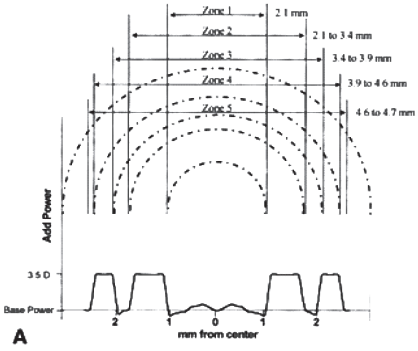
Review Article :

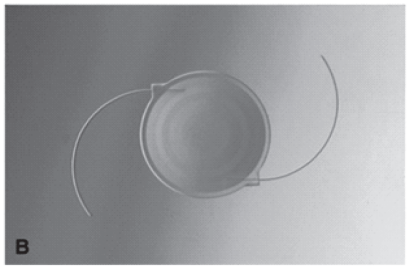
MULTIFOCAL IOLS : MYTHS AND REALITY

Dr. Praveen Subudhi MS DNB FRCS
RUBY EYE HOSPITAL, BERHAMPUR

Cataract surgical techniques and intraocular lenses have evolved significantly over the past few years. Despite excellent distance visual acuity with monofocal lenses patients remain dependent on glasses for near and intermediate vision. The ability to read is very essential now a days for the patients. Losing this ability limits patient independence and significantly decreases his or her quality of life. However older patients who are used to glasses does not face much problem but the younger patients definitely feel the brunt.

Various methods are available to tackle this problem. Monofocal IOLs with mono vision in which dominant eye is used for distance vision and non dominant eye is used for near and intermediate vision. Accommodative IOLs are also available recently but with variable visual outcome. But above all multifocal IOLs provide better uncorrected near visual acuity in most cases with less refractory surprises.





Schematic of the zonal-progressive multifocal lens design of the ARRAY lens (Allergan Surgical Products Inc., Irvine, CA)

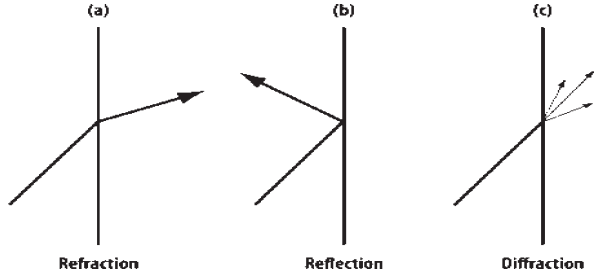
Types of multifocal IOLs

Refractive multifocal IOLs : Principle: In these types of IOL there are concentric refractive zones that refract light to the main foci. Total Light energy is split between far and near focus so that there is simultaneous presence of in focus image and out of focus image hence producing retinal rivalry which is overcome by brain's capability to use multifocality. However each lens zone has different effective aperture and this can effect the quality of image depending upon the pupillary diameter due to light and accommodative reflexes.

Types of refractive IOLs available:

1. Rezoom NXG (amo), Array (allergan inc) : It has 5 concentric rings, odd numbers are used for distance vision and second and fourth ring is used for near vision. Near vision add of + 3.50 D. An aspherical transition between zones is used for intermediate vision.

2. Other lenses were also present with 3 zones (storz truvista, alcon acurasee, isoptex) or with 7 zones (adatomed) did not got US FDA approval.



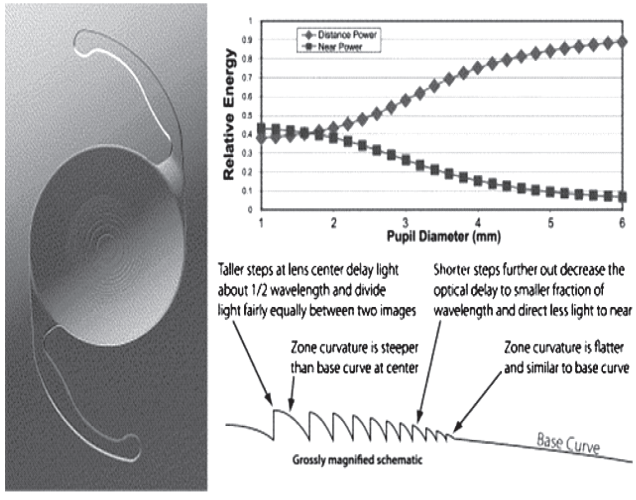
There are 3 methods to redirect light in a controlled manner: (*a*) Refraction: The refractive index difference between the 2 materials determines the angle. (*b*) Reflection: The reflected angle equals the incidence angle. (*c*) Diffraction: The grating period determines the diffracted angles, and the grating phase structure determines how much light goes into each diffraction order.

2. Diffractive IOLs:

Principle: Primary guiding principle during the development of this lens was that near vision is less important in cases of dim illumination as pupils are large and second that minimization of haloes and glare in dim illumination. In fact these two principles are coincidence to each other and this forms the basis of apodization, in which the energy balance of optical system varies with pupillary diameter consistent with natural pupillary responses. Diffraction occurs at all the steps creating the diffractive foci. The optical properties are relatively constant as pupil varies, 41% of light goes to each foci (distance and near) at the design wavelength and 18% of light is wasted as it is diffracted to higher orders.

Types of diffractive IOLs

ReSTOR (ALcon) ; apodized diffractive IOL: In this type of lens there are two focal points one for distance and other for near. The base lens has a refractive surface for distance focus and there are 12 concentric apodized steps/discontinuities incorporated anteriorly with near add equivalent to 3.5D at spectacle plane. Apodization cover central 3.6 mm of the optical plane and periphery to which constitutes monofocal lens for distance foci.



This figure depicts restor (AMO) lens and diffraction of light at various papillary diameters

Tecnis (AMO): this lens is similar to Alcon restor lens with apodized diffraction rings.

Acritwin (Carl zeiss) Visual outcomes of multifocal IOLs (a review of literature)

Visual acuity: The mean uncorrected distance visual acuity (mean of 15 latest reported studies) is 0.04+/-0.1 (logmar) and mean uncorrected near visual acuity is 0.02+/-0.1. Spectacle independency varies from 70-90%(mean 83%). Thus randomized clinical trials and meta analysis of RCTs comparing the results of multifocal implantation with the results of monofocal IOL implantation conclude that uncorrected near visual acuity is better with multifocal IOL without any compromise in distance visual acuity.

Intermediate vision: Intermediate vision is provided by contributions from the defocus characteristics of both primary lens powers. Approximately 13% of available light in a multifocal IOL is allocated to intermediate focus, leading to loss in visual performance. But this is for monochromatic light, in normal white light it may lead to increase in performance due to chromatic aberration.

Reading speed: In one of the studies it had reported that the mean uncorrected reading speed was 178+/-50 words per minute at a mean reading distance of 31cm. It was better with diffractive IOLs in comparison to refractive IOLs.

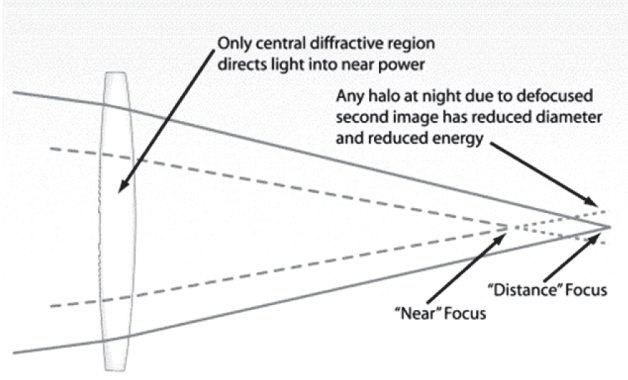
Contrast sensitivity: As such contrast sensitivity is less in comparison to monofocal IOLs. However in normal daylight and twilight with a weak lateral glare there is no significant difference from monofocal IOLs. But the difference is significant in daylight with peripheral glare (simulating sunshine) and in twilight with central glare (simulating an oncoming car with headlights on at night on a dark highway).

Night driving: In a study more than half of the patients reported to have problems driving at night, especially seeing low contrast objects alongside road.

Pupil diameter: diffractive IOLs has no relation with pupil diameters in other words it provides focus for a wide range of light conditions. However some authors believe that the effective diameter to acquire good near visual acuity is minimum of 3.0 mm. But preoperative pupil size does not predict post operative pupil size it usually depends on age and illumination so it may be difficult for a surgeon to decide on an appropriate patient from preoperative pupil size.

Assessment of depth: Holladay et al showed that the multifocal IOLs had 2 - 3 fold increase in depth of the field with atleast 50% lower contrast in the retinal image compared to monofocal IOLs.

Visual halos : It was the major concern in earlier models but with the advent of apodization technology quality of image has improved in dim illumination by reducing unwanted secondary images.



Limiting the diameter of the diffractive region reduces the size and energy of halos surrounding a point source at night.

Conclusion:

Multifocal IOLs have opened the gate for treatment of presbyopia which is the major concern for all geriatric population but still there are other visual problems like halos, glare and night driving, limiting widespread acceptability. Improvement in this technology in future may increase its spectrum of use so that it may become a part of refractive surgery instead of cataract surgery.

References.

1. Davison JA, Simpson MJ. History and development of the apodized diffractive intraocular lens. J Cataract Refract Surg. 2006 May;32(5):849-58. PubMed PMID:16765805.

2. Artigas JM, Menezo JL, Peris C, Felipe A, Díaz-Llopis M. Image quality withmultifocal intraocular lenses and the effect of pupil size: comparison of refractive and hybrid refractive-diffractive designs. J Cataract Refract Surg.2007 Dec;33(12):2111-7. PubMed PMID: 18053913.

3. Javitt JC, Steinert RF. Cataract extraction with multifocal intraocular lensimplantation: a multinational clinical trial evaluating clinical, functional, andquality-of-life outcomes. Ophthalmology. 2000 Nov;107(11):2040-8. PubMed PMID:11054329.

4. Kawamorita T, Uozato H. Modulation transfer function and pupil size inmultifocal and monofocal intraocular lenses in vitro. J Cataract Refract Surg.2005 Dec;31(12):2379-85. PubMed PMID: 16473235.

5. Rasp M, Bachernegg A, Seyeddain O, Ruckhofer J, Emesz M, Stoiber J, Grabner G,Dexl AK. Bilateral reading performance of 4 multifocal intraocular lens models and a monofocal intraocular lens under bright lighting conditions. J Cataract Refract Surg. 2012 Nov;38(11):1950-61. doi:10.1016/j.jcrs.2012.07.027. PubMedPMID: 23079311.

6. de Vries NE, Webers CA, Montés-Micó R, Tahzib NG, Cheng YY, de Brabander J,Hendrikse F, Nuijts RM. Long-term follow-up of a multifocal apodized diffractive intraocular lens after cataract surgery. J Cataract Refract Surg.2008 Sep;34(9):1476-82. doi: 10.1016/j.jcrs.2008.05.030. PubMed PMID: 18721706.

7. Nijkamp MD, Dolders MG, de Brabander J, van den Borne B, Hendrikse F, Nuijts RM. Effectiveness of multifocal intraocular lenses to correct presbyopia after cataract surgery: a randomized controlled trial. Ophthalmology. 2004 Oct;111(10):1832-9. Erratum in: Ophthalmology. 2004 Nov;111(11):2022. PubMed PMID: 15465543.