Journal of Optometry (2015) 8, 67–76

Journal of Optometry

www.journalofoptometry.org

REVIEW

Axial movement of the dual-optic accommodating intraocular lens for the correction of the presbyopia: Optical performance and clinical outcomes

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Received 1 March 2014; accepted 3 June 2014
Available online 22 September 2014

KEYWORDS
Accommodative intraocular lenses;
Dual optic intraocular lens;
Pseudophakic accommodation;
Presbyopia

Abstract Presbyopia occurs in the aging eye due to changes in the ciliary muscle, zonular fibers, crystalline lens, and an increased lens sclerosis. As a consequence, the capacity of accommodation decreases, which hampers to focus near objects. With the aim of restoring near vision, different devices that produce multiple focuses have been developed and introduced. However, these devices are still unable to restore accommodation. In order to achieve that goal, dual-optic accommodating Intraocular Lenses have been designed, whose anterior optic displaces axially to increase ocular power, and focus near objects. Although dual-optic accommodating IOLs are relatively new, their outcomes are promising, as they provide large amplitudes of accommodation and a greater IOL displacement than single-optic accommodating IOLs. The outcomes show comfortable near vision, higher patients' satisfaction rates, and minimal postoperative complications like Posterior Capsular Opacification and Anterior Capsular Opacification, due to their design and material.

PALABRAS CLAVE
Lentes intraoculares acomodativas;
Lentes intraoculares de óptica dual;

Movimiento axial de las lentes intraoculares acomodativas de doble óptica para la corrección de la presbicia: rendimiento óptico y resultados clínicos

Resumen La presbicia se produce en el ojo envejecido debido a los cambios en el músculo ciliar, las fibras zonulares y el cristalino, y al incremento de la esclerosis del mismo. Como consecuencia, disminuye la capacidad de acomodación, lo que dificulta el enfoque de los objetos

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http://dx.doi.org/10.1016/j.optom.2014.06.004
1888-4296/

Acomodación pseudofáquica; Presbicia

cercanos. Con el fin de restaurar la visión de cerca, se han desarrollado e introducido diferentes dispositivos que producen múltiples focos. Sin embargo, dichos dispositivos no son aún capaces de restaurar la acomodación. A fin de lograr este objetivo, se han diseñado las lentes intraoculares acomodativas de doble óptica, cuya óptica anterior se desplaza axialmente para incrementar la potencia ocular, y enfocar los objetos cercanos. Aunque estas LIOs acomodativas son relativamente nuevas, sus resultados son prometedores, ya que aportan grandes amplitudes de acomodación y un mayor desplazamiento de la LIO que las LIO acomodativas de óptica simple. Los resultados muestran una visión de cerca cómoda, unos índices elevados de satisfacción del paciente y unas mínimas complicaciones postoperatorias, tales como la opacificación capsular posterior y posterior, debido a su diseño y material.

Presbyopia is characterized by the difficulty of focusing objects in near vision, in persons over age 40, due to the progressive loss of accommodation.[1,2] Accommodation occurs as a result of the contraction of the ciliary body and the consequent lowering of tension of zonular fibers, producing an increase in the curvature of the crystalline lens.[3,4] However, in presbyopia, the capacity to accommodate is reduced due to the loss of contraction of the ciliary muscle,[2,4] lessening of zonular fibers,[2,5,6] changes in the thickness and elasticity of the crystalline lens capsule,[2–8] increase of equatorial diameter,[6] loss of elasticity of the Brüch's membrane,[9] and an increased lens sclerosis with age.[10] Despite the loss of accommodation caused by the weakening of the ciliary muscle, it has been shown through pharmacological stimulation by instillation of pilocarpine and in vivo and in vitro studies using ultrasound biomicroscopy and Magnetic Resonance Imaging (MRI) that the function of the ciliary body persist over the years, even in pseudophakic patients.[3,5,7] The persistence of the function of the ciliary body during presbyopia is expected, because each effort to focus on an object made by the presbyopic patient, even wearing reading glasses for near vision, will cause convergence and pupillary contraction, so it will activate the ciliary body.[6]

Monofocal intraocular lenses, despite providing good outcomes in distance vision after surgery, provide unsatisfactory near visual outcomes.[11] Due to the advances in cataract surgery with the introduction of the femtosecond laser and the micro-incision surgery (MICS), a large number of Intraocular Lenses have been introduced to restore the patient's vision.[1] Until relatively recently, among the corneal surgical alternatives that a patient had to improve his near vision, there were the techniques of monovision Near Vision Conductive Keratoplasty (Near-Vision CK) (Refractec, Irvine, CA),[6] multifocal corneal refractive surgical procedures (AMO, Santa Ana, CA),[6] and pinhole corneal inlay (AcuFocus, Irvine, CA), all of them aimed at increasing the depth of field.[2,6] Cataract surgery allows the implantation of diverse types of Intraocular Lenses to correct presbyopia, like multifocal intraocular lenses (refractive, diffractive and hybrid), which provide simultaneous images to the visual system.[2,3,6,9,12] However, despite the introduction of these devices that improve the near vision, the intermediate and distance vision are not sophisticated enough to restore the accommodation.[1]

Because the action of the ciliary muscle persists over time, it has been found that pseudo-accommodation occurs after cataract surgery with implantation of monofocal intraocular lenses,[7] which can induce approximately 2 Diopters of pseudo-accommodation.[9] For this reason, accommodative intraocular lenses have been developed with the aim of avoiding the side effects induced with multifocal intraocular lenses, like halos, glares, etc.[11] In recent years, there has been a considerable research on the possibility of replacing the opacified crystalline lens by an intraocular lens that responds to the contraction of the ciliary body causing the accommodation.[3,5] Therefore, accommodative lenses have been introduced to focus objects at all distances as the young crystalline lens would do in physiological conditions.[1,3,7]

The aim of this review is to describe the different dual-optic accommodating Intraocular Lenses for the correction of presbyopia, as well as their optical performance and design. For that purpose, the movement and the amplitude of accommodation of the dual-optic accommodating IOL is analyzed, the visual outcomes published in recent scientific literature are compared, and the potential complications of these accommodative intraocular lenses are assessed.

Dual-optic devices

Recently, a variety of intraocular lenses that use the contraction and relaxation of the ciliary muscle have been introduced, to produce accommodation by moving the Intraocular Lens forward, causing a myopic refractive change, and improving the patient's near vision.[2,12,13] Among the various devices that have been created single-optic accommodating IOLs stand out, as BiComFold (Morcher GmbH, Stuttgart, Germany), 1 CU (Human-Optics, Erlangen, Germany), Tetraflex (KH3500; Lenstec, St. Petersburg, FL, USA), and Crystalens (Bausch & Lomb, Rochester, NY, USA).[14–18] Furthermore, there are other single-optic accommodating IOLs as Acuity C-Well (OrYehuda, Israel), Tekia TekClear (Irvine, CA, USA), and Bausch & Lomb OPAL (Rochester, NY), but their performance has not been intensively studied.[6,16] Some single-optic accommodating IOLs have shown little movement,[7] and in some cases backwards movement have been reported.[6,9] With the aim of obtaining a greater movement of the lens in order to focus