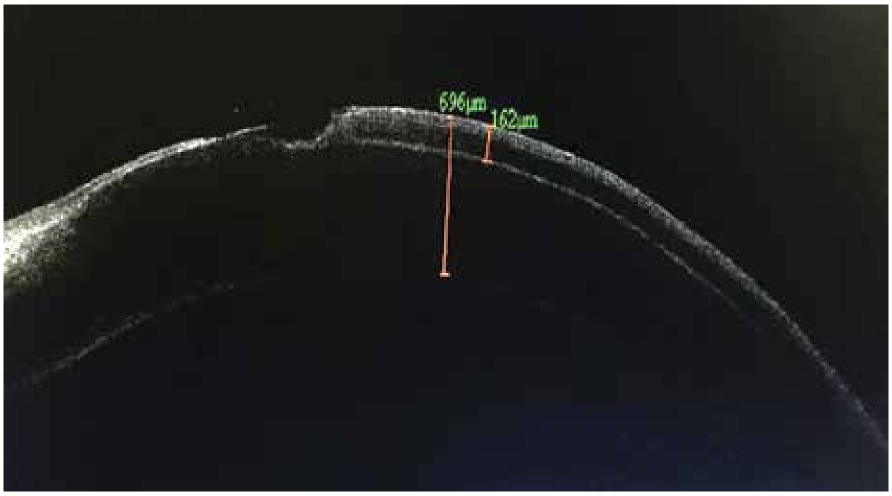

Figure 3

in the healing of the defect. Antibiotic drops were put.

AS-OCT was done post surgery (Figure 3). There was a defect present in the supero-nasal portion of the cornea with a depth of 102 microns.

Patient was started on moxifloxacin eye drops 4 times a day in OU, predacetate eye drops 6 times a day with taper to be started after 1 week and cycloplegia for 3 days.

Patient was followed up the next day. Vision in OD was 20/30 and in OS was 20/20. Bandage contact lens was removed. The defect in the cap had healed and patient was comfortable with no photophobia and good vision. Intraocular pressure was 12mm Hg in OD and 14 m Hg in OS.

Serial follow ups showed localized scarring in supero-nasal area near cap side cut. But patient had good vision and no intervention was required.

DISCUSSION

Everything was routine in our patient till the cap cut margin got stuck between the sleeve and hub of the forceps. This was a new complication and a rather unexpected one. Surgeon's focus is generally on the tip of the instrument and the working area. Also the instruments are generally designed in such a fashion that they do not engage the tissue from the portion they are not supposed to. Post surgery we reviewed the surgical video and there was clear cut evidence of the margin getting stuck between the hub and the sleeve. We also tried to engage a thin piece of paper from that area and it actually caught hold of it in 2 or 3 attempts and tore it apart. Thus, incidentally it can happen and caution has to be exerted if the junction of the forceps is at the cap side cut margin. If you are totally inside the interface or only a part of grasping portion is inside, this complication is unlikely.

Many complications have been associated with SMILE while dissecting the interface and extracting the lenticule like cap tear[5], cap side cut extension, inadvertent dissection of posterior plane prior to anterior plane[6], difficult lenticule extraction[7], entry into posterior stroma, retained lenticule[8], opaque bubble layer causing difficult dissection[9], black spots[10] causing increased resistance to dissection etc. But this complication has never been reported before.

Although it didn't lead to any adverse visual outcome. But, it could have if the cap tear would have extended till pupillary axis. So great caution should be exerted while performing the extraction using forceps. Vitreoretinal forceps in which there is no sleeve present can prove to be better alternative in cases lenticulorrhexis has to be done. Also if the lenticule is totally free, it can be extracted using a blunt spatula type instrument specifically designed for that purpose.

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Diagnosis and Management of Reverse Implantable Collamer Lens (ICL)

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Abstract: *With the use of intraoperative continuous Optical coherence tomography (icOCT), explantation and reimplantation of a reversely implanted Implantable Collamer Lens (ICL) was performed. The postoperative anterior segment OCT revealed an adequate vaulting of 0.96 mm in the right eye and the vision improved from 6/24 OD on day 5 to 6/6 OD on day 30 with an intraocular pressure of 14 mm of Hg. Intraoperative continuous OCT helps in guiding the proper orientation of the ICL during implantation and for confirming adequate vaulting. The reversely implanted ICL can be managed with good outcome by the described technique here for reimplantation*

The implantation of reverse Implantable Collamer Lens (ICL) is rarely reported because of prompt diagnosis of inversion intraoperatively and management in the same sitting; but rarely because of inexperience and improper technique, inversion can go unnoticed. Here we describe the diagnosis and management of Reverse ICL.

CASE SUMMARY

A 22-year-old female presented to us with complaints of pain, redness and diminution of vision in the right eye for the past three days with uncorrected visual acuity (UCVA) of finger counting OD and 6/6 OS. She had undergone both eye implantation of Visian Implantable Collamer Lens (ICL) with Centraflow (STAAR, Monrovia, CA) one month back. The lenses implanted were -5.00 D spheres OD and -5.50 D spheres, both of size 13.2 mm. The patient was noted to have high intraocular pressure (40 mm of Hg) in the right eye and had received oral acetazolamide 250mg four times a day for last 3 days along with 5ml/kg body weight of intravenous mannitol and topical brimonidine and timolol. On slit lamp examination (Figure 1A), right eye showed ciliary congestion, corneal edema, fine endothelial pigments, very shallow angle, a deep anterior chamber containing viscoelastic material with ICL touching the crystalline lens. A diagnosis of right eye reverse ICL with secondary angle closure glaucoma was made, and the patient was immediately taken up in emergency operation theatre for ICL explantation followed by reimplantation. The diagnosis was confirmed using microscope mounted intraoperative continuous Optic Coherence Tomography (Carl Zeiss Meditec RESCAN 700, icOCT) (Figure 1B).

Three microvitreoretinal (MVR) blade entries were made and viscoelastic (HPMC) was injected into the anterior chamber above and below the lens. The ICL was lifted using a Visco cannula and the trailing haptic followed by leading haptic taken out and positioned over the iris. This was followed by 3.2mm entry and ICL was removed using Mcpherson by holding at the optic-haptic junction. The ICL was reloaded and injected into anterior chamber followed by tucking of trailing and leading haptic under intraoperative continuous OCT (icOCT) guidance. Viscoaspiration followed by wound hydration was done and vaulting of ICL (Figure 1C) was confirmed on icOCT (video).

UCVA on post-operative day 1 was finger counting OD and 6/6 OS. Endothelial counts were 1916 cells/ cumm OD and 2785 cells/ cumm OS measured using specular microscopy (CEM-530, NIDEK, Japan). On post-operative day 5, uncorrected visual acuity was 6/24 OD and 6/6 OS and intraocular pressures were 14 mm Hg OD and 16 mm Hg OS. ASOCT revealed vaulting of 0.96 mm OD and 0.78 mm OS (Figure 1D) which was also checked on the Pentacam (Oculus Inc., Lynnwood, WA). On postoperative day 10 (Figure 2A) her UCVA was 6/12 OD and 6/6 OS with intraocular pressures of 12 mm Hg OD and 14 mm Hg OS. Patient was followed up on postoperative Day 30 (Figure 2B) and her UCVA was 6/6 OD and 6/6 OS with vaulting of 0.95 mm OD (Figure 2C and 2D) and 0.78 mm OS.

DISCUSSION

Phakic IOLs (pIOL) may rarely present with inversion and may be associated with cataract formation, pigment dispersion, and pupillary block glaucoma[1]. To avoid these complications, proper technique should be used for ICL loading and delivery, ensuring that the leading right haptic and trailing left haptic has a hole and a safe distance is maintained between the back surface of the pIOL and the anterior surface of the crystalline lens. Vaulting is the least distance perpendicularly from the ICL surface to the lens apex which ideally should be 1.0 to 1.5 times the central corneal thickness of the patient[3]. The patient had an inverted ICL implanted, which was there in the eye for 4 weeks and the ICL needed to be removed undamaged and reinjected. The correction of inadvertent placement of reverse ICL has been described using visco-cannula in the same sitting[2] or at a later sitting but as soon as possible.

Alio et al demonstrated the reasons and rates of ICL explantation and found cataract as the most frequent cause (55% overall for pIOLs and 65.28% for posterior chamber pIOLs)[4]. ICL-lens touch has been said to be the major cause behind cataract formation[5]. The Centraflow ICL has significantly reduced the chances of glaucoma and the need for peripheral iridectomy[6], however a reverse placement may lead to inadequate vaulting with shallowing or closure of angle[7]. The

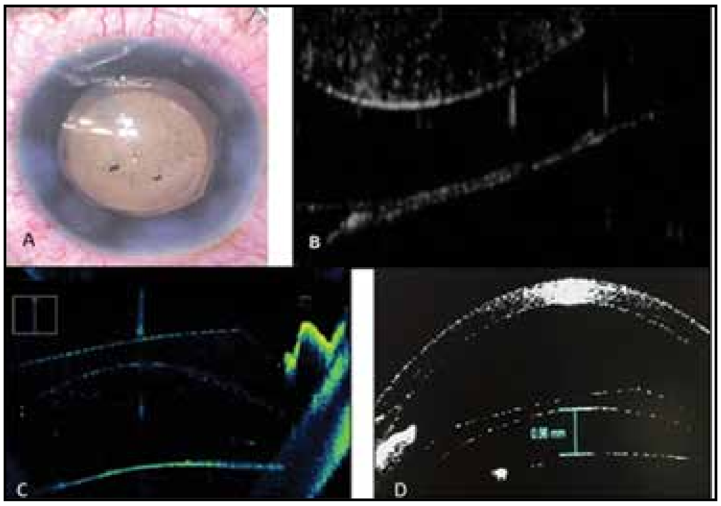

Figure 1: ***(A)*** *Intra-op image of right eye showing ciliary congestion, ICL in situ and retained viscoelastics behind the ICL.* ***(B)*** *Microscope integrated intraoperative OCT showing reversed right eye ICL before explantation.* ***(C)*** *After reimplantation* ***(D)*** *ASOCT image showing vaulting of ICL on postoperative day 10.*

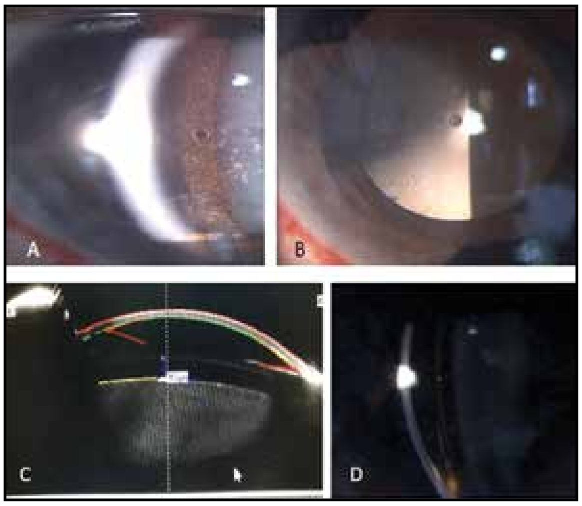

Figure 2A: *Postoperative clinical photographs of right eye showing the ICL in place on postoperative Day 10 (A) and Day 30* ***(B)****. Day 10 shows some viscoelastic material over anterior capsule which has reduced in Day 30.* ***(C)*** *Pentacam Scheimpflug image showing vaulting of ICL on postoperative Day 30.* ***(D)*** *Slit lamp picture showing adequate vaulting.*

early acute rise of intraocular pressure can happen due to viscoelastic material retention. Hence proper visco-aspiration should be done to remove the viscoelastic substance. Despite acute pupillary block glaucoma being much less common it can cause rapid and irreversible vision loss. In this case, the diagnosis of reverse ICL was confirmed using icOCT, which showed the ICL touching the lens and peripheral vaulting leading to shallowing of angle. Earlier ASOCT has been used to document a reverse ICL but icOCT not only helps in recognizing proper orientation and vault8 of the ICL during the surgery, it also avoids the inadvertent occurrence of a reverse ICL placement.

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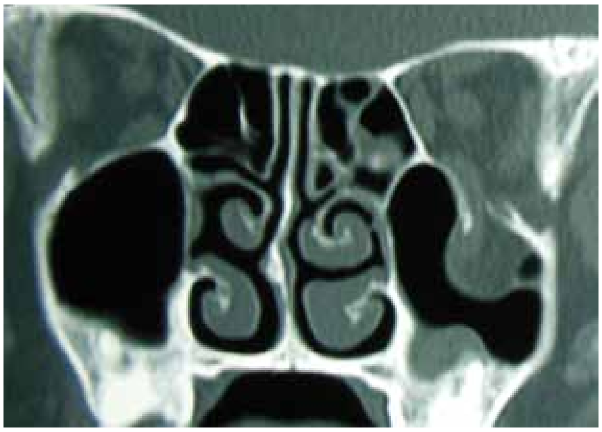
DOS Times Quiz 2017-18

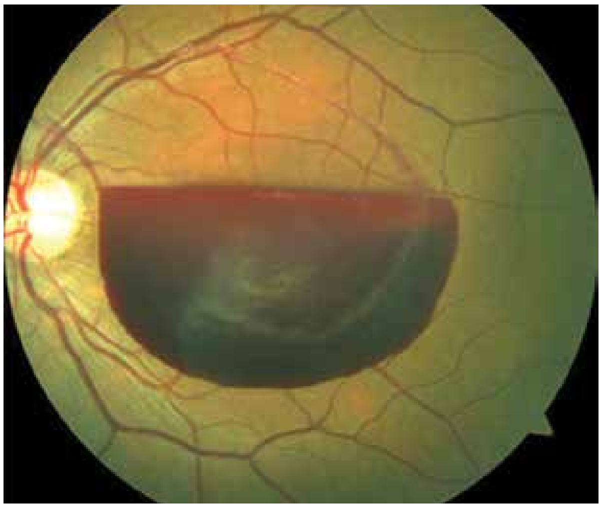
Episode-5

Last date: Completed responses to reach the DOS Office by e-mail or mail before 5 pm on 25th May, 2018

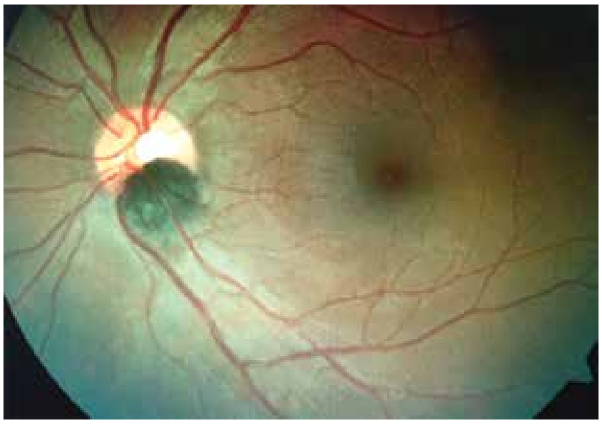
Q1. Identify the sign?



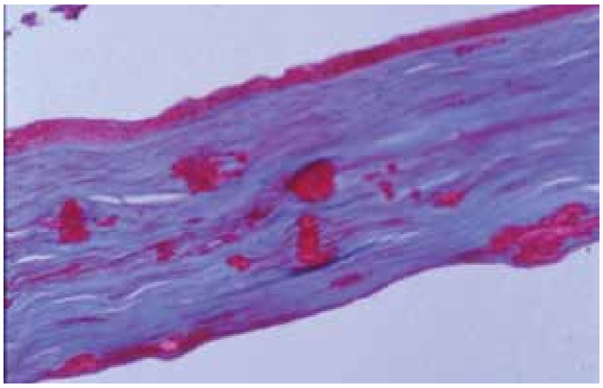
Q2. Identify the condition?



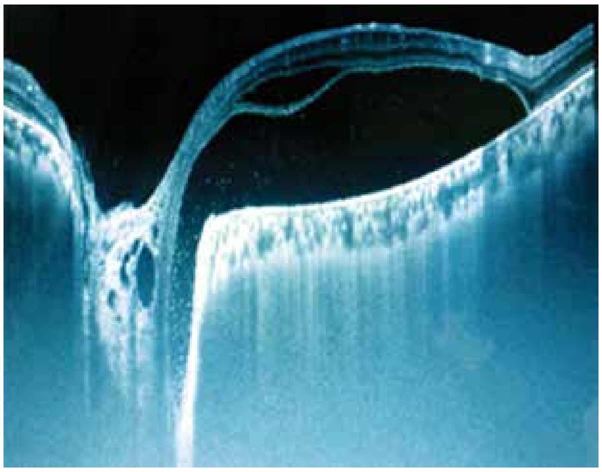
Q3. Identify the condition?



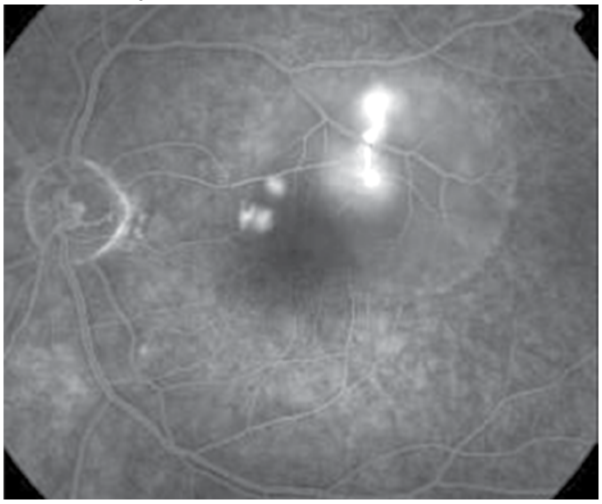
Q4. Stain used and diagnosis?



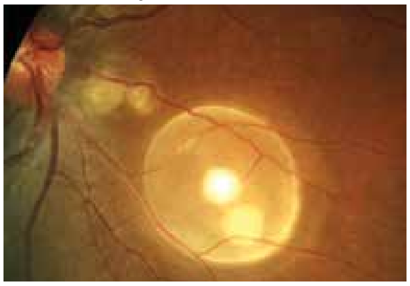
Q5. Identify the condition?



Q6. Identify the condition?



Q7. Identify the condition?



Q8. Name the flap?

Q9. Name this condition caused by a mid-brain lesion?

Q10. Identify this condition?

Compiled by:

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All India Institute of Medical Sciences,
New Delhi

Dr. Manish Mahabir

DOS Times Quiz Rules

1. DOS Times Quiz will now feature as **5 Episodes** (Episode 1: July-August, Episode 2: September – October, Episode 3: November – December, Episode 4: January – February, Episode 5: March – April). Entries will have to be emailed before the last date mentioned in the contest questions form. Late entries will not be entertained.
2. Please email (as scanned PDF Only) completed responses for the quiz along with details of the contestant **filled in and signed** to dostimes10@gmail.com (with cc to dosrecords@gmail.com) or mail to DOS Times Quiz, Dr. Subhash Dadeya, Room No. 205, 2nd Floor, OPD Block, Guru Nanak Eye Centre, Maharaja Ranjit Singh Marg, New Delhi.
3. Nonmembers may also send in their entries but will be required to send along with their completed entries, the completed membership application (with the required documents) to enroll as member. Failing this their entries into the contest will not be considered.
4. Contestants are requested to attempt all the 5 episodes of the Quiz contest and send in their applications within the date specified. No entries will be entertained after the last date. The scores of each contestant for all 5 episodes together will be compiled at the end of episode 5 and the winner will be announced in the DOS Annual Conference in April 2018. In the event of more than one winning contestants, a draw of lots will decide the winner. Winner of each episode will also be published in the next episode along with the previous episode answers.
5. Please write to dostimes10@gmail.com or dosrecords@gmail.com for further clarifications if any.

Q. No. Completed Responses for DOS Times Quiz: Episode 5

1. ____________________	6. ____________________
2. ____________________	7. ____________________
3. ____________________	8. ____________________
4. ____________________	9. ____________________
5. ____________________	10. ____________________

Contestant Details

Name: ______________________ Degree: ______________

Designation: ______________________ Address: ______________________

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DOS CROSSWORD

Episode-5

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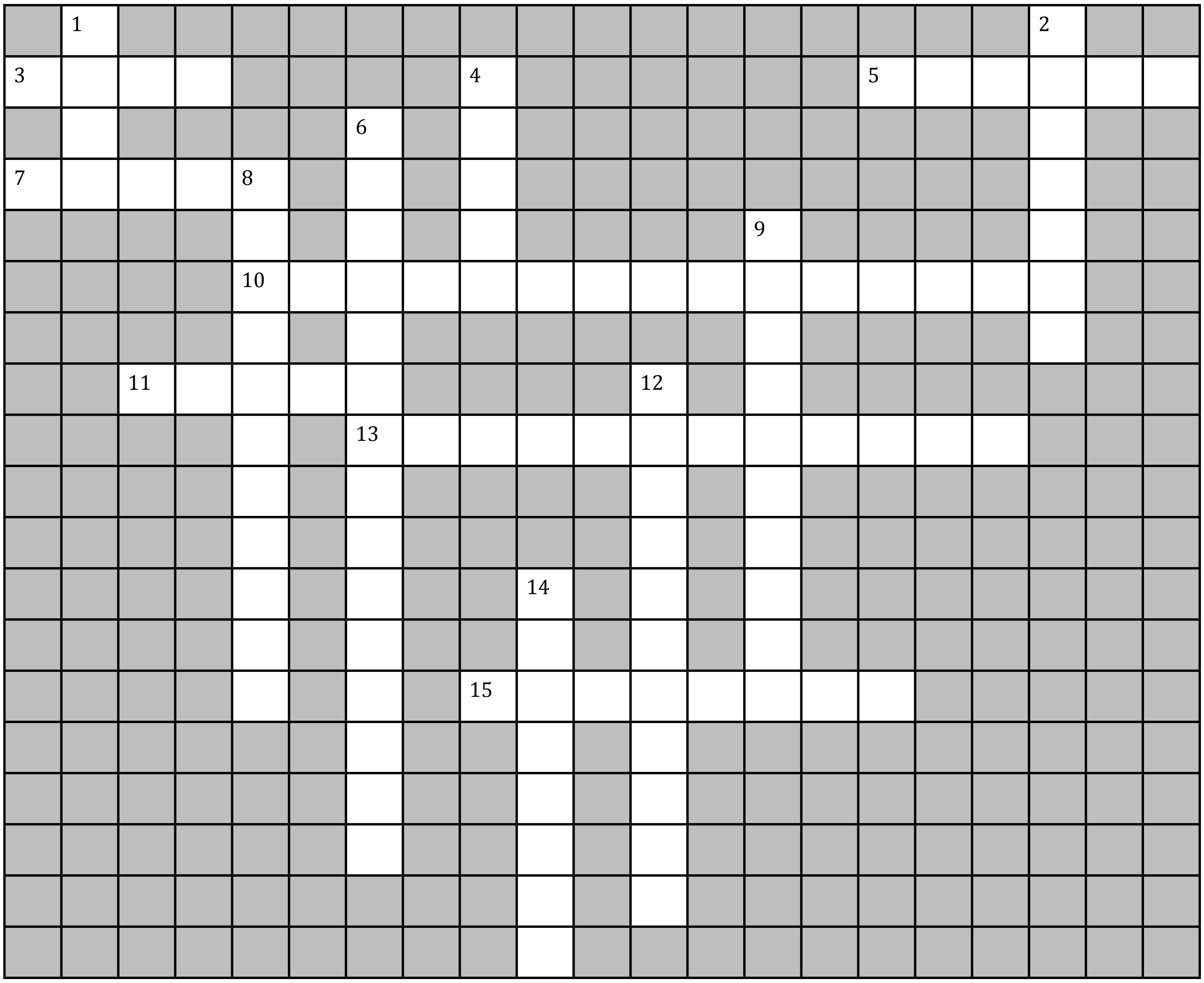
New Delhi



DOWN

3. Custom wavefront ablation generally removes _____ tissue than a standard ablation in the same eye(4)
5. Author of 'Through my Eyes, The Story of a Surgeon who Dared to Take on the Medical World'(6)
7. Inlay indicated for intrastromal corneal implantation to improve near vision by extending the depth of focus in(5)
10. Overnight use of RGP contact lens to temporarily reduce myopia(15)
11. Every 10 degree off-axis rotation of a toric lens reduces correction by approximately one ....(5)
13. Site of antibiotic use to reduced the occurrence of postoperative endophthalmitis(12)
15. Phenomenon in which, tangential incisions lead to flattening in the meridian of incision, and steepening in the meridian 90 degree away(8)

ACROSS

1. Common higher order aberration in patients with decentered corneal graft, keratoconus and decentered laser ablation(4)
2. Scleral lens for the therapeutic management of ocular surface disease from dry eye(7)
4. Electrical nanopulses delivered to a nitinol ring to create capsulotomy(5)
6. Laser transforms tissue into plasma(15)
8. Gradual tapering of diffractive steps from centre to periphery of a lens(11)
9. Introduced first phakic IOL(10)
12. Geometric rule that describes the orientation of the plane of focus when the lens plane is not parallel to the image plane(11)
14. Combined corneal and intraocular refractive procedure(8)

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DOS Times is published once in two months (i.e six issues in a year: July – August, September – October, November – December, January – February, March – April, May – June). Solicited and unsolicited manuscripts of good quality academics are accepted provided that they are not under consideration for publication in any other journal. All submitted manuscripts are subject to editorial review before acceptance.

You may submit your manuscripts along with a covering letter addressed to

Address for all correspondence
Dr. (Prof.) Subhash C. Dadeya
Secretary - Delhi Ophthalmological Society
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or by email to dostimes10@gmail.com
In case of any queries please contact Mr. Sunil Kumar, DOS Times assistant @ 011-65705229 or by email (dostimes10@gmail.com).

SCOPE OF THE JOURNAL

DOS Times covers clinical, experimental and basic science research studies related to medical, ethical and social issues in field of ophthalmology. Articles with clinical interest and implications are given preference.

MANUSCRIPT SUBMISSION AND PROCESSING

A manuscript is reviewed for possible publication with the understanding that it is being submitted to DOS times alone at that point in time and has not been published anywhere, simultaneously submitted, or already accepted for publication elsewhere. Initial screening by the editorial desk assesses the formatting, topicality and importance of the subject, the clarity of presentation, and relevance to the target audience of the journal. Acknowledgement of receipt of all manuscripts will be sent to the corresponding author, once the editorial desk reviews the manuscript for conforming to the requirements of the journal.

Manuscripts that are found suitable for publication are sent to two or more expert reviewers for Peer Review through an online reviewer system. The identities of reviewers and authors are kept confidential. Authors and Reviewers are required to disclose potential conflicts of interests/ financial interests.

The comments and suggestions (acceptance/ rejection/ amendments in manuscript) received from reviewers are conveyed to the corresponding author. Corresponding authors are requested to submit the revised manuscript along with one highlighted copy with revisions highlighted. The final decision on acceptance of the manuscript for publication lies with the Editor-in-chief. This process is repeated till reviewers and editors are satisfied with the manuscript. Manuscripts accepted for publication are copy edited for grammar, punctuation, print style, and format.

CONFLICTS OF INTEREST

All authors must disclose all conflicts of interest they may have with publication of the manuscript or an institution or product that is mentioned in the manuscript and/or is important to the outcome of the study presented

MANUSCRIPT PREPARATION

Manuscripts under the following subheadings may be submitted:

Type	Word limit	Reference limit	Abstract
Original article These include randomized clinical trials, prospective and retrospective observational and interventional studies, questionnaire-based studies, qualitative data based studies, quality of life studies etc. excluding references, abstract, figures and tables	2500	40	Structured 150-200 words
Review articles Includes comprehensive and systematic literature review and meta-analysis. Review articles can be commissioned either by editorial invitation or by submitted proposals	3000	50	Unstructured 150-200 words
Perspectives Authors will be asked to give opinion on a topic of interest. These should be evidence based and relevant and give perspective and practical applications to existing knowledge.	1500	30	Unstructured 100 words
Recent advances Summary of latest in clinical research, instrumentation and web resources in ophthalmology.	1500	30	Unstructured 100 words
Techniques Novel surgical techniques or instrumentation that have the potential to reduce surgical complexity and/or enhance outcomes.	1500	30	Unstructured 100 words
Case reports Interesting cases with immense clinical significance / rare case reports *Subheadings: Introduction, case and discussion*	1000	10	Unstructured 100 words
Photo-essay/snap shots Reports of unusual/uncommon clinical case scenarios with good photographic documentation *Subheadings: Introduction, case and comment*	500	10	Unstructured summary in 100 words

All manuscripts should have the following:

1. Title of the manuscript
2. Type of manuscript
3. Name(s) and surnames of authors with highest academic degree
4. Author affiliations: Department, Institution, and contact details
5. Corresponding author: name, designation and credentials, address, phone, fax, email and digital passport size photograph
6. Information about patient consent and approval for photographs that disclose the identity of the patient.
7. Please submit as word file with embedded figures
8. Figure legend at the bottom of figure
9. Tables with numbering and heading at the top embedded in the text file
10. References as superscripts without brackets numbered consecutively in text. References should be written in standard international format as in Pubmed: Authors. Title of citation quoted. Name of journal Year of publication; Volume number, Page numbers.
11. Abbreviations spelled out at the first appearance in the text.
12. Generic drug names are to be used in text, tables, and figures. Suppliers of drugs, equipment, and other brand-name material are to be credited in parentheses (company, name, city, state, country).

DOS Travel Fellowship for Partial Financial Assistance to Attend Conferences

Applications are invited for DOS Fellowship for partial financial assistance to attend conference(s).

Conferences
International: Eight fellowships per year.
- Maximum of Rs. 50,000/- per fellowship will be sanctioned

Partial travel fellowship to attend AIOC: Five fellowships per year

The last date of DOS Fellowship for Partial Financial Assistance to Attend Conference(s) for receiving application is 30th September for National Conference.

Maximum of Rs. 10,000/- per fellowship will be awarded out to five one to the winner of the DOS best paper (A C Aggarwal Trophy) for travel to present the paper in the forthcoming AIOC.

Eligibility
- DOS Life Members (Delhi Members only)
- 75 or More DCRS Points
- Accepted paper for oral presentation, poster, video or instruction course or invited guest speakers

Time since last DOS Fellowship
Preference will be given to member who has not attended conference in last three years. However if no applicant is found suitable the fellowship money will be passed on to next year. Members who has availed DOS fellowship once will not be eligible for next fellowship for a minimum period of three years.

Authorship
The fellowship will be given only to presenting author. Presenting author has to obtain certificate from all other co-authors that they are not attending the said conference or not applying for grant for the same conference. (Preference will be given to author where other authors are not attending the same conference). If there is repeatability of same author group in that case preference will be given to new author or new group of authors. Preference will also be given to presenter who is attending the conference for the first time.

Quality of Paper
The applicant has to submit abstract along with full text to the DOS Fellowship Committee. The committee will review the paper for its scientific and academic standard. The paper should be certified by the head of the department / institution, that the work has been carried out in the institution. In case of individual practitioner he or she should mention the place of study and give undertaking that work is genuine for invited guest speakers & instruction courses only acceptance letter is required. The fellowship committee while scrutinizing the paper may seek further clarification from the applicant before satisfying itself about the quality and authenticity of the paper. Only Single best paper has to be submitted by the applicant for review (6 copies). Quality of the paper will carry 50% weightage while deciding the final points.

Poster and Video
The applicant will need to submit poster and video for review.

Credit to DOS
The presenter will acknowledge DOS partial financial assistance in the abstract book / proceedings.
The author will present his or her paper in the immediate next DOS conference and it will be published in DJO / DOS Times.

Points Awarded

1) Age of the Applicant	**Points**
a) $\leq$ 35 years	10
b) 36 to 45 years	07
c) 45 years plus	05

2) Type of Presentation

a) Instructor/ Co-instructor of Course	12
b) Free Paper (Oral) / Video	07
c) Poster	05

3) Institutional Affiliation

a) Academic Institution	15
b) Private Practitioner	20

4) The points awarded for DCRS rating in the immediate past year

a) > 150	10
b) 75 – 150	5
c) < 75	Not Eligible

Documents

- Proof for age. Date of Birth Certificate
  Original / attested copy of letter of acceptance of paper for oral presentation / video / poster or instruction course / invited talks.
- Details of announcement of the conference
- Details of both International & National Conferences attended in previous three years.
- Copy of letter from other national or international agency / agencies committing to bear partial cost of conference if any.
- Original air travel boarding passes and photocopy of the attendance certificate of the conference.
- Fellowship Money will be reimbursed only after submission of all the required documents and verified by the committee.
- Undertaking from the applicant stating that above given information's are true.
- If found guilty the candidate is liable to be barred for future fellowships.

Application should reach **Secretary's office** and should be addressed to Chairman Travel Grant Fellowship Committee before February 20, June 30, September 30 and December 30 for International Conference and National Conference. The committee will meet thrice in a year in the month of August, November and February within 2 weeks of last date of receipt of applications. The committee will reply within four week of last date of submission in yes/no to the applicant. No fellowship will be given retrospectively.

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Pearls in IOL Power Calculation Post Refractive Surgery

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Patient counselling should be focused on the fact that all the possible assessments will be used for accurate biometry, but IOL exchange if a refractive surprise occurs will be an option.

Sources of prediction error in IOL power calculation after refractive surgery are the errors in estimating the true corneal power (corneal radius measurement error, the keratometer index error), effective lens position, and the IOL power calculation method error. Altered keratometric value is no longer predictive of the anterior chamber depth and ELP.

Conventional topography and keratometry measure the corneal radius of curvature in 3-4 mm paracentral area, which erroneously measures higher than the more central cornea in post RK and myopic laser vision correction, resulting in overestimation of the corneal power and eventually in a hyperopic postphaco refractive error.

Calculator methods for IOL power can be divided into 3 groups according to whether the refractive surgery data are known, partly known, or not known.

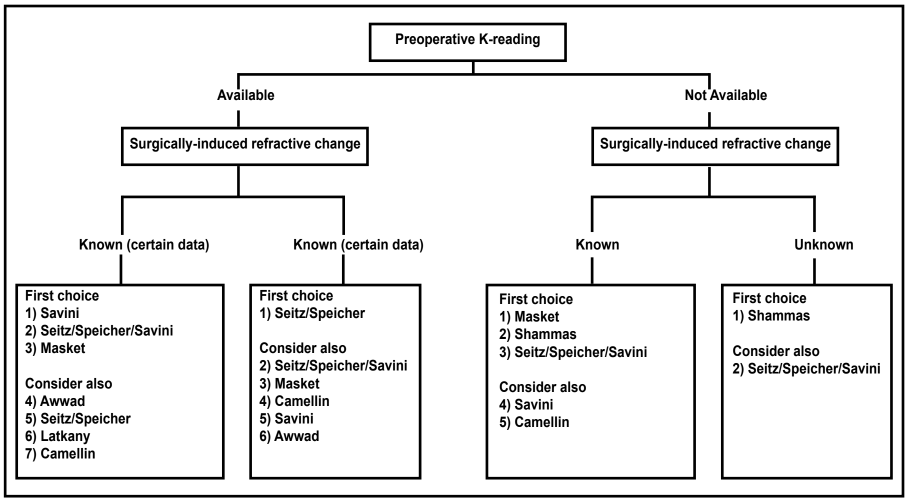
Methods that require pre-PRK/LASIK data (including the clinical history method, corneal bypass method, and Feiz-Mannis method) produced results associated with less accuracy in their predictions. It may be because they do not account for corneal changes resulting from the initial laser procedure.

Aramberri proposed an approach known as the double K method, which uses prerefractive surgery Ks to estimate the ELP and postrefractive surgery Ks to determine the actual corneal power for the vergence formula. This applies to all third-generation formulas (SRK-T, Holladay-I and Hoffer Q) except Haigis because the it does not include the K reading in the estimation of the ELP. Some fourth-generation formulae, as the Holladay-II, include a standard keratometric value of 43.86 D for the estimation of the ELP in cases of previous corneal refractive surgery, along with several other measured parameters.

The Haigis-L method is the most popular method for IOL power calculation after refractive surgery.

Metaanalysis suggest that the Masket method is more predictably accurate than the popular Haigis-L method.

For RK, using the IOL Master K values combined with the Haigis formula (not the Haigis L) set for target refraction of -1.00 D produces acceptable results aiming for -0.50 D final spherical equivalent.



The Geggel consensus uses 3 or 6 formulas to produce an average IOL power, the ASCRS average method uses 11 formulas, and the ocular MD calculator uses 20 methods. More clinical studies are needed to investigate the best of the combined formulas.

Following is a decision tree to help surgeons select the most appropriate method for each clinical situation.

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