# The WIOL-CF Accommodative Intraocular Lens

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## Abstract

A few years ago, the goal of cataract surgery was simply removal of an opaque crystalline lens. Nowadays, clear lens extraction is used in everyday clinical practice in order to correct refractive errors, especially presbyopia. Different intaocular lens (IOL) designs have been proposed, such as monofocal IOLs with monovision or multifocal IOLs. Accommodative IOLs are considered one of the greatest accomplishments in ophthalmology today. The WIOL-CF is an accommodative IOL with unique design and properties that guarantee excellent uncorrected vision at all distances, glare-free optics, position stability and posterior capsule opacification resistance. The WIOL-CF IOL can combine the advantages of other accommodative intraocular lenses regarding spectacle-free near vision, while at the same time its main technical parameters can overcome the major problems that other accommodative IOLs present.

## Keywords

Refractive lens exchange, intraocular lenses (IOLs), accommodative IOLs, WIOL-CF, pseudoaccommodation

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Until recently, the only goal of cataract surgery was the removal of an opaque crystalline lens and its replacement with an artificial intraocular lens (IOL). Reduced phacoemulsification energy, smaller incisions and improved IOL designs have turned cataract surgery into an extremely safe and successful procedure, and nowadays more than 90% of patients achieve visual acuity of 20/40 or better post-operatively.[1] The evolution of cataract surgery, in conjunction with changes in the demands made by patients, has introduced the concept of refractive lens exchange into everyday clinical practice. Refractive lens exchange is a surgical procedure that restores far and near vision by replacing the clear crystalline lens with an IOL.[2] The most common application of refractive lens exchange is the correction of presbyopia. Even though clear lens extraction for the restoration of near vision appears invasive, the desire to be spectacle-free, along with ever-higher everyday-life expectations, has increased the popularity of this procedure.

## Background Information

One of the biggest research fields in ophthalmology is the development of new artificial IOLs to replace the natural crystalline lens. Although construction materials are constantly improving, optimising the surgical outcome, visual performance is not ideal at all distances since natural lens accommodation cannot be replaced.

Until recently, the most common artificial IOLs used were monofocal IOLs, which provide exquisite results for either distance or near vision; however, due to their small depth of focus they cannot provide clear vision for both distances. One way to overcome this limitation is by applying the monovision technique, in which the dominant eye is corrected for distance vision whereas the non-dominant eye is corrected for near vision. The major drawback of the monovision technique is the fact that the patient may have difficulties with binocularity and stereopsis.[3,4]

Multifocal IOLs represent another treatment option, and result in satisfactory results for both distance and near vision without the use of spectacles. This is accomplished via lens multifocality, which creates a range of optical foci: near, distant and intermediate. Every multifocal IOL provides at least two dioptric powers, usually separated by a four-diopter interval to provide a three-diopter interval at the spectacle plane, with two images of the same object forming on the retina. The defocused image causes blurring of the focused image, reducing modulation.[5,6] Although multifocal IOLs provide functional vision for all distances, they are associated with quality problems such as reduced contrast sensitivity and dysphotic phenomena such as glare, halo and problematic night vision.[7]

Even though the lenses mentioned above have undeniable value, contemporary ophthalmology has not completely resolved the presbyopic dilemma by simulating the accommodative properties of the crystalline lens. The common assumption until now has been that pseudophakic patients are unable to accommodate. Accommodative IOLs were designed to fill this gap and provide satisfactory vision for all distances by restoring some degree of 'pseudoaccommodation'. The function of accomodative IOLs is based on the movement of the lens in the capsular bag as a result of accommodative effort.[3] This movement is probably the result of ciliary muscle contraction and increased vitreous pressure producing an increase in effective lens power.[8] The result is 0.8–2.3 diopters of pseudoaccommodation, which also correlates with other factors such as myopic astigmatism, pupillary miosis and corneal multifocality.[9] Comparative studies show



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that accommodative IOLs offer similar distance vision to monofocal IOLs and improved near vision during the first six months after implantation, but loss of this latter effect in the first year post-operatively due to capsular opacities.[10–12]

## The WIOL-CF Accommodative Intraocular Lens

The WIOL-CF accommodative IOL was invented by Professor Otto Wichterle and his collaborators at the Institute of Macromolecular Chemistry in Prague. Its design is based on the biomimetic principle: according to this principle, the hydro gel material used and the lens geometry simulate some of the key properties of the crystalline lens itself. The WIOL-CF can be actually considered more as a natural product and not a typical engineered one. The material used for the construction of the WIOL-CF has a high water content, a negative surface charge, a high carboxylate content and a low refractive index. These parameters ensure maximum biocompatibility, resistance to calcification and elimination of cell attachment or spreading, which are considered the main causes of lens and posterior capsule opacification. The geometry of the lens can be distinguished by its large outside diameter, convex anterior, posterior surfaces and relatively large sagittal depth (see *Figure 1*). These characteristics were selected to secure adequate contact with the biggest part of the posterior capsule but not alteration of the capsule shape. Additionally, the large continuous aspheric optics ensure lens centricity and reduce reflections and halos, which can cause night vision problems. The lens design is intended to provide pseudoaccommodation capability, facilitating near vision.

The large optics of the WIOL-CF ensure good optical performance even in large-diameter pupils in scotopic conditions. The large optical zone gives the lens a significant advantage over other IOLs, especially in young patients, in mesopic conditions and for vitroretinal surgery candidates. Disturbing optical side effects that can sometimes be observed with smaller-optic IOLs are not seen with the WIOL-CF. The WIOL-CF can be inserted through a 2.8mm incision. The small incision required can significantly reduce the induced stigmatism. The hydro gel lens is partly dehydrated and temporarily plasticised by a water-miscible non-toxic plasticiser. In its plasticised state, the lens is smaller and much stronger than in its fully hydrated state, and can be folded 'taco-style' prior to implantation (see *Figures 2* and *3*). Once the lens is inserted, it unfolds inside the capsule and gradually hydrates using the fluid present in the eye. Complete hydration is achieved within the first 48 hours, and full equilibrium with the eye fluids occurs.

The shape of the lens may be biconvex, planoconvex or convex–concave, according to the dioptric power. The suggested A-constant for implantation is 120 and the recommended formula for the calculation of the dioptric power of the WIOL-CF is SRK II or SRK – T. Pseudoaccommodation up to 2.5 diopters can be achieved with the WIOL-CF. Its soft material and continuous contact with the posterior capsule allows some axial movement and deformation of the lens following ciliary muscle contraction.

### Possible Mechanisms of Pseudoaccommodation

Several mechanisms are responsible for the accommodative effect of the WIOL-CF. The first is the anterior–posterior movement of the implant due to tightening and relaxation of the ciliary muscle. This type of accommodation is similar to natural accommodation, but rather than occurring due to a change in lens curvature and refractive power, the movement of the lens causes an increase or decrease in the distance between the lens plane and the retina.

**Figure 1: Geometry of the WIOL-CF**

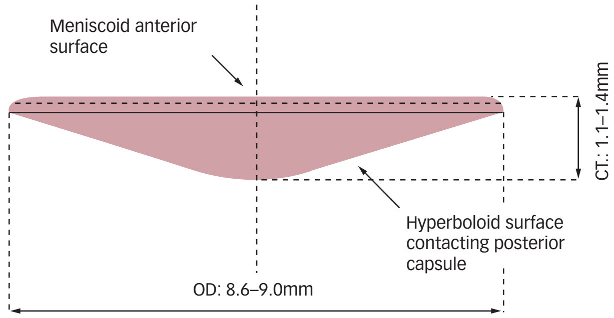



**Figure 2: Plasticised WIOL-CF Ready for Folding**

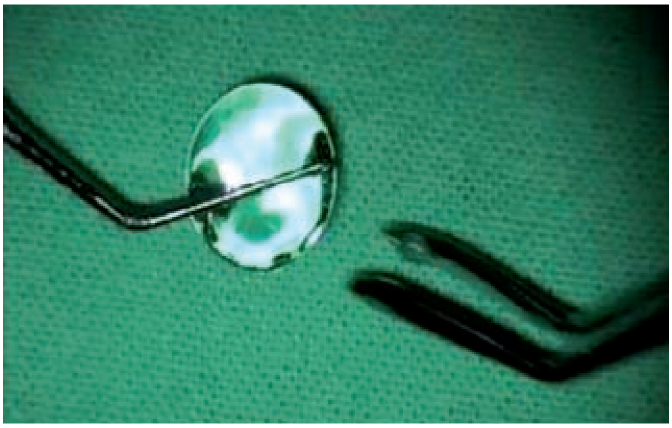
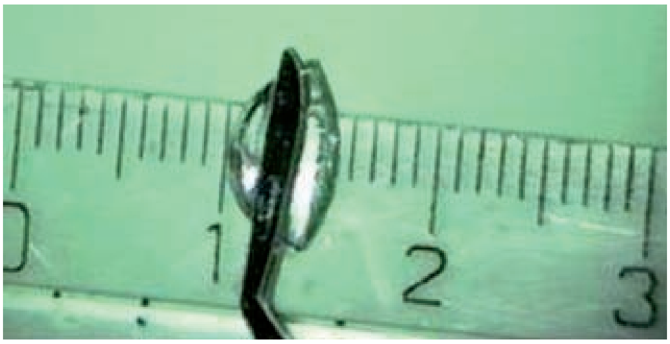


**Figure 3: Folded WIOL-CF Ready for Implantation**



Another theory to explain the accommodative effect of the WIOL-CF is anterior–posterior movement of the implant caused by increases and decreases in the pressure of the vitreous body, which are due to bulbus deformation created by the action of certain external muscles normally responsible for eye movement. The multifocality of the lens itself created by the hyperbolic posterior surface in conjunction with the multifocality of the cornea facilitates near vision, generating some degree of pseudoaccommodation. Of course, in order to achieve optimum results it is important to clarify to the patient that near vision accommodation requires effort and time. Patients should be trained to utilise the accommodative features of the lens, which will allow them to lead an active life without being spectacle-dependent. The extent of the pseudoaccommodation properties of the WIOL-CF cannot be predicted, and patients should be thoroughly informed of this. In every case, realistic expectations should be established before surgery.

## Discussion

Refractive lens exchange can be considered the future of refractive surgery. The biggest challenge in ophthalmological research is the continuous development of new artificial IOLs that can provide satisfactory vision at all distances. Accommodative lenses represent a new category that, by accomplishing lens movement, can restore some degree of natural accommodation.[13,14] The biggest limitations associated with the use of accommodative lenses are capsular fibrosis, which annuls the accommodative effect, and the high incidence of posterior capsule opacification.[15] The WIOL-CF is a new-generation accommodative lens that possesses certain qualities that seem to overcome the drawbacks of accommodative IOL implantation. The high water content of the lens offers high biocompatibility and permeability, and its negatively charged surface allows resistance to protein deposits, cell attachment, opacification of the posterior capsule and minimum adhesion to tissues such as capsule, iris and cornea. Another important quality of the lens is its sharp-edged continuous rim, which supports resistance to posterior capsule opacification; in addition, the continuous transition between optics and rim, in conjunction with the low refractive index of the lens, offers improved night vision undisturbed by glare and halos. The accommodative function of the WIOL-CF is based on its aspheric hyperboloid optics, which can improve quality of vision and give greater depth of focus, providing pseudoaccommodation and eliminating spherical aberrations. In general, the WIOL-CF can be considered a promising alternative solution for patients under 60 years of age who lead an active life and require good near, intermediate and far vision. Post-operative patient training is important in order to achieve the maximum degree of pseudoaccommodation and provide high-quality spectacle-independent near vision. ■

Ioannis G Pallikaris is a Professor of Ophthalmology, Rector and a member of the Board of the Department of Materials Science and Technology at the University of Crete. During his time at the University of Crete, he founded and was Director of the Vardinoyannion Eye Institute of Crete and the Institute of Vision and Optics, and has been Chairman of the Department of Ophthalmology and Director of the Eye Clinic of the University Hospital of Heraklion.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## Editor's Recommendation

### Ultrasound Biomicroscopic Changes During Accommodation in Eyes with Accommodating Intraocular Lenses

Marchini G, et al., *J Cataract Refract Surg*, 2004;30:2476–82.

This study aimed to document ciliary body constriction and movement with the Crystalens AT-45 intraocular lens (IOL) (eyeonics) using ultrasound biomicroscopy. Patients with no pre-existing ocular conditions other than cataract who agreed to return for follow-up were considered. Twenty eyes of 14 patients with a best corrected visual acuity of 5/10 or worse and a refractive error (spherical equivalent) of ±1.0 diopter (D) had implantation of a Crystalens AT-45 accommodating IOL. Six patients had bilateral implantation. Ultrasound biomicroscopy was performed post-operatively at one and six months. Before and during accommodation, the anterior chamber depth (ACD) was measured to assess the endothelium–IOL distance and measure the scleral–ciliary process angle to determine whether there was anterior rotation of the ciliary body. The uncorrected distance acuity, best corrected distance acuity, uncorrected near acuity, distance corrected near acuity, best corrected near acuity and accommodative amplitude were determined. Analysis was performed to determine whether there was a correlation between the accommodative amplitude and the percentage variation in the ACD and scleral–ciliary process angle. Results showed that all surgical procedures were uneventful. The mean uncorrected distance acuity at one month was 0.±0.14 (SD) and remained stable at six months. Three of 20 eyes (15%) and eight of 20 eyes (40%) had a Jaeger acuity of J1 and J3, respectively, without additional power correction. During accommodation, the mean reduction in ACD was 0.32±0.16mm at one month and 0.33±0.25mm at six months. The mean narrowing of the scleral–ciliary process angle was 4.32±1.87º at one month and 4.43±1.85º at six months. There was a correlation between accommodative amplitude and a decrease in the ACD (r=0.404) and a decrease in scleral–ciliary process angle (r=0.773). The authors concluded that aterior displacement of the Crystalens IOL and corresponding anterior rotation of the ciliary body occurred during near vision. The IOL displacement and rotation were proportional to the accommodation capacity. ■