KERA Sight

July - August 2023

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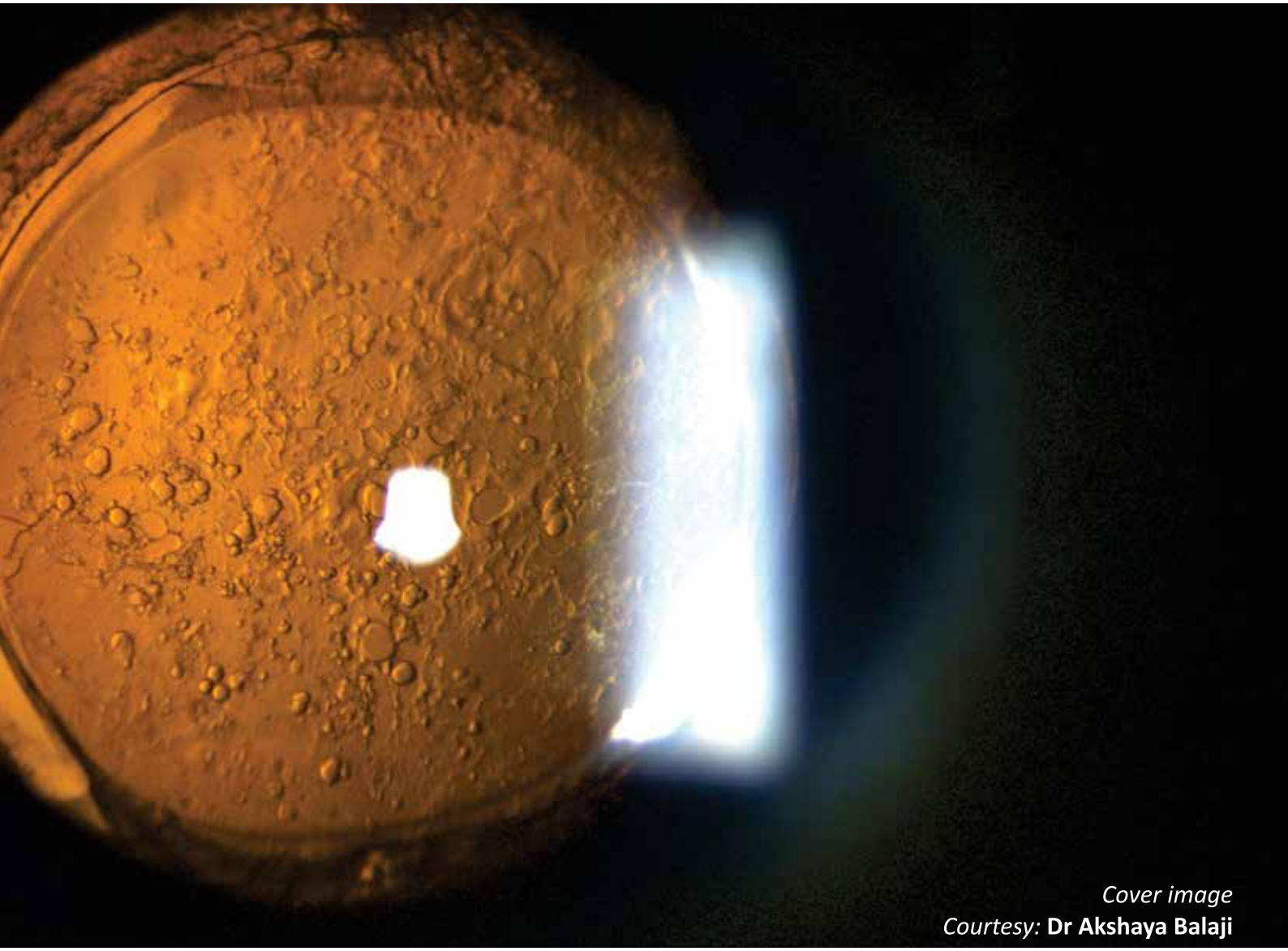

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A Scientific Publication by

Indian Society of Cornea & Keratorefractive Surgeons

KeraSight
Official Publication of Indian Society of Cornea and Keratorefractive Surgeons

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Editorial

Dear Friends,

After a long gap we have once again revived the Kerasight Newsletter which I promise will remain regular from now on. There were multiple requests from readers as they had liked the earlier issues of Kerasight. For any scientific publication to be accepted and well read, the contents have to be very good and more importantly useful for the readers in their day-to-day practice.

A large proportion of readers are young ophthalmologists and postgraduates and hence articles that can provide information for their examinations should also be a part of the newsletter. This is the reason why we have made different sections which includes Experts' Corner wherein opinions of people who have loads of experience in a particular field is incorporated so that the readers can get practical tips on those issues.

For the same reason we have included a topic on preferred practice patterns and also on recent advances which will help us to know what is latest in a particular field.

There are many investigative modalities that have come up over the last decade or so. Some information about these tools can make us wiser in using them. We also have a case report section, and a photo essay in which authors can share interesting cases with us. There is a PG section wherein some basic information will be given for the benefit of postgraduates.

To end we have a Quiz section wherein one interesting case is presented for the readers to answer. The correct answer will be displayed in the next issue with 3 lucky winners who will get interesting prizes.

The ISCKRS Meet 2023 will be held at Hotel Ashok on 11-13 August 2023. The sessions will have topics that are encountered by the practitioners in their day-to-day practice. There will be Orations by stalwarts in the field of Ophthalmology and many scientific sessions which will help us to enhance our knowledge about the latest in our field. We have tried to have a nice scientific feast for you. However, there can be some shortcomings for which I would like to apologize. I would be happy to get your feedbacks on the same so that we can improve further.

To make the Kerasight useful and acceptable to all, I would like to have your feedback and suggestions to improve, further.

I invite good quality articles from you all so that we can raise the standards of this newsletter.

I thank you all for being a part of the ISCKRS Family and request you for your guidance and support. I hope this issue of Kerasight is useful for you all.

Best regards
Dr. Rajesh Sinha
MD, DNB, FIACLE, FRCS
Editor, Kerasight & Gen. Secretary, ISCKRS

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AND KERATOREFRACTIVE SURGEONS

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Toric Intraocular Lenses- Preferred Practice & Surgical Tips

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Toric intraocular lenses (IOLs) are the procedure of choice in patients with 1D or more of corneal astigmatism undergoing cataract surgery. Optimal outcomes depend on ideal patient selection, accurate IOL power calculation and precise intraoperative alignment. We asked our experts regarding their preferred practices and surgical tips and tricks while implanting toric IOLs. Our panel of experts included Prof. Jeewan S Titiyal, Chief, RP Centre for Ophthalmic Sciences, AIIMS, New Delhi; Dr D Ramamurthy; Dr Abhay Vasavada; Dr Arul Mozhi Varman and Dr Kumar Doctor.

1 What is your threshold for implanting toric IOLs? What percentage of your practice constitutes toric IOL implantation?

Prof Jeewan Titiyal: I prefer to implant toric IOLs in all cases with a corneal cylinder of 1D or more. My threshold for implanting toric IOLs is lower still in cases where I have planned multifocal IOLs- I may implant multifocal toric IOLs even with corneal astigmatism of 0.6 DC or more. I use Barrett true K with toric calculator in all cases, and if the biometer suggests a toric IOL of T2 in a case planned for multifocal IOL, I go ahead with multifocal toric IOL implantation. Nearly 60% of my current cataract practise consists of toric IOL implantation.

Dr D Ramamurthy: I used to routinely implant toric IOLs in all cases with a corneal astigmatism of more than 0.75DC. Nowadays, I enter the biometry values in Barrett toric calculator for all cases and implant toric IOL if the calculator suggests so. Usually, the cutoff is 0.6 DC for ATR astigmatism and 1DC for WTR astigmatism. Nearly 60-65% of my cases consist of toric IOL implantation.

Dr Abhay Vasavada: Earlier, I used to implant toric IOLs in cases with corneal astigmatism of more than 1DC. Now, my cutoff has decreased, and I implant a toric IOL in all cases with a cylinder more than 0.5 D, irrespective of whether I am implanting a monofocal or a multifocal IOL. In select cases planned for femtosecond laser assisted cataract surgery, I may perform astigmatic keratotomies for lower magnitude of corneal cylinder of 0.75DC. At present, toric IOLs constitute 50-60% of my cases.

Dr Arul Mozhi Varman: My cutoff for implanting toric IOLs is more than 1.25D. I prefer to perform Limbal Relaxing Incisions (LRI) in corneal cylinder from 1 to 1.25D. Earlier, toric IOLs used to constitute nearly 20% of my practise, which has now increased to 40%.

Dr Kumar Doctor: I implant toric IOLs in cases with corneal cylinder greater than 0.5DC. My threshold is higher for vertical cylinder, where I tend to undercorrect as compared with a horizontal cylinder where I go in for a full correction. Approximately 40% of my practise consists of toric IOLs.

2 What is your method of choice for accurate keratometry estimation and IOL power calculation? Is it mandatory to consider the posterior corneal astigmatism as well?

Prof Jeewan Titiyal: Optical biometry is my method of choice, and I routinely use IOL Master 700 to obtain accurate keratometry values. I rely on Barrett True K and Barrett Toric Calculator for my IOL power calculations. IOL Master 700 is based on swept-source OCT and accounts for posterior corneal curvature providing true keratometry values. It is essential to take into account the posterior corneal curvature, especially when implanting multifocal toric IOLs, and in post-refractive surgery cases. Nowadays, there are numerous online calculators which consider posterior corneal curvature as well. In addition, nomograms such as Baylor nomogram may be employed.

Dr D Ramamurthy: Modern optical biometers are my preferred choice for biometry and IOL power calculation. I use IOL Master 700 with integrated Barrett toric calculator. I do understand that not

everyone may have access to optical biometers. In that case, autokeratometry values may be used; however, it is essential to document repeatability of measurements. Also, you should definitely account for posterior corneal curvature, either by directly measuring it with any of the modern-day devices or using nomograms to apply appropriate corrective factors. Most of the modern day biometers and online toric IOL calculators do account for posterior corneal astigmatism.

Dr Abhay Vasavada: I routinely use optical biometers for keratometry estimation and IOL power calculation. I earlier used Lenstaar and IOL Master 700; recently I have shifted to Argos by Alcon. I have obtained precise results with all modern biometers. It is very relevant in present-day cataract practice to account for posterior corneal astigmatism and enhance precision of refractive outcomes post-surgery; thankfully, most modern day biometers and calculators including Barrett's calculator take care of the posterior corneal astigmatism.

Dr Arul Mozhi Varman: I prefer IOL Master 700 for biometry and IOL power calculation in all cases. I use the Barrett's true K and Barrett toric calculator for toric IOL power calculation.

Dr Kumar Doctor: I use ANTERION Multimodal Imaging Platform for biometry and IOL power calculation, which also has inbuilt Barrett calculator. In all cases with elevated posterior float values on Anterion, I perform a Pentacam to rule out keratoconus.

3 What is your take on implanting toric IOLs in challenging situations, such as ectasia, post-keratoplasty cases and pediatric patients.

Prof Jeewan Titiyal: The ectasia should be non-progressive and stability of keratometry has to be documented. If the patient is dependent on rigid contact lenses for optimal visual quality before development of cataract, then as such the patient is not a good candidate for toric IOL implantation and you may plan a monofocal IOL, followed by postoperative visual rehabilitation with contact lenses. Mild to moderate cases of keratoconus typically have good results with toric IOLs; however, in advanced keratoconus cases I prefer to implant a plain monofocal IOL.

Post-keratoplasty and post-radial keratometry patients also fare well with toric IOLs if they have relatively regular astigmatism in the visual axis. Again, both the magnitude and axis of corneal cylinder should be stable and repeatable.

Pediatric patients usually have WTR astigmatism. There is a tendency for the astigmatism to shift from WTR to ATR with age, so that has to be considered while planning for a toric IOL. A good biometry, of course, is a prerequisite, and the patient should be able to sit on the optical biometer and allow reliable data acquisition. The patient should also allow preoperative reference axis marking. Intraoperative aberrometry using ORA is a good tool for alignment of the toric IOL in pediatric patients.

Dr D Ramamurthy: In keratoconus cases, the first pre-requisite is to document stability of the disease, and perform CXL or INTACS if necessary. If the patient has an acceptable spectacle corrected distance visual acuity before the development of cataract, then he or she is a good candidate for toric IOL implantation. However, if Rose K or semi-scleral contact lenses are required to achieve acceptable visual acuity, then the patient is not a good candidate for toric IOL implantation as the disease is advanced. Central cone with relatively regular astigmatism in the central 3 mm visual axis zone fare well after implantation of toric IOLs.

For post-keratoplasty patients, again if they have regular orthogonal astigmatism in the central 3 mm zone and have acceptable best spectacle corrected distance visual acuity, I will consider a toric IOL implantation.

In pediatric cases, I do not correct even upto 1.5D of WTR astigmatism, as there is a shift from WTR to ATR astigmatism with age. If significant ATR

astigmatism is present, I may implant a toric IOL provided accurate repeatable biometry can be obtained. I always perform topography to rule out keratoconus in children with significant ATR astigmatism.

Dr Abhay Vasavada: The first step in all these challenging cases is to counsel them well, for even if you implant a toric IOL, the results are not going to be as good as in normal corneas. For ectasia, cases with relatively regular astigmatism of 1.5-2 D magnitude in the visual axis with non-progressive disease are good candidates for toric IOL. Same holds true for post-refractive surgery and post-keratoplasty cases as well.

In pediatric patients, if I am able to obtain good biometry in the sitting position with any modern-day optical biometer, I prefer to implant a toric IOL in cases with more than 1D of corneal cylinder. The keratometry should be stable, and I prefer to take two readings atleast 3-6 months apart to document stability before I go ahead with toric IOL implantation in any of the above scenarios.

Dr Arul Mozhi Varman: In keratoconus patients, I base my decision to implant a toric IOL on the amount of skewing. Highly skewed cones have a poor outcome with toric IOL implantation. Central cones with minimal skewing of the radial axis of astigmatism have encouraging outcomes with toric IOL implantation.

Dr Kumar Doctor: For patients with ectasia, if the best spectacle corrected visual acuity before the development of cataract was 6/12 or better, I will go ahead with a toric IOL implantation. However, if the best spectacle corrected visual acuity was 6/36 or worse, the patient is unlikely to benefit from toric IOL implantation. In these cases, I may prefer to implant an INTACS ring to centralise the cone, wait 3-6 months for refractive stabilisation and then go ahead with implanting a toric IOL. My results have been promising with INTACS followed by toric IOL implantation in cases with relatively advanced keratoconus, with patients achieving good uncorrected distance visual acuity and even near vision of N8 due to the depth provided by the central cone.

I do perform toric IOL implantation in post-keratoplasty and post-radial keratotomy patients, if I can achieve reliable and repeatable keratometry values.

For pediatric patients, I do not prefer toric IOLs in toddlers, but I will go ahead with toric IOL implantation in patients more than 10 years of age.

4 What is your preferred choice for intraoperative alignment of toric IOLs?

Prof Jeewan Titiyal: Nowadays I rely on image-guided systems for intraoperative toric alignment. We have access to CALLISTO, VERION as well as ORA, and all these devices give accurate results.

Manual marking still plays a role in cases where you may not be able to capture a preoperative reference image. In experienced hands, conventional three-step marking employing a bubble marker is fairly accurate. In fact, we compared three-step bubble marking with CALLISTO and observed similar results in terms of visual acuity; however, the visual quality was superior in CALLISTO group with less induced higher order aberrations and more precise marking.

Dr D Ramamurthy: I prefer image-guided methods such as CALLISTO and VERION. They are less time-consuming and are not dependent on surgeon experience. We have observed comparable results with manual marking methods and VERION; however, manual marking relies on expertise of the person performing the markings.

Dr Abhay Vasavada: I prefer digital marking using VERION for intraoperative alignment of toric IOLs. I have in earlier days performed freehand marking, 3-step marking using bubble marker etc as well with accurate results; however, expertise and experience is essential with manual marking techniques.

Dr Arul Mozhi Varman: I prefer image-guided marking using CALLISTO in my patients. Slit-lamp marking works as well- a thin slit should be made before marking, and mark both 0-180 degree and 90 degree axis; thin, long marks should be made coming into the pupillary zone and lastly, while aligning the toric IOL intraoperatively, ensure that all the purkinje images are aligned.

Dr Kumar Doctor: I prefer VERION for intraoperative alignment of toric IOLs. We have compared VERION with manual marking as well, with comparable results.

5 What are your indications and timing of intervention in cases with postoperative toric IOL misalignment? What is your preferred method for re-rotation?

Prof Jeewan Titiyal: I prefer to perform toric IOL rotation in cases with more than 10 degree of misalignment and visual acuity worse than 6/9. I perform ray tracing aberrometry (iTRACE) in all cases with toric IOL implantation, and the toric enhancement software provides the magnitude and direction of rotation required as well as the anticipated change in refraction after rotation. If the predicted residual refraction does not show a significant change even after rotation, then the problem may lie with IOL power calculation rather than alignment.

In cases where the IOL has been implanted in the wrong axis due to human error, I prefer to intervene as soon as possible. In cases with rotation in the postoperative period, it is advisable to wait atleast one week to allow for refractive stability and then re-assess the need for rotation.

For re-alignment, I take into account both ray tracing aberrometry and Barrett toric calculator to decide the target axis and perform image-guided intraoperative alignment for enhanced precision.

Dr D Ramamurthy: I take the patient requirements into account while deciding for rotation of toric IOL in a case with postoperative misalignment. If the patient is 6/9P but satisfied with visual outcomes, I may decide against rotation. Re-rotation may not help in cases with a pure residual cylinder- that points towards wrong IOL power calculation rather than rotation. Re-rotation is indicated if the manifest refraction spherical equivalent is nearly zero.

I prefer to intervene at 2 weeks- the IOL is relatively stable at that time and the IOL-bag complex has not fibrosed significantly to make rotation difficult.

Before performing a re-rotation, I recalculate the target axis using Barrett RX formula. While performing a re-rotation, I do not inject any OVD and just use irrigation cannula and Sinskey hook to rotate the IOL. For highly myopic patients with a large bag, I may also implant an endocapsular ring.

Dr Abhay Vasavada: My indications for intervention in a case with toric IOL misalignment are clinically symptomatic patient with 20 degree or more of rotation. I prefer to intervene at 3-4 weeks as the IOL has stabilised in the bag by that time.

Dr Arul Mozhi Varman: We know that 70-80% of rotations are observed in the initial couple of hours after surgery. I assess the case one hour after surgery on slit-lamp, and re-rotate immediately if significant rotation is present.

In other cases presenting the next day or later, my indications for postoperative intervention are more than 0.75D residual cylinder induced by the rotation, and more than 10 degree rotation from target axis. I employ ray tracing aberrometry (iTRACE) to calculate the amount of rotation required and new target axis.

I prefer to wait 10-12 days before intervention, to allow the IOL to stabilise and some amount of fibrosis to occur.

Dr Kumar Doctor: I rarely need to perform re-rotation after toric IOLs. I prefer femto-rhexis in my toric IOL cases, and the perfect wraparound

and centration provided by the femto-rhexis helps maintain IOL stability and alignment in the postoperative period.

In cases of re-rotation, I prefer to intervene immediately before fibrosis sets in, and recalculate the target axis and amount of rotation required using www.astigmaticfix.com.

6 Any surgical tip for ensuring optimal toric IOL alignment and preventing postoperative rotation?

Prof Jeewan Titiyal: Image guided systems allow for precise IOL alignment and decrease errors induced by smudged or inaccurate manual marks. Complete OVD removal should be ensured at the ned of surgery to prevent postoperative rotation, and aspirate OVD from beneath the IOL as well. A well-centered rhexis with 360 degree IOL coverage ensures postoperative stability of the IOL. Leave the IOL 3-5 degrees anticlockwise at the end of aspiration, and final alignment of IOL should be performed while hydrating the wound, as wound hydration may in itself cause minor IOL rotation.

Dr D Ramamurthy: Most of the postoperative rotations are observed in the first hour after surgery. I ensure that the toric IOL is well-aligned after removing the speculum on-table. I patch the patient's eye and make them lie down for a couple of hours to minimize chances of rotation.

Dr Abhay Vasavada: Most of the rotation occurs in initial few hours, so I advise the patient to lie down for initial 3-4 hours after surgery and patch all cases. OVD removal has to be complete to prevent postoperative rotation- remove the OVD from beneath the optic as well, especially in myopic eyes with bigger bags.

Dr Arul Mozhi Varman: I ensure that the IOL is completely unfolded- both the haptics as well as the optic, while performing intraoperative alignment of toric IOLs. The optic should be flat, and I tap down the IOL at the end of surgery. Overinflation of the bag should be avoided to decrease the incidence of rotation.

Dr Kumar Doctor: I perform a femtosecond laser-assisted rhexis in all cases planned for toric IOL implantation. It ensures well-centered optimally sized rhexis with good IOL-capsular rim coverage and helps minimize postoperative rotation. Image guided surgery helps in precise intraoperative alignment, and complete OVD removal at the end of surgery is essential to prevent postoperative rotation.

Advances in Presbyopia Management

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Shivani Joshi

Abstract

There is a large burden of visual impairment due to presbyopia as reported by the world report on vision. Multiple modalities of correction have been proposed and tested. With recent FDA approvals of medical management of presbyopia this article gives an overview of the recent advances in the management of presbyopia.

Introduction

WHO has given the definition of near visual impairment as presenting near visual acuity worse than N6 or M.08 with existing correction under ICD-11.[1] The World report on vision published in 2019 reported that 1.8 billion individuals have uncorrected presbyopia and this number is expected to increase to 2.1 billion by the year 2030.[2] These astonishingly large numbers beg our attention as to what the recent advances in presbyopia management are with the rising prevalence of presbyopia, as the average age of survival of our population increases.

Presbyopia is a common age-related vision disorder characterized by a progressive inability to focus on near objects. It is hypothesized to be caused by either a weakening of the ciliary muscles or a loss of lens elasticity preventing focal point change which is typically diagnosed at around 40 years of age.[3] Uncorrected or under-corrected presbyopia has a substantial impact on quality of life, regardless of the nature of daily activities performed. However, most affected individuals experience a significant increase in productivity in their daily activities when given proper correction.

Modes of management is detailed in figure 1.

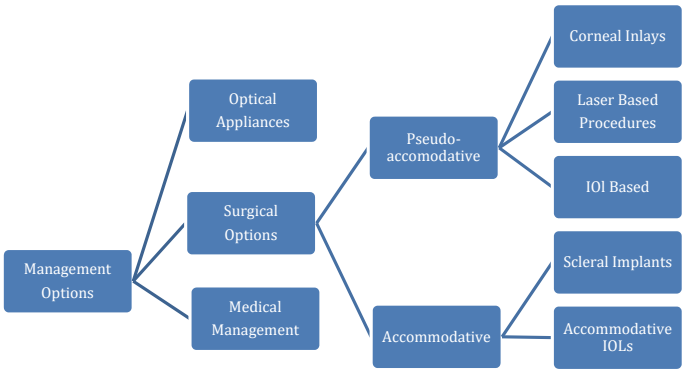

Figure 1: Flow chart on management options in presbyopia

Optical appliances

1. **Spectacle correction** – it is the most accessible means of correction (figure 2). For supplementing accommodation using spectacles, various modes are available and they are:

   a. Single vision reading glasses – available over the counter. They are useful in those individuals who do not have a significant distance correction. Disadvantage of these glasses is that they must be removed during distance and intermediate viewing conditions.

   b. Bifocals - they consist of two different powers: upper segment for distance vision and lower segment for near vision. Bifocals are suitable for high add power

requirements. Major disadvantage of these glasses is the image jump at the segmentation area and the cosmesis due to the noticeably visible segment line.

c. PALs- Progressive add lenses - power gradually increases from the distance zone through a progression to a near zone. The most evident advantage of PALS over other modes of spectacle prescription is the absence of image jump and good cosmesis as the segment top is not present. But a large peripheral distortion zone can be optically disturbing to many individuals.[4]

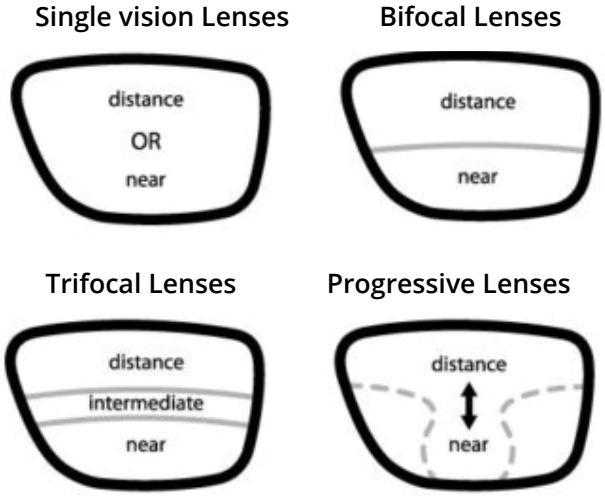

Figure 2: Spectacle correction options for presbyopia[4]

2. Contact lenses

a. Multifocal contact lenses - It is designed to correct distance and near vision along with intermediate vision and astigmatism as well.

b. Monovision contact lens – one eye is corrected for distance and the other eye is corrected for near vision

3. **Optofluidics and optoelectronics** - The geometry of lenses made of soft elastomers (such as polydimethylsiloxane), fluid or gels encapsulated within rigid or deformable enclosures, with a refractive index higher than the surround, can be modified by changing the internal gas pressure or applying an electrical field. This has been proposed as a basis for variable-focus technology for presbyopia correcting adaptive spectacles which are now under trial.[5]

Surgical options

1. **Pseudo-accommodative** – static methods to increase the depth of focus so as to provide functional near vision.

a. Corneal inlays – materials placed at different depths within the cornea to provide increased depth of focus (figure 3).

i. Small aperture inlay - KAMRA – FDA approved in 2015, this inlay improves near and intermediate vision by way of its small central aperture, placed in the area on or between the pupil centre and the corneal vertex, thereby creating a "pinhole effect" and increasing depth-of-focus.[6] It is made of polyvinyl fluoride.

ii. Refractive inlay – alters the refractive index of the cornea by the means of a bifocal optic. Examples are Flexivue Microlens (made of hydroxyethyl methacrylate and methyl methacrylate) and IcoLens. The mechanism of action of this inlay lies in its multifocality, with light passing through the central zone of the inlay brought into focus on the retina during far vision, and light passing through the peripheral zone focused onto the retina during near vision.

iii. Corneal reshaping inlay – which changes the corneal curvature like the raindrop inlay (made of hydrogel) and Presbylens.

iv. Allogenic inlays - Two types of allograft corneal inlays are currently available. The TransFormTM Corneal Allograft (TCA) (Allotex, Boston, Massachusetts,

United States) is currently pursuing FDA approval in the US. The second type is a presbyopic allogenic refractive lenticule (PEARL). Both corneal inlays use small-incision lenticule extraction (SMILE) to harvest the lenticules. Initial results for allograft corneal inlays are promising, but corneal rejection remains a potential risk.[7]

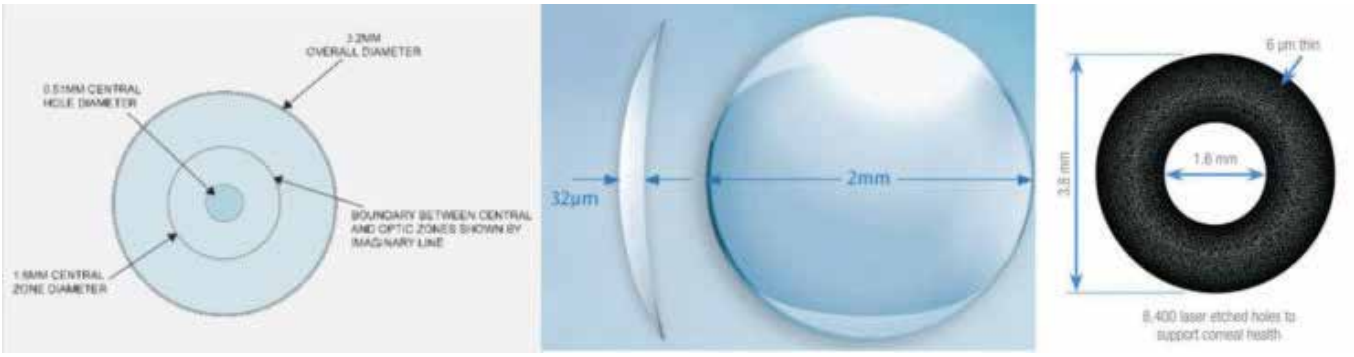

Figure 3: The Flexivue Microlens, Raindrop Near Vision Inlay, and Kamra Inlay (8)

b. Laser based procedures

i. INTRACOR – it involves placement of multiple femtosecond-based incision rings in the cornea creating a multifocal corneal surface. It leads to central corneal steepening thereby increasing the depth of focus. Procedure is suitable for hyperopes with presbyopia but studies have found a myopic shift after the procedure hence it is unsuitable for myopes with presbyopia.

ii. Monovision laser – it is based on the principle of interocular blur suppression. It causes intentional anisometropia. The dominant eye is corrected for distance vision while the non-dominant eye is corrected for near vision. There is a limitation of intermediate vision and loss of stereoacuity along with reduced contrast sensitivity. [8,9]

iii. Multifocal corneal ablation (figure 4) –

1. Central PresbyLASIK – creates bifocality. Central cornea is ablated for near vision and peripheral cornea for distance vision. This procedure is suitable for both hyperopes and myopes but it is dependent on adequate centration of ablation.

2. Peripheral PresbyLASIK – causes an increase in range of pseudoaccommodation. Central cornea is utilised for distance vision and peripheral cornea for near vision. This procedure is not suitable for myopes as large amount of tissue is ablated. Both the types of PresbyLASIK have been reported to cause a significant decrease in contrast sensitivity.[10]

3. Laser blended vision – increased depth of focus in each eye by introducing subtle changes in the corneal spherical aberrations. The dominant eye is meant for distance to intermediate vision and the non-dominant eye for near to intermediate with a blend zone common between both eyes. Our brain fuses the images between the eyes in the blend zone and provides binocularity in comparison to traditional monovision where there is a significant disparity between the two eyes.

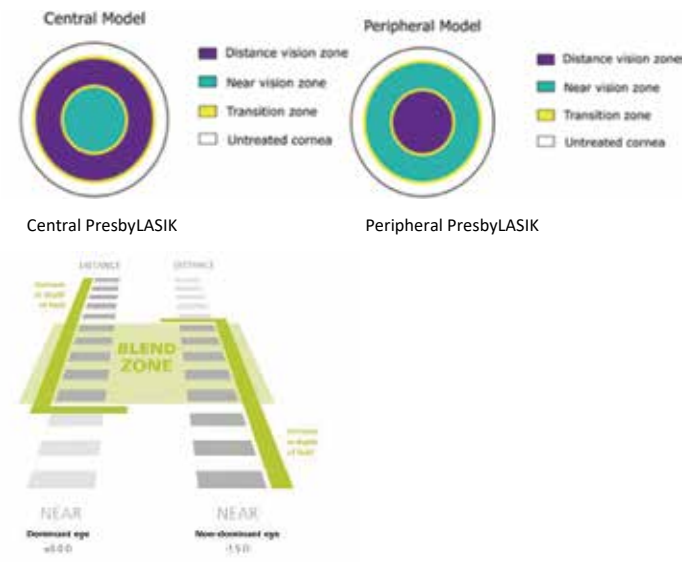

Figure 4: Laser Blended vision

c. IOL based procedures

i. Multifocal IOLs

Over a 100 multifocal and extended depth of focus IOLs are now available. Extended depth of focus lenses does not provide a sufficient range of clear focus for sustained near task performance, whereas for multifocal intraocular lenses, in-focus (providing suitable vision for the distance of interest) and out-of-focus images (which must be suppressed) are presented at the retina simultaneously. Refractive multifocal designs have zones of different power, aspheric optics, or a combination of both arranged in rings. Such optical systems are dependent on pupil dynamics and centration, and can cause photic phenomena such as halos and glare. Diffractive designs can cover the entire optic of the lens thus becoming pupil independent and the eschelets can be alternated in height profile to create trifocal designs. Small apertures can also increase the depth of focus and decentred optics can provide multifocality with less dysphotopsia.[5]

Pseudophakic monovision is another means to treat presbyopia by creating an ametropia of 1-2D in patients who must undergo both eye cataract surgery or refractive lens extraction.

ii. Presbyopic phakic IOL – Presbyopic phakic contact lens (IPCL) are now available indicated in phakic patients between 40-60 years of age with a clear lens. Extended depth of focus implantable collamer lens (EDOF ICL) is also being developed with promising initial results.[11]

2. Accommodative mechanisms

a. Accommodating IOLs – these IOLs alter their dioptric power to focus on various points in the line of sight and are based on the principle of changing the axial position, shape or refractive index of the IOL with accommodation.

i. Changing axial position – can be single optic or dual optic hinged with a string haptic. 1mm of positional change can cause 2D of accommodation. Single optic IOLs are implanted in the capsular bag and they translate the accommodative effort to change the position of the IOL. E.g., Morcher BioComFold 43E, Human Optics 1CU. Dual optic lens system is also placed inside the capsular bag and accommodative effort deforms this system in such a way that the gap between the two optics increases with increase in power of the system. E.g., Sarfarazi elliptical IOL and Synchrony IOL.

ii. Changing refractive index / shape – these IOLs have deformable optics with higher amplitudes of

accommodation. E.g. – FluidVision IOL, FlexOptix, NuLens IOLs.[5]

b. Femtosecond lentotomy - the photodisruption effect of femtosecond laser is used to create micro-incisions inside the lens. These defined gliding planes thereby restore the lost flexibility of the lens that occurs with aging and causes presbyopia. This treatment method, known as fs-lentotomy, causes regeneration of real dynamic accommodation. The laser is applied in various patterns usually sparing the central 2mm of the crystalline lens.[12]

c. Scleral implants – they have been used to increase the area between the ciliary muscle and the sclera to restore accommodation based on Schachar theory. This model describes a decreasing gap between the lens perimeter and the ciliary ring with age, due to a combination of anatomical changes, as the cause of presbyopia. FDA trials are undergoing for PMMA inserts. The implants are placed about 3000-4000 µm from the limbus and to a depth of 400 µm within the sclera. Patients are placed under monitored anaesthesia care for the duration of the procedure, approximately 1 h bilaterally. The implants aim to lift the sclera and the ciliary muscle to tighten the zonular fibres holding the lens. Studies have shown improvement of near vision but complications such as anterior segment ischemia, scleral perforation and migration of implants have been reported. [13]

d. Scleral laser micro-excision

Scleral laser anterior ciliary excision (LaserACE) uses excimer YAG laser to make micro excisions in the sclera at a depth of 90% thickness to increase the plasticity of the scleral tissue during ciliary tissue contraction and improve accommodation. Clinical studies show improved near and intermediate vision. But on the downside, microperforation of sclera intraoperatively has been reported. LaserACE is not based on the Schachar model but instead follows from VisioDynamics theory, which is a biomechanical model for the aging eye. VisioDynamics theory contends that presbyopia is not a refractive error or the loss of accommodation solely, but rather an aging disease limited by structural/mechanical, extracellular and intracellular, and physiological aspects of the eye. It argues that as the eye ages, the connective tissues within begin to change and impact ocular biomechanical efficiency. This, in turn, influences visual function and ocular physiology including ocular metabolic efficiency, and ocular biotransport. [13]

Medical Management options

1. Vuity - Allergan's Vuity (pilocarpine hydrochloride ophthalmic solution 1.25%) was approved in October 2021. It is indicated for once-a-day dosing in adults with mild to moderate presbyopia. Pilocarpine acts by two mechanisms. It constricts the pupil in a dynamic way and has a small effect on the ciliary body muscles. Pupil size reduces to about 40 to 50 percent of the pre-drop level. This helps improve the depth of focus without affecting distance vision. This is the dynamic pupil modulation process. Pilocarpine also stimulates the ciliary body to constrict, which can create some improved reading vision although this effect is more prominent among younger presbyopes (around 40 years of age) since these patients may still have some ciliary body muscle effect. Side effects include headache and there is a risk of retinal detachment as well, as demonstrated in the GEMINI trials.

2. CSF-1 – low dose pilocarpine 0.4% pilocarpine hydrochloride used to create a pinhole

effect to increase depth of focus. CSF-1 demonstrated fewer side effects associated with pilocarpine, namely headache, or brow ache. There was also a low incidence of stinging upon instillation among participants in the NEAR trials.

3. Microline - Eyenovia is developing an investigational, proprietary pilocarpine 2% formulation for presbyopia treatment called MicroLine. The drug comes pre-packaged in Eyenovia's Optejet microdosing spray dispenser, which delivers the solution to the ocular surface in a directional mist, rather than in an eyedrop. In VISION-1, very few of pilocarpine's usual side effects, such as headache and dim vision were seen. Less than three percent of the MicroLine-treated patients reported brow or headache.

4. Brimochol-PF - Brimochol-PF, a presbyopia-correcting eyedrop that's a combination of carbachol 2.75% and brimonidine tartrate 0.1%. Brimochol-PF relies on a small-aperture optic approach to increase depth of field and depth of focus for presbyopic patients using the pinhole principle.

5. Aceclidine - Aceclidine's features distinguishing it from pilocarpine or carbachol is its significant decoupling of the miotic effect and the stimulation of the ciliary muscle, with accompanying myopic shift. Aceclidine targets different muscarinic receptors than pilocarpine. With pilocarpine and carbachol, there tends to be a myopic shift along with miosis. Patients tend to get a brow ache with ciliary muscle contraction. With aceclidine, there is an absence of ciliary muscle activity. Theoretically there is a lesser risk of retinal tears due to this. This drug is under phase II trial at present.

6. Nyxol - Phentolamine ophthalmic solution 0.75% has demonstrated moderate pupil-diameter reduction and improvement in near visual acuity alone, but the addition of low-dose pilocarpine may allow the formula to achieve the pinhole effect to improve depth of focus and near reading vision.

7. UNR844- It is a prodrug that uses lipoic acid choline ester 1.5% to reduce the disulfide bonds in the crystalline lens. When UNR844 penetrates the cornea, it is metabolized into choline and R-lipoic acid. The lipoic acid is broken down by the lens into its active form, dihydrolipoic acid or DHLA. This DHLA is thought to be responsible for reducing the disulfide bonds and increasing the lens' elasticity. [14]

In conclusion, multiple modalities of management are now available for presbyopia, a growing epidemic.

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Management of Adenoviral Conjunctivitis

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Introduction

Viral conjunctivitis is the most common type of infectious conjunctivitis accounting for 75% of all conjunctivitis cases. Human adenoviruses (HAdVs) are believed to account for 65% to 90% of cases of viral conjunctivitis.[1] Epidemic keratoconjunctivitis (EKC) is a highly infectious subset of conjunctivitis caused by Human Adenoviruses (HAdVs). It is more prevalent in hot humid seasons.

Importance

The disease is extremely contagious, spreading through contact with ocular secretions via contaminated surfaces, instruments, eyedroppers, bottle tips, or hands. Outbreaks of EKC can occur in healthcare environments such as hospitals and eye clinics and in the community settings like schools and institutions. The incubation period for adenoviral ocular infections is 2 to 14 days.[2] It assumes public health significance as a significant number of days of work or school are lost by patients and invariably there occurs an irrational use of over the counter (OTC) eyedrops by the patients in an attempt of early recovery.

Clinically, it is important to differentiate viral conjunctivitis from conjunctivitis caused by other organisms and sight-threatening eye diseases like uveitis and herpetic keratitis. EKC can result in persistent and visually significant subepithelial corneal infiltrates (SEI) and pseudomembrane formation.[3]

Diagnosis

Diagnosis of the disease is largely clinical as laboratory testing, using viral culture or polymerase chain reaction (PCR) assays, genome sequencing, rapid screening tests to detect HAdV in conjunctival specimens, are neither widely available nor routinely performed. (4) EKC begins unilaterally, but often spreads to the unaffected eye.

Patients present with non-specific complaints like redness of the eyes (“pink eye”), foreign body sensation, sticky eyes, watery discharge, swelling of lids, itching and at times blurring of vision. (Fig 1) Patients may have associated fever and respiratory symptoms. On examination, follicular conjunctivitis, presence of preauricular lymph nodes and SEI are suggestive of EKC. The patients may also develop chemosis, pseudomembranes and petechial conjunctival hemorrhages. SEI can take months to up to an year to clear. [5] (Fig 2)


Figure 1: Adenoviral conjunctivitis with lid edema, congestion, watery discharge

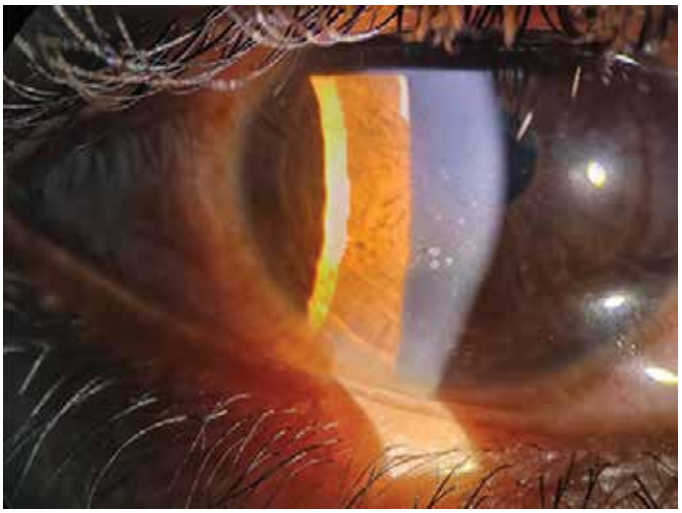

Figure 2: Subepithelial infiltrates in EKC

Management

Mild EKC infections usually resolve on their own without treatment. There is currently no FDA approved medication for management of EKC. Treatment preferences for EKC are wide-ranging and there is a lack of consensus regarding effective treatment.[6] The goals of therapy are to lessen the severity of symptoms; shorten the duration of signs and symptoms; restore comfort and visual function; and decrease complications.

a. Cold compresses can help reduce eye swelling and discomfort.

b. Topical Lubricants 4-6 times a day reduce grittiness and dry eye.

c. Topical antihistamine eye drops- cause vasoconstriction and reduce redness as a short- term measure. However, their overuse can cause rebound redness.

d. Role of topical steroids- Steroids are indicated in severe EKC with superficial punctate keratitis (SPK), SEI affecting vision and pseudomembrane formation. They help by reducing the inflammation and shortening the duration of illness. These patients should be closely observed for clinical response and side effects. However, indiscriminate use of steroids in all mild cases can increase the duration of viral shedding and aggravate secondary infection, besides exposing the patient to side effects.[7]

e. Role of Povidone Iodine (PI) – various studies have reported the use of PI as an off-label treatment in EKC. The majority of studies have investigated daily instillation of 0.4 to 2% PI. The treatment regimes have varied widely, and high-quality evidence for its use is limited. Several practioners advocate the use of a single time instillation of PI drops in the clinic.[8]

f. Role of Cyclosporin and Tacrolimus – immunomodulatory drugs, used as steroid sparing agents. They can help treat persistent corneal opacities.[9]

g. Oral Non-steroidal anti-inflammatory drugs (NSAIDs)- supportive therapy especially in patients with eyelid involvement.

h. Combination of PI and corticosteroids- PI combined with 0.1% dexamethasone eye drops showed positive outcomes in several studies and is better than using 0.1% dexamethasone alone.[10]

i. Role of topical antibiotics- a broad spectrum antibiotic eye drop (preferably avoiding newer fluoroquniolones) maybe indicated if secondary bacterial infection is suspected or in immunocompromised patients at risk of developing secondary infection.

i. Role of antivirals- no oral or topical antiviral drug has been shown to have clinical benefit in EKC.

Prevention

Prevention of spread of the infection is of utmost importance and the following measures help in curtailing the outbreaks.

a. Patients are encouraged to stay home for 2 weeks.

b. Meticulous hand hygiene

c. Avoid contact with cases

d. Avoid touching or rubbing the eyes

e. Avoid sharing of hankerchiefs/ towels

f. Avoid use of contact lenses

g. Cleaning and disinfection of surfaces in healthcare setups, especially slit lamps, door handles, table tops etc with 1% sodium hypochlorite or isopropyl alcohol during outbreaks and after seeing patients with red eye.

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CASE REPORT

Post-traumatic Dislocation of Phakic IOL

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Introduction

Implantation of posterior chamber phakic intra-ocular lens has been an effective alternative for the correction of refractive errors in eyes which are considered to be unfit for kerato-refractive surgery.[1] The Visian Implantable Collamer Lens (ICL) and Visian Toric ICL (ICL™, STAAR Surgical, Nidau, Switzerland) are two such phakic IOLs. They are made from a 100% biocompatible material known as collamer and have the ability to correct a wide range of refractive errors; from +10D to -18D and astigmatism from 1D to 6D.

In spite of being a rare entity, dislocation of ICL has been reported by several authors. We present one such case of dislocation of ICL with pupillary capture following blunt injury and its subsequent management.

Case report

A 25-year-old lady reported to our Emergency department with an alleged history of assault which took place 3 days prior to the presentation. The mode of injury, as described by the patient, was blunt trauma with the thenar eminence of the attacker's right hand, over the left lateral orbital margin. The injury occurred in the evening between 7 to 8 pm. As per the patient's recall, the room was dimly lit at the time of the injury. Following the incident, she had complaints of mild pain over the left eye and swelling over the left upper lid. Mild blurring of vision was reported. The patient had undergone bilateral uneventful implantation of toric ICLs 4 years before the presentation.

Her BCVA was 6/9 in the RE and 6/18 in the left eye, intra-ocular pressure as measured by the non-contact tonometer was 15 and 13 mm hg RE and LE respectively. Anterior segment of the RE revealed an ICL in-situ, rest was WNL. Torch light examination of the LE revealed ecchymosis over the upper eyelid and mild conjunctival congestion with irregular pupillary margins. On slit lamp examination, we detected a dislocated Implanted collamer lens with its supero-temporal footplate displaced in the anterior chamber capturing the pupillary margin (figure 1) There were 4+ cells in the AC, multiple sphincter tears and the crystalline lens was clear; there was no contact between the dislocated ICL and the crystalline lens (figure 2). Tessellated fundus was seen on dilated examination. No peripheral treatable lesions were detected.

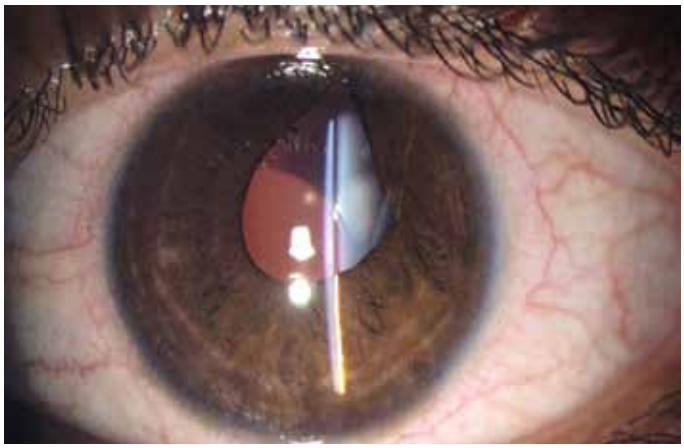
Figure 1: Dislocated ICL with haptic in anterior chamber

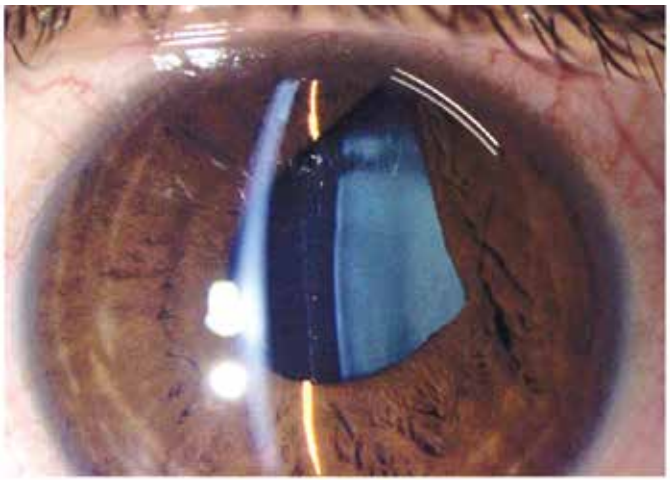

Figure 2 : Slit image showing absence of ICL-lenticular touch

The dislocation of the ICL was surgically corrected under topical anesthesia. Two 1.2mm side ports were made and the anterior chamber was formed with OVD. The ICL was rotated and re-positioned beneath the plane of pupillary capture followed by removal of the OVD. Intracameral pilocarpine was injected to constrict the pupil. Side ports were hydrated and topical anti-biotics put. Post-operatively the patient was prescribed E/d Moxifloxacin 0.5% TDS, E/d Prednisolone sodium phosphate 6 times/ day, E/d Homatropine 2% QID and E/d Tropicamide cycles twice daily. Tab Acetazolamide 250 mg stat was give post-operatively. Risk of cataract formation, secondary glaucoma and other complications related to a closed globe injury were explained to the patient.

On day 1 post-op, the patient's UCVA was 6/9p on Snellen's visual acuity chart. On slit lamp examination, the anterior chamber was formed with 4+ cells in AC. Low ICL vault was detected clinically which was confirmed to be 122 microns on ASOCT. Refraction at 2/3m under tropicamide yielded a correction of -1.75DS/-0.25DC at 180 degrees (acceptance at 6/9). At 1 month follow-up, the patient's UCVA was 6/9 and BCVA was found to be 6/6. Anterior segment examination revealed no abnormalities.

Discussion

Phakic IOL implantation is a surgical procedure that corrects refractive errors in eyes that are not fit to undergo corneal ablative procedures. ICL is phakic IOL that is implanted behind the iris, in front of the crystalline lens. The haptics rest in the ciliary sulcus and are in contact with the zonules. Numerous studies have demonstrated the safety and efficacy of this procedure. However, akin to any surgical procedure in the body – phakic IOL implantation may result in certain complications such as corneal decompensation[2], cataract[2], glaucoma[3], pigment dispersion, uveitis[4] and/ or retinal detachment. The dislocation of phakic IOL is a rare but plausible complication of phakic IOL implantation.[5] In our patient, the trauma occurred in the evening, a time when the patient's pupil would likely be dilated owing to the light conditions. This would have increased the risk of anterior dislocation of phakic IOL at the time of injury. Another reason for dislocation could be smaller than the required size of phakic IOL, as was also indicated by a low post-operative vault. Early identification and prompt surgical management of this patient ensured favorable outcomes in the post-operative period.

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Corneal Biomechanics – The Missing Link

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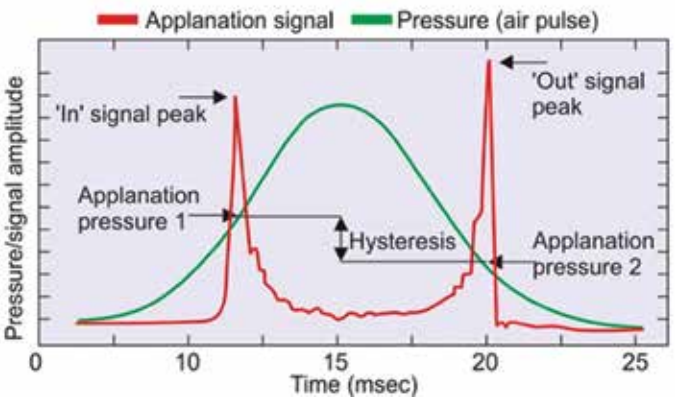
Corneal biomechanical properties reflect the capacity of the cornea to respond to applied mechanical forces.[1] The cornea has a viscoelastic behavior – it does not instantly regain the initial form after applying an external force and instead, a proportion of the energy is released as the cornea returns to the initial shape and dimension.[2]

Among the corneal layers, the stroma and the Bowman's membrane have the most important contribution to the resistance and elasticity of the cornea, due to the large proportion of collagen fibers in their structure[3]. Characteristics of collagen fibers, including density, spatial orientation, and degree of crosslinking, have a significant impact on the biomechanical behavior of the cornea.[4]

The study of corneal biomechanics has gained significant momentum over the last decades due to the increasing clinical utility in understanding the structural and material properties of cornea. It has the potential to be used for screening and planning for refractive surgeries, providing an earlier diagnosis of keratoconus, planning and evaluating corneal collagen cross linking treatments, correcting intraocular pressure (IOP) measurements, and as a possible indicator of disease risk.

Measuring Corneal Biomechanical Parameters

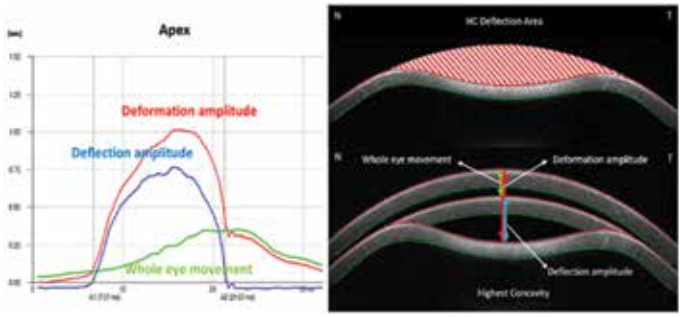
The Ocular Response Analyzer is a device using the principles of non-contact tonometry in measuring both intraocular pressure (IOP) and several biomechanical parameters. The ORA releases an air puff that leads to a deformation of the cornea, towards a concave shape.[5] During this process, the cornea initially reaches a flat shape, which is noted as the first applanation (P1); it continues towards a concave shape and then returns to the convex normal shape, passing through the second applanation (P2). An infrared light electrooptic system detects the two moments.[6] The device calculates the intraocular pressure based on the time it takes the cornea to reach the first applanation.



The main biomechanical properties estimated by ORA, corneal hysteresis (CH) and corneal resistance factor (CRF), are both measured in mm Hg; CH equals the difference in pressure between the two applanations, and reflects the capacity

of the cornea to absorb and release mechanical energy (CH = P1 - P2), while CRF is equal to the same difference but P2 is multiplied with a constant calculated using P1, P2 and the central corneal thickness (CCT) (CRF = P1 - k x P2). Thus, CH reflects the viscoelastic behavior of the cornea, while CRF is a more accurate indicator of corneal resistance and elasticity.[6]

The Corneal Visualization Scheimpflug Technology device is another tool that registers the corneal response to the application of an air puff. A Scheimpflug camera follows the cornea as it changes and regains its initial shape and registers the IOP and central corneal thickness. While it does not record hysteresis,[7] the CorVis ST records parameters such as the duration needed to reach the first applanation, the deformation amplitude and the radius of the corneal concavity resulted in the deformation.[8]



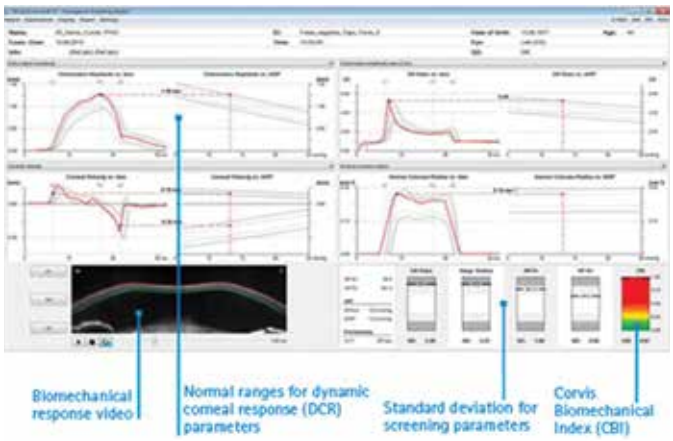
Corneal Biomechanics In Keratoconus

Keratoconus is the most frequent corneal ectasia, usually bilateral but with an asymmetrical evolution. It leads to a progressive thinning and protruding of the cornea. In terms of histopathology, the main element of the disease is the thinning of the stromal layer, along with breaks in the Bowman membrane, a decrease of collagen fibrillary diameter and lamellae organization.[9]

Biomechanical parameters are severely affected in keratoconus – usually, both CH and CRF are lower compared to normal eyes. Investigating these parameters has a supplementary role in the diagnosis of keratoconus.[10] Similarly, certain CorVis ST parameters are affected during keratoconus progression, namely the corneal biomechanics index and the integrated inverse radius – which signify a decrease in corneal stiffness as the disease progresses.[11]

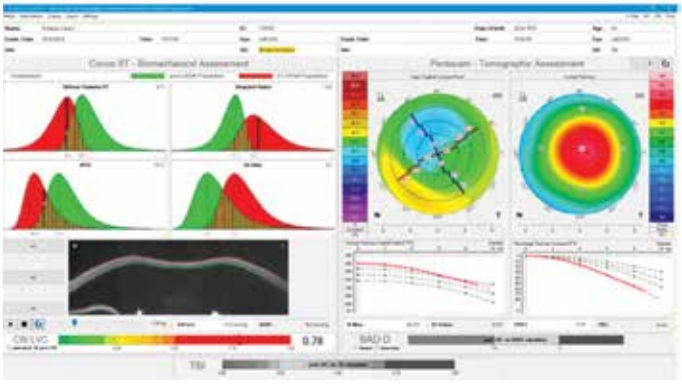
Corvis Biomechanical Index (CBI)

Corvis-ST machine provides comprehensive biomechanical screening and keratoconus detection. The Vinciguerra Screening Report displays the patient's results in comparison with normative values, presented in easy-to-grasp charts.



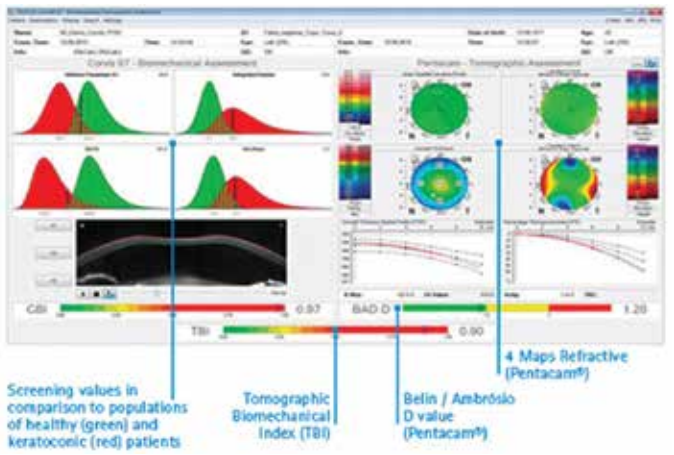
Corneal Biomechanics And Laser Vision Correction

Pre-operatively, several screening methods exist to analyse the risk for developing ectasia after Laser Vision Correction. However, until now limited possibilities exist to evaluate ectasia risk post-operatively. The CBI_LVC display allows an automatic assessment of the biomechanical stability post-operatively. The software also detects automatically whether the examined patient has a treated cornea. As a final output the CBI-LVC estimates the risk for an ectasia after laser vision correction. This is an aid for clinical decisions such as corneal crosslinking or laser touch-ups.



Tomographic Biomechanical Index (TBI)

Integration of Pentacam data for a combined tomographic and biomechanical analysis. TBI is calculated using an artificial intelligence approach to optimize ectasia detection. By combining tomographic data from the Pentacam with biomechanical data from the Corvis ST we can further improve sensitivity and specificity in the detection of patients with a significant risk for developing ectasia after refractive surgery.



Corneal Biomechanics in Glaucoma

Glaucoma is a progressive optic neuropathy which leads to thinning of the nerve fiber layer and specific visual field loss, in which IOP is an important risk factor.[7] Several studies have pointed out the connection between corneal biomechanical parameters, mainly hysteresis, and the diagnosis and evolution of glaucoma.

There is an inverse connection between IOP and CH – a low hysteresis is associated with a high IOP. Furthermore, CH is on average lower in primary open angle glaucoma (POAG) compared to ocular hypertension (OHT) for the same IOP.[12,13]

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Pre-Existing Posterior Capsular Defect in a Developmental Cataract

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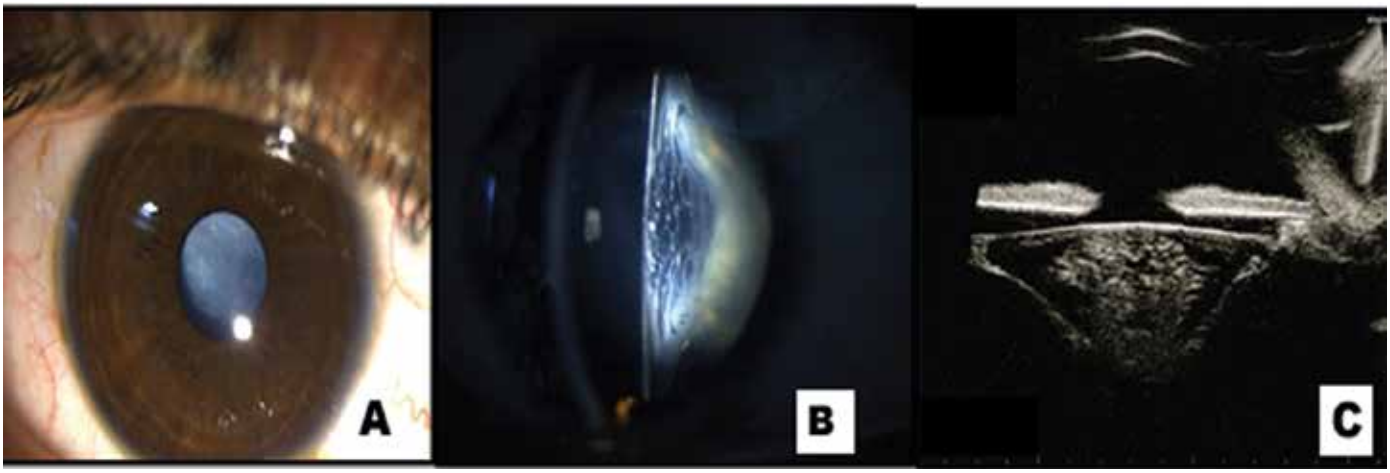

A 14 - year old boy presented with complaints of diminution of vision in his right eye for 2 years duration with no significant history of trauma. The slit lamp examination as seen in the figure A showed total cataractous lens filled with fluid clefts. Dilated examination as in figure B showed loss of lens matter in the centre which gives suspicion of posterior capsular defect. Anterior segment optical coherence tomography was done to see posterior capsule details but the swollen-up lens matter didn't allow penetration till the posterior capsule. Hence an ultrasound biomicroscopy was done which showed the presence of a large posterior capsular defect as seen in figure C. This helped to plan surgery -lens aspiration with anterior vitrectomy with three-piece intraocular lens in sulcus. UBM is a great diagnostic tool in such cases which helps us to plan surgery, anticipate complications and explain prognosis to the patient accordingly.

Artificial Tears

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The Dry Eye Workshop - II (DEWS - II) defined dry eyes as a "multifactorial disease of the ocular surface characterized by loss of homeostasis of the tear film and accompanied by ocular symptoms in which tear film instability and hyperosmolarity, ocular surface inflammation and damage and neurosensory abnormalities play etiological roles".[1] It is one of the most common entities encountered in an ophthalmology clinic. The patient may present with varying complaints ranging from occasional irritation and foreign body sensation to redness, pain and watering of eyes. On examination, the clinician may not find any significant abnormalities. However, on the other end of the spectrum conjunctival congestion, epithelial erosions and defects may be found on examination.

A plethora of topical medications are available for the management of DED. Among these medications, the ones acting directly on tear film are often grouped under the umbrella term "Artificial Tears". Despite falling under a common category, each artificial tear formulation is comprised of different components and each such component has a specific function. A succinct understanding of the mechanism of these agents allows the judicious use of artificial tears to provide optimal outcomes to the patient.

Constituents of a tear substitute

The major component of any artificial tear formulation is demulcent, also known as viscosity enhancing agent. To enhance the action of the medication, other molecules incorporated in artificial tears include osmoprotectants, anti-oxidants, oily agents, electrolytes and preservatives. (Fig 1)

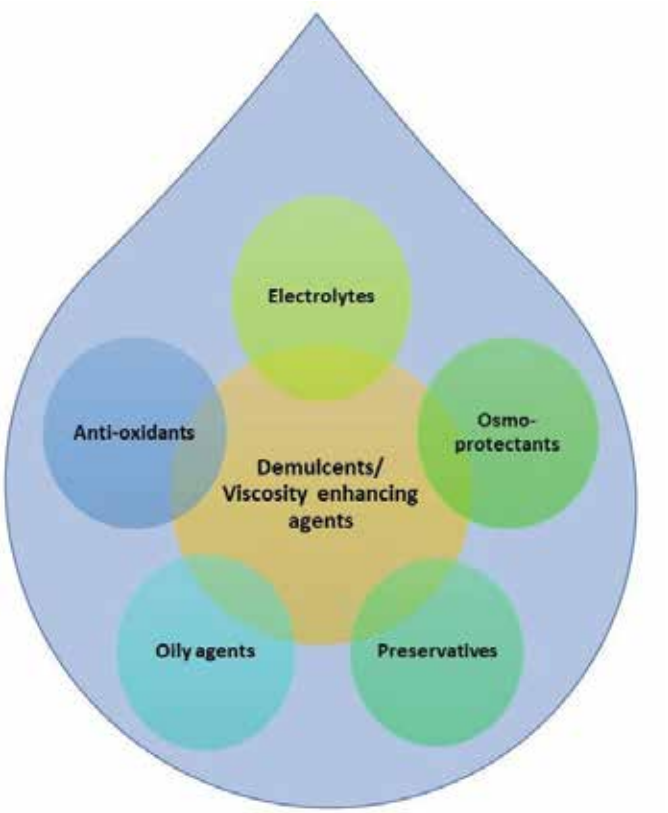

Figure 1: Components of artificial tears

The various functions of these constituents of artificial tears are as follows (Table 1):

Table 1: Summary of Constituents of AT formulation

	Viscosity enhancing agents	Electrolytes	Osmoprotectants	Oily agents	Anti-oxidants	Preservatives
Compounds	Cellulose derivatives, Liquid Polyols, Polyvinyl alcohol, Gelatin, Dextran-70, Povidone	Bicarbonate, Potassium, calcium chloride	L-carnitine, erythritol, betaine, sorbitol, glycerine, trehalose	Available in forms of liposomes and oil nano droplets	Vitamin A, Vitamin E, co-Enzyme q10, Lipoic acid	POLYQUAD®, PURITE® or OcuPURE®, EDTA, Benzalkonium chloride (BAK)
Function	Increase tear film thickness by increasing retention of ATs Prevent loss of water Increase wettability of corneal surface	-Reproduce the electrolyte profile of a healthy tear film -Provide essential ions for the maintenance of corneal epithelium -Counterbalance the hyperosmolarity induced by DED	- Reduce MMP synthesis and oxidative stress - Protect the ocular surface from hyperosmolar stress	-Replenish lipid layer - Can help provide a smooth optical surface for the cornea and help to maintain a good quality of vision[11]	Some evidence suggests that oxidative stress in tear film also contributes to the pathogenesis of Dry Eye Disease	-Prolong Shelf Life - Anti-microbial properties
Adverse Effects	Transient blurring of vision following instillation May leave residue on lid margin when it dries				Vitamin A – found to induce MGD in animal models, unstable in liquid formulation, not very well tolerated in ointment form	Prolong use may increase symptoms of Dry Eye Disease and cause further damage

1. Viscosity-enhancing agents

Ophthalmic demulcents or viscosity-enhancing agents have been found to act on the aqueous-mucin layer of the tear film. They help minimize the abrasive action of lids on the ocular surface. These agents act by increasing tear film thickness by increasing retention, preventing loss of water, and increasing wettability of the corneal surface. The US FDA recognizes six classes of ophthalmic demulcents (Table 2).

Table 2: FDA approved classes of Ophthalmic demulcents

Category	Concentration	Components
Cellulose derivative	0.2 – 2.5%	CMC, HPMC
Liquid Polyols	0.2 – 1%	Glycerin, PEG 300, Polyene glycol
Polyvinyl alcohol	0.1 – 4%	
Gelatin	0.01%	
Dextran-70	0.1 % - always used with other polymeric demulcent(s)	
Povidone	0.1 – 2% - always used with other polymeric demulcent(s)	

Among the various viscosity-enhancing agents used in the ATs formulations, sodium carboxymethylcellulose (CMC), a cellulose derivative from plants, is the most frequently utilized. CMC has been shown to be beneficial for patients with mild to moderate DED by improving the corneal surface wettability and tear film integrity.[2]

Other viscosity-enhancing agents are used in marketed ATs including hydroxypropyl methylcellulose (HPMC), carbomer, hyaluronic acid (HA), polyvinyl alcohol, povidone, dextran and hydroxylpropyl-guar (HP-guar). These agents are known to be mucoadhesive and muco-mimetic due to their branched structure similar to mucin 1, a mucin formed by the goblet cells and play a protective role on the ocular surface.[3]

In addition to its viscosity, Hyaluronic acid (HA), especially high molecular weight HA (HMW-HA), has also been shown in vivo to accelerate wound healing of the epithelium after corneal debridement, corneal abrasion, and alkali burn injuries.[4,5] This outcome is most likely due to the presence of ligands on the HMW-HA molecule that can bind to the CD44 receptor present in most cell types, including human corneal epithelial cells (HCEC).[6] Similarly, CMC has been found to bind HCEC and promote in vivo corneal re-epithelialization. HA has also been combined with other agents in order to improve epithelial cell re-epithelialization. Even though the individual actions of these agents on corneal epithelization have been seen in various studies, the superiority of one agent over the other is yet to be established in the literature. However, the combination of agents such as HA with CMC may increase the efficacy of these agents in promoting corneal epithelization.

Polyene glycol has been found to improve mean goblet cell density and have a role in reversing squamous metaplasia induced by DED.[7]

2. Electrolytes

Naturally excreted electrolytes constitute the tear film, which maintains the osmotic balance of the ocular surface. For this reason, electrolytes (sodium, potassium, chloride, magnesium, and calcium) are largely used in tear substitutes in order to reproduce the electrolyte profile of a healthy tear film.[8] Electrolytes also help counterbalance the hyperosmolarity induced by DED. Some electrolytes, such as boric acid, act as a buffering agent to stabilize the pH of the formulation.

They may also be used as preservative agents. The most commonly found electrolytes in tear substitutes are Bicarbonate and Potassium. Bicarbonate can help in the recovery of damaged epithelium[9], whereas Potassium is a useful element due to its ability to retain corneal thickness.[10]

3. Osmo-protectants

Hyper-osmolarity of tear film has been found to induce inflammatory damage and apoptosis of the corneal and conjunctival epithelial cells. Osmo-protectants such as L-carnitine, erythritol, betaine, sorbitol, glycerin, and trehalose have been included in formulated artificial tears to overcome this issue. These agents are effective in preventing ocular surface cell apoptosis induced by DED.

L-carnitine and erythritol have been found to protect corneal epithelial cells from hyperosmolar stress. Some agents such as betaine, L-carnitine, erythritol and phosphate buffered saline (PBS) have also been found to decrease corneal fluorescein staining.[11]

Trehalose, a naturally occurring disaccharide of glucose, suppresses corneal inflammation, scar formation, and corneal neovascularization when administered to an injured cornea.[12] Osmo-protectants also appear to reduce matrix metalloproteinase (MMP) synthesis and oxidative stress.[13]

Therefore, in patients who exhibit signs of inflammation and punctate corneal staining, AT formulations containing osmo-protective agents should be preferred.

4. Oily agents

The superficial layer of the tear film is composed of the lipid layer, which prevents evaporation of the tear film and maintains a smooth surface for refraction at the air-tear film interphase. Any abnormality in the lipid layer – most common being meibomian gland dysfunction – can deteriorate the quality of the tear film by causing increased evaporation of the tear film. In recent years, there has been an increase in the popularity and availability of lipid-based drops, which target the superficial tear lipid layer. Oily agents have been incorporated in artificial tear formulations to replenish the tear film lipid layer (TFLL). They are available in the form of liposomes and nano-droplets.

Studies have shown that liposomal sprays improved TFLL thickness and tear film stability as well as patient comfort. These sprays are applied over closed lids and thus may be useful in patients who find it difficult to instill eyedrops. AT formulations may also contain oily agents in the form of oil-in-water emulsions, which alleviate symptoms of dry eye disease caused primarily due to meibomian gland dysfunction.

5. Anti-oxidants

There is some evidence that oxidative stress in tear film also contributes to the pathogenesis of Dry Eye Disease. Therefore, antioxidants or free radical scavengers have been used in the formulation of tear substitutes including vitamin A, vitamin E, co-enzyme q10 or lipoic acid. However, their substantial role in the management of dry eye disease is yet to be studied.

6 Preservatives

Preservatives are required in multi-dose artificial tear formulations in order to prolong their shelf life. They also possess anti-microbial properties, thus maintain sterility of the composition. The most commonly used preservative in ophthalmic solutions is Benzalkonium chloride (BAK). However, prolonged use of ATs with BAK as a preservative may incite ocular surface inflammation, increase symptoms of Dry Eye Disease and cause further damage. To overcome this issue, certain "Soft" or "vanishing" preservatives – such as polyquaternium-1 (PQ, POLYQUAD®), sodium chlorite (PURITE® or OcuPURE®), edetate disodium (EDTA) – are also available. The so-called "preservative-free" artificial tear eye drops contain these preservatives as no truly preservative-free multi-dose AT formulation is currently available in the market.

However, the absence of preservatives has been shown to improve ex vivo corneal wound healing, which has not been observed even with the use of soft preservatives such as PURITE®. Therefore, patients who are intolerant to preservatives may be prescribed single-use AT formulation vials.

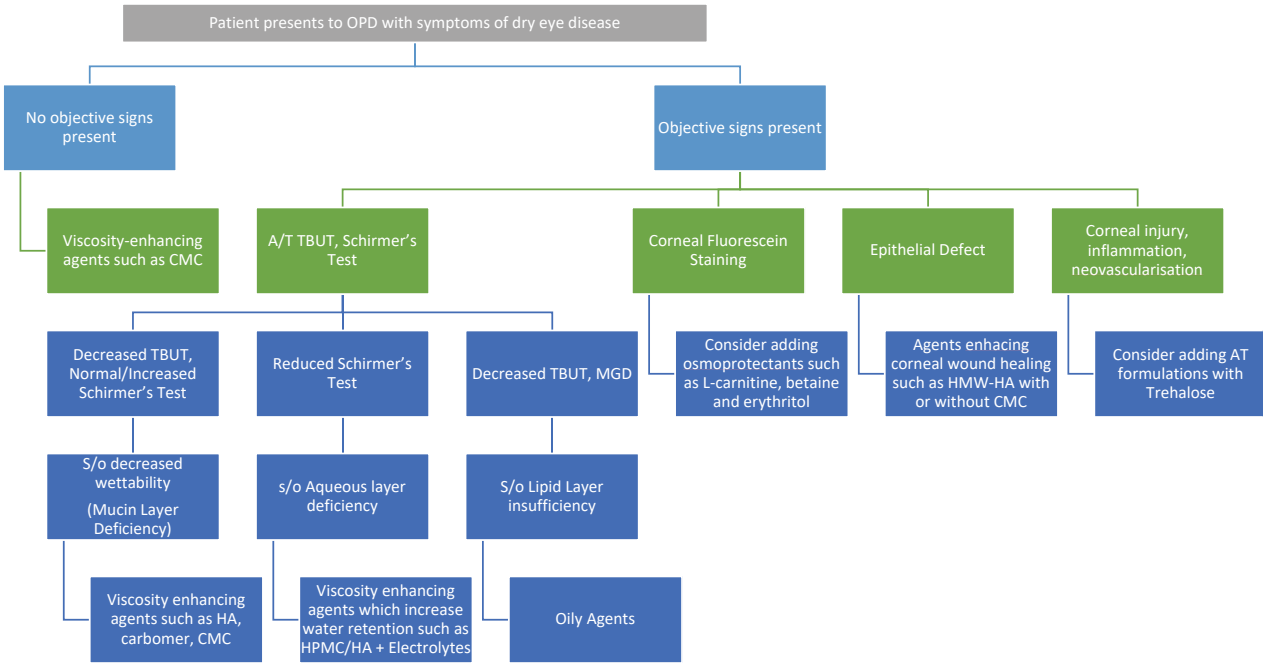

Figure 2: Management of patients with dry eye disease

To conclude, a variety of artificial tear formulations are available in the market. However, a succinct understanding of the various components comprising any artificial tear formulation helps in deciding the most appropriate formulation for each individual patient. Figure 2 gives a basic overview of the considerations to be taken into account while prescribing these medications.

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Ophthalmology Quiz

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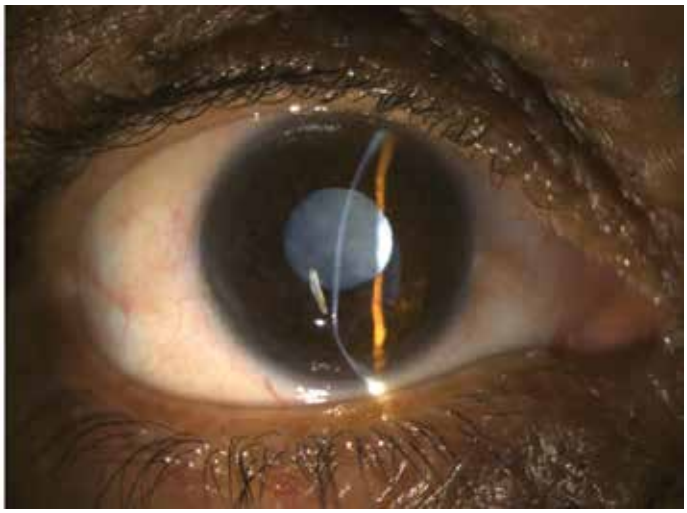
Figure 1: Clinical picture of Right Eye

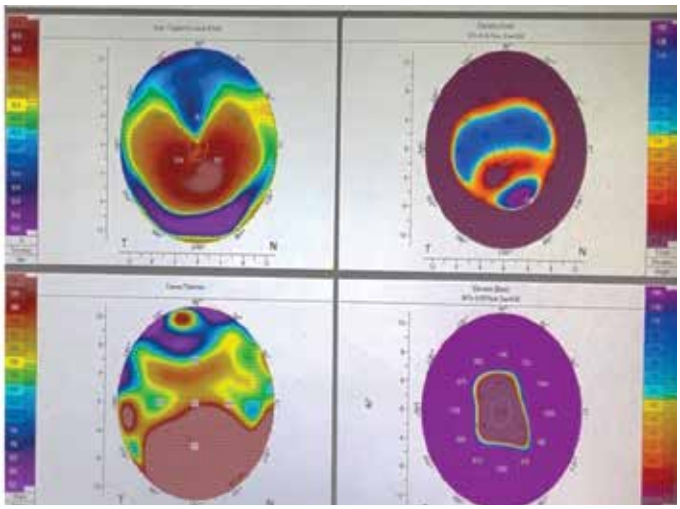
Figure 2: Pentacam quad map of Right eye

A 60 yr old female patient presented with complaint of gradually progressive painless diminution of vision in both eyes which had severely aggravated in the last one year. On examination, she had VA of Hand Movement Close to Face (HMCF) with accurate projection of rays not improving further with refraction in both eyes. Intra-ocular pressure in RE was 18 mmHg and in LE was 16 mm Hg. Clinical picture of the Right eye is given above in fig.1 and the pentacam quad map image of the same eye is shown in fig 2. The clinical picture of the Left eye was similar to that of the Right eye. On fundus examination, the glow was poor so a USG B-scan was done which showed a normal posterior segment with no optic nerve head cupping in either eye. Based on the above clinical description what is the complete diagnosis?

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- CMC: Restore the lost cellular volume[3]; Provides moisterization[3]
- Glycerine: Restore the lost cellular volume[3]; Provides moisterization[3]
- Erythritol: Protects the ocular surface from tear film hyperosmotic stress[3]; Reduces the levels of MAP kinases which triggers inflammation[3]
- L-Carnitine: Protects the ocular surface from tear film hyperosmotic stress[3]; Reduces the levels of MAP kinases which triggers inflammation[3]

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