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Original research

Optical aberrations, accommodation, and visual acuity with a bioanalogic continuous focus intraocular lens after cataract surgery

Heidar Siatiri, Mehrdad Mohammadpour*, Afsaneh Gholami, Elham Ashrafi, Nassim Siatiri, Reza Mirshahi

Ophthalmology Department and Eye Research Center, Farabi Eye Hospital, Tehran University of Medical Sciences, Tehran, Iran

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Abstract

Purpose: To evaluate the visual outcomes, pseudoaccommodation, and wavefront aberrometry after implantation of Wichterle IOL-Continuous Focus (WIOL-CF®, Gelmed International, Kamenne Zehrovice, Czech Republic) by i-Trace aberrometry.
Methods: In this retrospective interventional case series study, after cataract surgery with implantation of accommodative WIOL-CF®, the patients were evaluated with i-Trace aberrometer for measurement of modulation transfer function (MTF), point spread function (PSF), total aberrations, higher order aberrations (HOAs) at far and near and pseudoaccommodation. The pre and postoperative visual acuity at near and distance were also measured.
Results: Forty eyes of 20 patients (aged 40–77 years) were enrolled in this study with mean follow-up time of up 13.10 ± 5.52 months. The mean logMAR corrected distance visual acuity (CDVA) improved from 0.20 ± 0.14 preoperatively to 0.10 ± 0.09 at the last follow-up after surgery ($P = 0.002$). The 0 was 60% J1, 70% J2, 85% J3, 90% J4, 95% J5 and 100% for J6. The mean pseudoaccommodation, range of accommodation volume, and average of peak accommodation were −2.52 ± 1.56 diopters (D), 1.50 to 5.25 D and −3.25 ± 1.25 D, respectively. The mean MTF at 5 cycles per degree at far was 0.200 ± 0.10 and for near was 0.207 ± 0.10. PSF at far and near was 0.0002 and 0.001, respectively. The mean root mean square (RMS) value of HOAs; total, coma spherical aberration, trefoil, and secondary astigmatism were 1.08 ± 0.48 μm, 0.89 ± 0.45 μm, −0.33 ± 0.23 μm, 0.25 ± 0.17 μm, and 0.15 ± 0.13 μm for far and 0.88 ± 0.49 μm, 0.73 ± 0.46 μm, −0.25 ± 0.22 μm, 0.19 ± 0.16 μm and 0.11 ± 0.10 μm for near, respectively. There was a decrease in HOAs at near relative to far ($P < 0.05$).
Conclusion: WIOL-CF® seems to be an acceptable accommodative intraocular lens (IOL) in terms of uncorrected near and distant visual outcomes, MTF and HOA.

Introduction

There are numerous acceptable modalities to compensate for post-cataract surgery near vision including monovision, multifocal, and accommodative intraocular lenses (IOLs).[1]

The major drawback of using the monovision technique is the problems with stereopsis and binocular vision.[2] Regarding such difficulties, multifocal IOLs were introduced as an alternative option. The goal of using multifocal IOLs is to provide the patients with satisfactory vision for both near and distant targets and create a range of clear vision at intermediate; however, the lack of good quality vision and limitations such as decrease in contrast sensitivity, halo, and night glares are the major concerns in implantation of multifocal IOLs.[3]

Another treatment modality for correction of presbyopia after phacoemulsification is using accommodative IOLs that offer acceptable vision for targets at different distances by

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* Corresponding author. Eye Research Center, Farabi Eye Hospital, Tehran University of Medical Sciences, Tehran, Iran.

E-mail address: mahammadpour@yahoo.com (M. Mohammadpour).

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restoring part of accommodation. Currently, there are multiple options as accommodative IOLs; Diffractiva® (Human Optics, Germany), BioComFold (Morcher, Germany), AT-45 Crystalens (Eyeonics, Inc., Bausch & Lomb, Rochester, NY, USA), and a newer generation of Crystalens HD (Bausch & Lomb, Rochester, NY, USA).[3] The most important limitation in implantation of accommodative IOLs is reduction of accommodative capacity in the course of postoperative period, that is largely due to formation of adhesive bands between anterior and posterior capsule and capsular phimosis that restrict their presumed accommodative ability.[4]

Wichterle and his colleagues designed a newfangled accommodative IOL, so-called Wichterle IOL-Continuous Focus (WIOL-CF®), a polyfocal hydrogel IOL.[5] The changes in anterior−posterior position of the IOL resulting from contraction of ciliary muscle or vitreous pressure and its multiple focal points with alterations in lens curvature and refractive power are mainly the source of accommodative capacity of this implant.[6,7]

There are multiple studies in literature regarding visual outcomes and stability of implantation of WIOL-CF® (Gelmed International, Kamenne Zehrovice, Czech Republic) and qualitative assessment of dysphotic phenomena.[7−9]

Herein, we report visual and quantitative optical outcomes of WIOL-CF® implantation in a group of patients in terms of near and far visual acuities, the range of pseudoaccommodative function, modulation transfer function (MTF), point spread function (PSF), total aberrations, and higher order aberrations (HOAs) by i-Trace technology.

Methods

In this retrospective interventional case series, patients who underwent uncomplicated phacoemulsification and WIOL-CF® implantation from 2011 to 2013 were enrolled.

Exclusion criteria included corneal astigmatism higher than 1.00 diopter (D), amblyopia, corneal diseases (dystrophy, scar or endothelial diseases), retinal and optic nerve problems, previous refractive or intraocular surgery other than phacoemulsification, uveitis and inflammatory ocular disease, history of ocular trauma, incomplete or damaged zonula, intra and postoperative complications including vitreous loss, Descemet's membrane detachment and pseudophakic bullous keratopathy.

Surgical technique

An experienced surgeon (M.M.) performed cataract surgery for all patients using standard technique of phacoemulsification through a 2.8 mm clear cornea temporal incision and a 5.5−6.5 mm centered capsulorhexis. After insertion of WIOL-CF®, cohesive viscoelastic material from behind the lens was cleaned by gentle irrigation. The lens was pushed gently down and inside of the posterior capsular bag for 5 s in order to achieve proper adhesion of IOL to the capsule and prevention of IOL decentration. At the end of surgery, the anterior chamber was formed by hydration of the incision sites.

Preoperative biometric measurement and IOL power calculation were performed using Zeiss IOL Master 500 (Zeiss, Jena, Germany) and SRK-T formula for emmetropia.[5]

The outcome variables that were analyzed for all patients included preoperative and postoperative measurement of uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), and postoperative monoocular measurement of uncorrected near visual acuity (UNVA) with Snellen chart at 20 feet and Birkhauser card (as well as Jaeger charts at a distance of 40 cm). Distance visual acuity was converted to logMAR for analysis.

In the last follow-up exam, all patients were tested with i-Trace aberrometry (Tracey Technologies Corp., Houston, TX) at far and near. Pupils were dilated for evaluation of MTF, PSF, encircled energy function (EEF); the two-dimensional integral of the PSF, total aberrations, HOAs total, coma, spherical aberration, trefoil and secondary astigmatism. The analysis of MTF and HOA were standardized for 5.0 mm pupil. We also measured pseudoaccommodation which is a phenomenon attributed to gaining near vision with-out changes in refractive power of the ocular system.[6]

Data were analyzed using non-parametric test (Wilcoxon) and were analyzed by SPSS for windows v22 (IBM Corp Armonk, NY). $P < 0.05$ was considered statistically significant.

Results

Forty eyes of 20 patients were enrolled in this study. The patients' age ranged from 40 to 77 years (mean; 55.31 ± 8.94 years).

The mean logMAR CDVA improved from 0.20 ± 0.14 (0.00−0.54) before surgery to 0.10 ± 0.09 (0.00−0.30) at the last follow-up that was statistically significant ($P = 0.002$). No loss of line in CDVA happened. Mean follow-up was 13.10 ± 5.52 months with the range of 4−23 months. The results of UNVA were 60% J1, 70% J2, 85% J3, 90% J4, 95% J5, and 100% J6.

The mean pseudoaccommodation, the range of accommodation volume, and average of p accommodation are shown in Table 1. In Fig. 1, wavefront map is shown for estimation of objective pseudoaccommodation in one of the patients.

The mean postoperative MTF at near was increased relative to far, in all spatial frequency except at 15 cycles per degree (cpd). However, these changes were not statistically significant (Table 2).

Table 1
Objective accommodation data analysis.

Parameter	Value
Mean accommodation	−2.52 ± 1.56 diopter
Average peak accommodation	−3.25 ± 1.25 diopter
Range of accommodation volume	1.50−5.25 diopter

Mean accommodation show the average of the myopic shift in the measurement area (pupil); however, it does not have a clinical implication.[5]
Peak accommodation exhibit maximum myopic shift in the lens and control the image location in retina.[5]
Intraocular lens (IOL) flexibility is measured by accommodation volume.[5]