Multifocal IOL-An Overview
Dr. Minu M Mathen

Advances in intraocular lens (IOL) design have significantly improved the visual outcomes of cataract surgery. Multifocal IOLs are designed to reduce dependence on spectacles after cataract surgery, and IOLs are gaining acceptance as potential refractive surgical options in selected patients.

Monofocal IOLs provide excellent distance visual function. But because of their limited depth-of-focus, they do not provide clear vision at near without spectacle correction. Monovision techniques may be helpful for some patients but can sacrifice binocularity.

The introduction of the multifocal IOL in the early-mid 1980s provided the potential for a range of uncorrected vision from near to far. Providing distance and near vision increases the depth of field and improves visual quality at near- that improves with time. Multifocality is the brain’s natural ability to adapt to near and far vision as it chooses, based on the object being viewed, between the 2 images (near and far) produced by the optical elements of the IOL. These multifocal IOLs provide distance, intermediate, and near correction.
**Principle**

When a person is viewing a distant object, a sharp retinal image is provided by the parts of the IOL within the pupillary area that have the distance correction; a somewhat blurred image is provided by the other parts of the IOL as the images are superimposed on the retina. The decrease in contrast of the in-focus image is produced by the split of the total light energy between the far and near focus, while the simultaneous presence (superimposition) on the retina of the in-focus image and out-of-focus image can produce a sort of retinal confusion; however, this is overcome by the brain’s capability to use multifocality.

Multifocality theoretically implies that more straylight reaches the retina. However, psychometric measures show that perceived straylight is not different in eyes with monofocal IOLs, thus the importance of brain adaptation.

The optical quality of the eye depends on defocus, light scattering, eye aberrations, and diffraction. After lens extraction and IOL implantation, this quality will also be affected by aberrations and scattering induced by the IOL. Reduced image contrast and unwanted visual phenomena, including glare and halos, have been associated with multifocal IOLs. One possible solution to improve the performance of multifocal IOLs is to direct different amounts of the refracted–diffracted light to the different foci, thus giving preference to distance or near vision. Another way is to direct different amounts of light to the different foci depending on pupil diameter.

Refraction and diffraction principles have traditionally been used to create multifocality from near to distance. In refractive optics, the different zones of equal refractive power have a mutual focus. Phases of incoming light are incoherent, creating some destructive interference. This interference affects the intensity of the focus light and thus leads to a reduction in brightness and visual acuity. The retinal image with multifocal refractive IOLs depends on pupil diameter because of the IOLs' power profile. Diffractive IOLs are less pupil dependent and have advantages over refractive IOLs in near vision.

**The profile of the most recent and commonly used multifocal IOLs.**

The AcrySof IQ ReSTOR (SN6AD1&SA6AD3) (fig 1) multifocal IOL combines the functions of the apodized diffractive region and the refractive region. The apodized diffractive optics are within the central 3.6 mm optical zone of the IOL. This area comprises 12 concentric steps of gradually decreasing (1.3 to 0.2 μm) heights, creating bifocality from near to far (2 foci). The refractive region of the optic surrounds the apodized diffractive region. This area directs light to a distant focal point for a larger pupil diameter and is dedicated to distance vision. The overall diameter of the IOL is 13.0 mm, and the optic diameter is 6.0 mm. The IOL power varies from +10.0 to +30.0 D and incorporates a +4.0 D near addition (add) and recently a +3.0 D near add which provides better intermediate vision. The asphericity

Figure 1
was incorporated into the IOLs to prevent optical contrast reduction and to compensate for the physiologic spherical aberration inherent in the average cornea. IOLs are single piece with an anterior aspheric optic surface and are composed of an acrylate–methacrylate copolymer containing a blue light–filtering chromophore.

The ReZoom multizone IOL (fig 2) has 5 concentric refractive zones that refract light toward the main foci. Zones 1, 3, and 5 are distance dominant, and zones 2 and 4 are near dominant. The transitions between the zones are aspherical to provide balanced intermediate vision. The difference in intensity on the focal points makes the ReZoom a distance-dominant IOL with better intermediate visual function. The overall diameter of the IOL is 13.0 mm, and the optic diameter is 6.0 mm. The IOL power varies from +6.0 to +30.0 D and incorporates a +3.5 D near add.

The Acri.LISA 366D (fig 3) is a bifocal biconvex refractive–diffractive single-piece IOL with a 6.0 mm foldable acrylate aspherical optic, an overall diameter of 11.0 mm, and 0-degree haptic angulation. The surface is divided into main zones and phase zones; the phase zones assume the function of the steps of diffractive IOLs. The phase zones have a mean refractive power corresponding to the zero diffractive power of the main zones. The IOL power responsible for distance vision is refractive and diffractive at the same time. The first diffractive power used for near vision is formed by in-phase interference of waves from the main zones. The 2 focal points are created by phase zones on the anterior surface of the IOL. The incident light is distributed with 65% to distance focus and 35% to near focus. The diffractive structure has a soft transition of the phase zones between the main zones. The adjusted phase zones were designed to reduce disturbing light phenomena (eg, scattered light, halos) to improve retinal imaging quality and visual performance. The IOL has an aspherical profile to correct positive spherical aberration of the cornea. The optic is made of acrylate (refractive index 1.46) with 25% water content and ultraviolet wavelength–absorbing properties (Acri. Lyc material). The hydrophobic surface of the Acri. LISA 366D IOL, has sharp edges to reduce posterior capsule opacification. The IOL power varies from
Figure 4

Surgical considerations

Pre operative

Premium IOLs maximize patients’ outcomes and satisfaction by combining cataract and refractive surgery. Patient selection is probably the single most important determinant of success for the surgeon as well as for patients’ satisfaction. A thorough preoperative counselling is very important before choosing the right patient for a multifocal IOL. Let the patients view a video (which most IOL manufacturers have now) regarding the principles of a multifocal IOL. A highly demanding patient is not a right candidate for a multifocal IOL.

We need to explain the advantages (minimal spectacle dependance & spectacle independence improves with time) and disadvantages (possible reduction in contrast sensitivity, mild glare and halos around light sources, need for bilateral implantation for maximum effect of neuroadaptation, need for a refractive laser procedure for a possible residual refractive error and a possibility of need for near vision glasses for very fine print or for intermediate distance). Knowing all these, if the patient has the drive to go for these IOLs, they would be more willing to overlook these minor problems. We need to make sure that the patient does not go in for the surgery with the idea of getting perfect results as there is always a possibility of varied human response to surgery and these IOLs are not the perfect replacements for the vision one would have enjoyed in the second or third decade of life.

Patients who have corneal irregularities, limited BCVA, and macular pathology which would compromise the final visual outcome should be excluded. Patients who have a corneal astigmatism of more that 0.75 D should be told about the persistance of this residual refractive error postoperatively. (we could always reduce it by performing limbal relaxing incisions according to the astigmatism if it is less than 1.5 D but their predictability is not always same). The option of a laser correction for this also can be put forward like bioptics, where a LASIK flap is cut 1 to 2 weeks before proceeding with the cataract surgery and when the refraction is stable postoperatively, 3 to 6 weeks after surgery, the flap can be lifted to perform LASIK in order to treat the preexisting refractive astigmatism or any residual sphere.
So always set realistic expectations postoperatively. The ideal candidate for a multifocal IOL is one who understands the technology’s abilities and limitations, with minimal astigmatism and an otherwise healthy ocular surface, retina, macula, and optic nerve.

**Intra operative**

A successful outcome with any multifocal IOL requires great attention to detail on the part of the surgeon. An emmetropic result and centration of the lens must be obtained to maximize quality of vision, facilitate neuroadaptation, and minimize dysphotopsia. If these endpoints are not obtained, aberration will result, which will lower patients’ satisfaction.

The IOL needs to be centered over the visual axis versus over the geographical center or slightly nasal to it. To identify the visual axis ask the patient to fixate on the microscope’s filament and mark the anterior Purkinje image with methylene blue. Then center a circular capsulorhexis around it so that there is a 360 degree CCC overlap on the IOL optic. Single piece models should always be implanted inside the capsular bag (restore and acrylisa). We should always keep a back up of multi piece IOLs for sulcus placement in case of a posterior capsule rupture.

**Post Operative**

Causes of suboptimal results after multifocal IOL implantation are monocular implantation, minimal residual refractive error, posterior capsular opacities, ocular surface disease, cystoid macular edema (CME), and a decentered IOL.

The patient needs to be encouraged to start reading and using their eyes for near work as early as possible to get used to the multifocality. We should avoid giving the patient a near vision addition during the initial postoperative weeks. Also encourage the patient to undergo a multifocal IOL implantation in the other eye also within a few weeks to enhance the neuroadaptation which improves the multifocal visual function.

YAG laser capsulotomy might be required earlier and more frequently in these patients whose quality of vision can be affected by early capsular fibrosis. But if an IOL exchange is deemed necessary (because of unacceptable residual power or dissatisfied patient), it is advantageous to perform it prior to YAG laser capsulotomy.

Emmetropia must be obtained to maximize outcomes and meet patients’ expectations (as many of them are highly sensitive to minor residual powers) for which we could perform either LASIK or surface ablation. It is usually required for eyes with residual sphere of 0.50 D or greater and cylinder of 0.75 D or greater which is not accepted by the patient.

Dry eye disease is common in older patients. Even a mild breakdown of the corneal epithelium reduces the tear film’s ability to smooth out the ocular surface. A more regular tear film and ocular surface improve quality of vision.

The loss of contrast sensitivity associated with a multifocal IOL is worsened by CME. Once the normal architecture of the retina is lost, visual quality is degraded for life. Snellen visual acuity will improve, but contrast sensitivity will be permanently reduced. The best way to look for CME after cataract surgery is with OCT. In addition, OCT is a very effective preoperative screening tool for foveal membranes, which will reduce quality of vision after cataract surgery. The pre and post operative use of topical NSAIDs is very beneficial in multifocal IOL cases.

**Conclusion**

The goal of any refractive surgery is primarily to meet or exceed the patients’ expectations. Making sure that they have a realistic expectation of the
limits of refractive IOL surgery is important, as no surgery is perfect. With very careful patient selection, adequate preoperative patient counseling and attention to detail during surgery and proper post operative follow up and treatment can make the vast majority of our multifocal IOL patients happy.

References


