Premium Intraocular Lenses in Cataract Surgery

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Cataract surgery has evolved from just replacing the ageing crystalline lens with an intraocular lens (IOL) to giving back the patient spectacle free vision. The IOL have also evolved to match these expectations. In this article we will briefly discuss

1. Workup to assess patient’s eligibility for premium IOL surgery
2. Premium IOL’s available
3. Follow up

Workup to assess eligibility

The workup that is followed at our institute comprises of thorough slit lamp examination followed by dilated fundus examination. As the patient may desire to undergo a femtosecond assisted cataract surgery, it’s worth noting the position of eyeball relative to the socket. In patients with deep set eyes and/or prominent supraorbital ridge, small palpebral aperture or blepharochalasis docking may be difficult. Patients with evidence of glaucoma, retinal problems (diabetic retinopathy, macular problems, high myopes etc.) are selectively counseled against undergoing premium IOL surgery. A written informed consent is taken from all. Special consent is taken from the patients who wish to undergo premium IOL surgery but have one or more relative contradictions as mentioned earlier. A basic workup requires good topography and accurate biometry. Additionally, aberrometry can be done to look for higher order aberrations.

Topography gives the surgeon the keratometry (K) values and a good idea about the regularity of the cornea. Pentacam gives Keratometry (both anterior and posterior), magnitude of astigmatism, corneal thickness, anterior chamber depth.

Keratometric Power Difference (KPD) is the difference between the anterior dioptic axial (sagittal) curvature and the true net power providing an assessment of the influence of the posterior corneal surface. KPD values up to 1.5 D are within normal limits, with greater values indicating abnormal steepening (e.g., keratoconus) or flattening (e.g., refractive surgery) of the cornea. The Effective Keratometry Reading (EKR) gives zonal keratometry values till 7 mm. In post LASIK patients these values can be used to enter the zonal keratometry values in the ASCRS calculator if one does not have access to the ALTAS. Patients having corneas with wide distribution of K are not good candidates for premium IOL surgery.

The Galilei G4 being a dual Scheimpflug based imaging device gives more accurate measurements, theoretically. The Total corneal power in Galilei uses ray tracing, which compensates for the posterior corneal curvature to give the true power of the cornea. Galilei G6 has additional optical biometry with all the functionality of G4.

Both Scheimpflug devices give little information about the magnitude of irregularity beyond 3 mm. One can look at the Orbscan to get irregularity indices at 3 and 5 mm zone on the cornea. Corneas with >1.5 D irregularity in 3 mm zone and >2.5 in 5 mm zone are better off without a premium IOL. It’s worth noting that in patients with high corneal irregularity in 3 mm and 5 mm zones are acceptable for premium IOLs, if the difference in the Higher Order Aberrations (HOA) is within 20% of each other.

Accurate biometry is the backbone for success in premium IOL surgery. We prefer to do both optical and immersion biometry in our patients and correlate the two to pick out inadvertent operator errors while performing the biometry. In case of discrepancies even on repeating the tests, we...
prefer the optical biometry readings over immersion technique which in our experience is more accurate. It is difficult to perform an optical biometry in patients with dense media opacities. Pentacam K values are preferred while using the immersion technique at our institute.

Higher order aberrations can significantly reduce visual quality. The Scheimpflug devices also give us Zernike coefficients for optical aberration of the cornea. We follow a simple rule while looking at the aberrations: corneas with \( \text{HOA} > 0.700 \text{ microns} \), Spherical aberrations \( > 0.400 \text{ microns} \), Coma \( > 0.300 \text{ microns} \) are not good candidates for premium IOL surgery.

More advanced workup requires dedicated Aberrometers which unlike the tomographers tell us about the variation of aberrations according to pupil size. We use Aberrometers based on Ray tracing (iTrace, Tracey Technologies) or Dynamic Skiascopy (OPD III, Nidek technologies). These Aberrometers can differentiate between the origin of aberrations by giving us total, corneal and internal aberrations.

Angle kappa \( > 0.4 \text{mm} \) can cause decentration of the optical axis of the IOL relative to the visual axis, leading to visual symptoms after MFIOL implantation.

We also perform macular OCT (if possible) in patients posted for premium IOL surgery which is evaluated by a retinal imaging expert to detect for changes that can lead to unexpected visual outcomes after premium IOL surgery.

**Premium Intraocular Lenses**

**Premium IOL’s can be**

1. Multifocal IOL with or without Toric correction
2. Trifocal IOL with or without Toric correction
3. Accommodating IOL’s
4. Others

**Multifocal IOL’s**: Diffractive multifocal IOLs (MFIOL) utilize microscopic steps, or diffractive zones, across the lens surface. As light encounters these steps, it is directed toward the distant and near focal points. The step height determines the phase delay and therefore designates the focal point, near or distant, where the light rays will be directed.

To improve distance vision the diffractive MFIOL underwent a design change with gradual reduction in diffractive step heights (from 1.3 microns to 0.2 microns) from center to periphery. Pupillary dilatation in the dark leads to exposure of diffractive zones with smaller step heights (Apodization) and direct a larger proportion of light particles to the distant focal point with increasing pupil size. Width between steps determine the add power. Alcon ReSTOR (Figure 1A) has a central 3.6-mm apodized diffractive optic region and a refractive peripheral portion. Add power of ReSTOR can be +3D or +2.5 D at the lens plane, which corresponds to +1.75 -2.25 D and +2.25-2.5 D in spectacle plane, respectively. Patients with astigmatism of > 1D are candidates for Toric MFIOL (TMFIOL). The Alcon TMFIOL can correct astigmatism from 1.5 D – 3.75 D (in the IOL plane).

Tecnis MFIOL (Figure 1B) has diffractive steps with uniform height from the center to the periphery thereby directing an equal amount of light to the near and distant primary foci for all pupil diameters. The near add in Tecnis TMFIOL is 4 D with four models to correct astigmatism, from 1.5D to 4 D in the corneal plane. ReZoom is a multi zonal refractive MFIOL which is no longer preferred.

Rotational stability is very important while correcting astigmatism, keeping this in mind rotationally asymmetric MFIOL were developed (LentisMplus LS-312). The lens has a surface embedded near section that makes the IOL independent of pupil sizes \( > 2.0 \text{mm} \) (Figure 1C). There is a sector shaped near vision segment characterized by seamless transitions between the near and far vision zones. It has a +3D Near Add with correction of +2.25 to +2.5 D at the spectacle plane.

Multifocal IOLs distribute the light energy into different focal planes leading to loss of contrast sensitivity. Increased glare from bright light can make driving difficult at night (Figure 2A). The halos are formed when the near image forms an image blur along with the sharply focused image for distance. The next challenge was to decrease these complications, which led to newer generation of Premium IOL’s (Figure 2B).

The design of the Trifocal IOL enables the patients to see clearly at intermediate distances. Their influence on contrast sensitivity is less as compared to traditional Multifocal designs. Zeiss AT LISA TRI series provides a near addition...
of +3.33 D for a comfortable reading and an intermediate addition of +1.66 D (Figure 3A). Trifocal design in the Fine Vision IOL (PhysIOL) optic combines two diffractive structures that are adjusted to offer the +3.5D addition for near vision and +1.75D addition for intermediate vision (Figure 3B). It is designed so as to reduce the loss of light energy resulting from any diffractive system. This energy gain results in a significantly improved performance for intermediate vision while maintaining the performance for far and near vision.

Single-optic accommodating IOLs e.g CrystaLens AO (Bausch & Lomb), aims to correct presbyopia (Figure 4A) by altering the focal length of the IOL-eye optical system primarily by anterior movement of the lens and changes in the lens architecture (Pseudoaccommodation). The dual-optic accommodating IOL (Synchrony) uses 2 lenses, 1 of high positive power and 1 of negative power, typically with the higher power lens anterior and the negative power lens posterior along the visual axis. It has 5.5 mm diameter high-powered anterior optic (+32D) and a 6mm diameter minus-power posterior optic of whose dioptric power is varied in order to correct each individual eye to emmetropia (Figure 4B). The two optics are connected and separated by silicone struts that exert a specific amount of spring-like tension against the capsular bag, keeping it open at all times. The third IOL that exhibits pseudo-accommodation is ZEISS AT LISA 909MP whose optical design enhances the depth of field, which in turn enhances the static apparent accommodation. A “pseudo-accommodation” range of 5 D at a visual acuity of 0.6 is theoretically achieved which is beyond the range of most “accommodating” IOLs.

Other Premium lenses (Figure 5) less commonly used include, NuLens, which has two rigid PMMA plates and a flexible polymer. Vitreous pressure on the back plate during accommodation forces increased anterior optic curvature of a soft optical material. In FluidVision IOL there is fluid in peripheral chambers which is designed to be pumped into the middle of a flexible fluid-filled optic during accommodation, thereby increasing its radius of curvature. Sarfarazi Elliptical IOL (Bausch & Lomb) is a single piece foldable lens with 2 optics which are connected by 3 haptics. The anterior biconvex optic moves 1.9 mm with respect to the posterior concave-convex optic, producing 4 D of accommodation. It has demonstrated 7-8 D in animal eyes. Tetraflex IOL (Lenstec) is an anteriorly vaulted flexible acrylic lens with a 5.75 mm square-edged optic to reduce posterior capsular opacification. It has accommodative amplitude of 2.4 ± 1.0 D. FlexOptic Lens (Quest Vision Technologies) lens conforms to the geometry of the capsular bag so that the optic moves forward and...
changes curvature with accommodation to produce up to 4.5 D of power. LiquiLens (Vision Solutions), the dual liquid gravity dependent lens is composed of a single optic with 2 immiscible fluids of different refractive index. With downgaze, the liquids change position producing increased power of at least 30 D. SmartIOL (Medennium), Thermoplastic flexible acrylic gel polymer can be manufactured to precise optical specifications and customizable into any size, shape, and power. Polymer undergoes a temperature dependent configuration change: it is converted to a thin rod at room temperature, implanted through a microincision, and returns to its original shape (approximately 9.5 mm wide and 3.5 mm thick) and power at body temperature.

Rayner's Sulcoflex piggyback lens can provide multifocality in a previously implanted monofocal IOL.

The light-adjustable lens (LAL, Calhoun vision) allows the post-implantation correction of up to 2.5 D in sphere and cylinder, and multiple adjustments are possible. A digital light delivery device is used to polymerize the lens material in fine-tuning the patients' post-implantation manifest refraction spherical equivalent (MRSE) at 2 weeks after the cataract surgery to allow for corneal wound healing. Once it has been verified that emmetropia has been achieved the refractive power of the lens is locked in.

It's worth mentioning that for these lenses to perform to the best of their ability one has to perform meticulous surgery with a perfectly centered in the bag IOL implantation targeting emmetropia.

Follow Up

The follow up includes topical steroids and antibiotics to control inflammation and prevent infections. Dry eye incidence after cataract surgery can be as high as 10 %, and addition of topical lubricant to the post-operative regimen can help to prevent these13. Visual Acuity for both distance and near should be taken at every follow up visit.

Plotting a defocus curve can give objective proof of the visual performance of the optical system after implantation of premium IOL. Defocus curves evaluate visual acuity at different distances from the patient or through different levels of defocus induced with trial lenses. Of these 2 methods, the technique of measuring acuity at differing distances is often impractical because the angular image size and target illuminance have to be controlled. The lens-induced magnification affects the latter method; however, this can be easily compensated for mathematically14.

Visual quality indices should be done at each follow up visit. We monitor the Modulation Transfer function (MTF), Strehl Ratio derived from the point spread function (PSF) using the Aberrometers mentioned above. Additional information about scatter is also taken from Optical Quality Assessment System II (OQAS II, Visionmetrics, Spain), which gives us an Optical Scatter Index (OSI). In our practice the MTF varies from 20-30 in patients with diffractive MFIOL, 25-40 in patients with Trifocal design IOL's. A Strehl ratio of 0.3 to 0.5 is desirable in patients with MFIOLs. An OSI of <1.2 is considered good after premium IOL surgery.

To summarize, a detailed preoperative workup to carefully select the right candidates for premium IOL implantation followed by meticulous surgery can give us the best results in terms of visual quality and patient satisfaction.

References

Intraocular Lenses


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