

Intraocular Solutions for Presbyopia Correction

The efficacy of any method to restore near vision depends on patient characteristics.

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The eye's ability to accommodate is progressively lost with age, which is why this phenomenon is called *presbyopia* (from the Greek words *présbys*, meaning old, and *ōps*, meaning eyes). The condition can be treated with corrective lenses, a method that has been widely used for a long time; however, this approach may not be the most comfortable treatment option for the patient.

Today, patients have increasing expectations regarding ophthalmic treatments, often hoping to achieve good uncorrected near, intermediate, and distance visual acuity and therefore be made completely independent from glasses. In recent years, a major challenge for ophthalmology has been the restoration of near vision in patients with presbyopia.

Presbyopia correction methods can be divided into accommodative and nonaccommodative; reversible and irreversible; and corneal, scleral, and lens-based surgical corrections. When presbyopia is accompanied by an early cataract, patients who desire presbyopic correction are often referred for cataract rather than corneal surgery. When the lens is clear (ie, without sign of cataract formation), the surgery performed in this situation is called *refractive lens exchange*.

Current surgical techniques for presbyopia correction are based on three principal approaches. The first is to achieve monovision, meaning to create acquired anisometropia, with one eye corrected for distance vision and the other for near. The second approach is to increase functional ocular depth of focus by creating simultaneous multifocality, thus achieving satisfactory distance and near vision. The third approach is to surgically achieve real changes in accommodation, or changes in ocular lens power.

Surgical methods of monovision and multifocality can be achieved with corneal or intraocular procedures. Corneal methods are more suitable for young presbyopes, aged 40 to 50 years, and those without cataracts. For patients with cataracts or for refractive lens

exchange in older patients, monovision can be achieved with binocular implantation of monofocal lenses. In these cases, proper patient selection is crucial.

Satisfactory results with multifocality can be achieved via the implantation of a range of IOLs, including multifocal, bifocal, and trifocal lenses. Accommodating IOLs offer partial restoration of accommodation through the forward movement of the lens during accommodative effort. Recently, implants with accommodative qualities have been combined with a multifocal design.

The efficacy of all these methods to restore near vision depends on characteristics of the individual patient, including biometric parameters, age, and near-vision needs in everyday life. We must remember to explain to patients that, even if the operation is properly performed, the results for a given individual may be unsatisfactory. It is also important to note that not every method is designed for all patients, and not all patients are candidates for every approach.

IOLs FOR PRESBYOPIA CORRECTION

IOLs that can be used for presbyopia correction include the following types:

- Monofocal IOLs in a monovision strategy;
- Multifocal and multifocal toric IOLs;
- Bifocal and trifocal IOLs;
- Accommodating IOLs;
- Accommodating bioanalytic lens;
- The Light-Adjustable Lens (LAL; Calhoun Vision); and
- Add-on or supplementary lenses.

MONOVISION

Monovision is a method of correcting presbyopia in which one eye is corrected for distance vision and the other for near, thereby creating anisometropia. Historically, the dominant eye has been targeted for distance and the nondominant for near.

Literature on monovision cites excellent results with

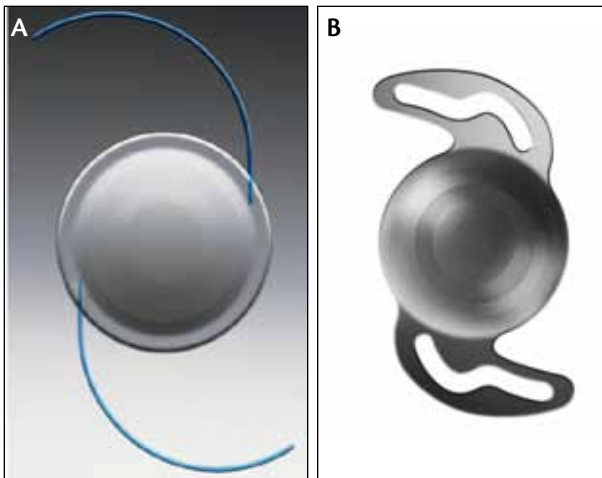


Figure 1. The ReZoom (A) and M-Flex (B) lenses are multifocal IOLs with a refractive design.

anisometropia of 1.50 to 2.50 D. Crossed monovision occurs when the nondominant eye is corrected for near, either intentionally or due to a surgical error or an unpredictable outcome yielding an undercorrection.

Monovision can be achieved with contact lenses (mean success rate, 73%), PRK, LASIK, refractive lens exchange, and cataract surgery with appropriate IOL calculation. Usually, monofocal IOLs are used for lens-based monovision correction. Ideally, patients with monovision should see clearly at most distances, experiencing continuous and smooth binocular depth of focus, and stereoacuity should not be significantly impaired to a degree that could interfere with everyday activities.

MODERN IOL DESIGNS

IOLs were introduced into cataract surgery in the early 1950s and have since significantly improved the outcomes of the procedure. The indications for IOL/lens surgery have changed over the years, from dense cataracts to mild cataracts to correction of refractive error with refractive lens exchange. Clear lens surgery is now popular for refractive error correction, especially in presbyopes.

Lens power is adjusted individually, based on the appropriate calculations, usually to achieve emmetropia. For the patient, the use of artificial monofocal IOLs in lenticular or cataract surgery means achieving selective visual acuity. After implantation, the eye loses its ability to accommodate and requires additional correction with glasses for medium and short distances, which can be a major problem, especially for working patients. One way to avoid this situation is to implant accommodating or pseudoaccommodating lenses.

Multifocal IOLs. Multifocal IOLs are the most common method of intraocular presbyopia correction. These lenses are equipped with a so-called *pseudoaccommodating system*

that disperses incident rays reaching the eye so that good visual acuity is possible for near, intermediate, and distance vision. There are two types of pseudoaccommodating systems: refractive and diffractive.

Refractive designs are based on different zonal areas, typically annular in shape, that have different refractive powers. These lenses tend to use a series of zones with two main foci, near and distance. These IOLs are dependent on pupil size and perform differently under various light conditions. Common side effects include halos, especially in low-level light conditions.

The advantages of refractive-designed multifocal IOLs include good distance vision and relatively good intermediate vision, whereas the results for near vision tend to be worse than with a diffractive design. In refractive lenses, 100% of the light that comes to the eye is used, whereas in diffractive IOLs only 80% of the light is effectively utilized, the rest being lost to higher-order diffraction. Diffractive designs are based on the principle of Huygens-Fresnel. A disadvantage of diffractive IOLs is lower intermediate visual acuity compared with refractive IOLs.

Which multifocal lens design is used depends on the individual needs of the patient. Refractive lenses are more appropriate if the patient wants to see well at distance and intermediate, and diffractive lenses may be better for patients who need good focus for near vision. An alternative option is the mix-and-match approach, in which a diffractive lens is implanted in one eye and a refractive lens in the other.

Multifocal IOLs with a refractive system include the ReZoom lens (Abbot Medical Optics Inc.; Figure 1A) and the M-Flex IOL (Rayner Intraocular Lenses, Ltd.; Figure 1B). A diffractive system is used in AcrySof Restor implants (Alcon; Figures 2A and 2B), Tecnis IOLs (Abbott Medical Optics Inc.; Figure 2C), and the AT LISA lens (Carl Zeiss Meditec).

The disadvantage of multifocal lenses is a reduction in contrast sensitivity compared with monofocal lenses. To avoid or significantly reduce this phenomenon, the apodized diffractive design approach was created. For diffractive apodized IOLs, the step height of the diffractive elements is reduced from the center to the periphery. This effect improves the patient's near vision but does not reduce the occurrence of glare or halos.

Many available multifocal IOLs have an aspheric optic design to optimize visual function. It is also possible to correct astigmatism with a multifocal toric IOL design.

In my opinion, to avoid side effects, the most important aspect of multifocal IOL implantation is proper patient selection. Do not forget: Multifocal IOLs are not a good solution for every patient.

Bifocal and trifocal IOLs. Other types of multifocal IOLs include bifocal and trifocal lenses. The Lentis



Figure 2. The AcrySof Restor IOL (A,B) and the Tecnis IOL (C) are multifocal IOLs that have diffractive designs.

Mplus (Oculentis) bifocal IOL gives patients good and balanced visual acuity at all distances, even in the intermediate area, and sharp contrast and color vision due to a maximum light exploitation of more than 93%. Furthermore, the minimal halo and/or glare phenomena associated with these lenses make surgeons and patients feel more comfortable than with a multifocal IOL. Additionally, patient satisfaction is still above average at 95%. This lens is promising in select groups of patients. The FineVision IOL (PhysIOL) is a trifocal diffractive lens that provides near, intermediate, and distance foci and, like the Mplus, reduces the amount of light lost to scatter in comparison with other diffractive IOLs.

Light-Adjustable Lens. The LAL is composed of a molded flexible silicone polymer matrix containing photorefractive silicone macromers, a benzoin photoinitiator, and ultraviolet-A (UV-A) light absorbers. LAL irradiation with UV-A light (365 nm) causes photopolymerization of the macromer molecules. A period of 7 to 21 days is then required for healing and refractive stabilization. Customized multifocal optics have been created on the LAL in vitro. Arturo S. Chayet, MD, has performed the bulk of the clinical investigations to date and has implanted the LAL in more than 50 eyes. The achieved corrections ranged from 0.50 to 1.75 D. The results show that 95% of eyes are within ± 0.25 D of intended correction.¹

Accommodating IOLs. Instead of implanting an IOL with a fixed power into the capsular bag, a more recent approach is based on the implantation of an IOL that is designed to change the focal power of the eye, thus imitating natural accommodation.

An example of a pseudoaccommodating lens is the 1CU lens (HumanOptics AG). It is a foldable acrylic lens with flexible haptics, designed to enable the shape of

the IOL optic to change through the action of the ciliary muscle. Movements occur in the anteroposterior axis. However, the calculated scope of accommodation is narrower than in the case of multifocal lenses. Other available or proposed lens models designed to restore dynamic accommodation include the following:

- Bag-filling IOL designs—injectable polymers that can fill the lens capsule and change shape in a manner similar to the natural lens or, alternatively, a small dehydrated rod lens (SmartLens; Medennium Inc.) inserted into the capsular bag that, when hydrated, takes the shape of the full-size lens;
- Sagittal-axial translating lenses, which change accommodation by axially moving the lens closer to the cornea (Crystalens; Bausch + Lomb);
- Lateral translating accommodating IOLs—a recently developed dual-lens system (Turtle IOL; Abbott Medical Optics Inc.) of two lenses that move in opposite directions, parallel to the plane of their contact; the dual-lens Turtle IOL is placed in the lens capsule, and accommodation activation is obtained by changing the distance between the two lenses during ciliary muscle contraction; and
- Posterior piston bulge, a system working similarly to a piston mechanism (DynaCurve IOL; NuLens, Ltd.) that decreases dioptric power when the ciliary muscle is constricted.

Experience with the majority of these lenses is limited to date.

Bioanalogic IOL. One of the latest solutions for presbyopia correction is the implantation of a bioanalogic lens, the WIOL-CF (Medicem; Figure 3). The WIOL-CF is a polyfocal accommodating hydrogel IOL. Wigel is a proprietary bio-compatible hydrogel material, the surface of which resem-



Figure 3. The WIOL-CF is a polyfocal accommodating hydrogel IOL.

bles the natural lens material more closely than other IOLs, making the IOL extremely resistant to protein, cell deposits, and calcification.

The design of the WIOL-CF enables polyfocal accommodation capability with a continuous range from near to distant foci, for improved vision without further correction such as spectacles. This makes the WIOL-CF especially suitable for younger patients with active lifestyles.

The first bioanalogic lens was implanted in our hospital in December 2012. Since then, we have implanted 20 WIOL-

TAKE-HOME MESSAGE

- The efficacy of methods to restore near vision depends largely on patient characteristics such as biometric parameters and age.
- Presbyopia correction methods can be divided into accommodative and nonaccommodative; reversible and irreversible; and corneal, scleral, and lens-based surgical corrections.
- Room for improvement exists in the accommodative capability of IOLs, their ease of handling in surgery, the quality of postoperative night and peripheral vision, the occurrence of complications, and the reversibility of the procedure.

CF lenses. The WIOL-CF has further advantages over other IOLs, including:

- A large optic (9-mm diameter) facilitating vitreoretinal diagnostics and surgery (eg in patients with diabetes);
- A glare-free optic ensuring undisturbed night and peripheral vision;
- Low incidence of posterior capsular opacification;
- Perfect centration and resistance to dislocation;
- Ability to be injected through a small incision;
- Reversibility (can be replaced with a lens of the same or a different type);
- No need for special surgical equipment or training; and
- Long-term reliable outcomes.

CONCLUSION

Many types of lenses have been developed for intraocular correction of presbyopia; however, room for improvement exists in the accommodative capability of implantable lenses, their ease of handling during eye surgery, the quality of night and peripheral vision postoperatively, the occurrence of short- and long-term complications, and the reversibility of the procedure in the event of an unfavorable outcome. ■

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