American Journal of Ophthalmology Case Reports 20 (2020) 100935

Contents lists available at ScienceDirect

American Journal of Ophthalmology Case Reports

journal homepage: www.ajocasereports.com/

Don't be afraid of the dark - OCT angiography through a black intraocular lens

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ARTICLE INFO

Presented in part at the 112nd Annual Meeting of the Swiss Ophthalmological Society on August 30, 2019, in Interlaken, Switzerland; Abstract Number 3860

Keywords:
Black intraocular lens
Occlusive intraocular lens
Optical coherence tomography
Optical coherence tomography angiography

ABSTRACT

Purpose: To report a case in which optical coherence tomography (OCT) and OCT angiography (OCT-A) allowed imaging of the posterior pole in a patient fitted with a black occlusive intraocular lens (IOL).

Observations: Following retinal central artery occlusion, a 52-year-old patient suffered from disturbing residual light perception. Occlusive contact lenses blocked the light insufficiently, so that the patient had to rely on an eye patch for relief of symptoms. After no neovascularization had formed during an observation period of 12 months, a black IOL (Morcher 85F) was implanted, blocking wavelengths in the visible spectrum but allowing transmission in the near-infrared spectrum. Slit lamp photography, OCT and OCT-A were performed pre- and postoperatively. Postoperatively, slit lamp photography could no longer provide images of the posterior pole, proving the effective blockade of wavelengths in the visible light spectrum. In contrast, transmission in the near-infrared spectrum allowed for OCT and OCT-A imaging of the fundus. The complete suppression of the disturbing perception of light succeeded only temporarily.

Conclusions and Importance: The implantation of a black IOL does not prevent the imaging of the retinal microvasculature by OCT-A. Black IOLs can therefore be considered even if continued monitoring of the vascular situation of the posterior pole is required.

1. Introduction

Black occlusive intraocular lenses (IOL) represent a therapeutic alternative to occlusive contact lenses, eye patches, and corneal tattoos for the treatment of leukocoria and neuro-ophthalmic disorders such as intractable diplopia, image delay and photophobia.[1,2] Although documented implantations of black IOLs date as far back as 2001[1] and despite high levels of patient satisfaction, concerns that the omission of fundus visualization prevents the detection of posterior pole pathologies stood in the way of their widespread use.[3] The situation changed with the accidental discovery that the near-infrared light of a scanning laser ophthalmoscopy (SLO)/optical coherence tomography (OCT) imaging system was capable of capturing high-quality images of the posterior pole through a black IOL.[4] This near-infrared window of transmission has been extensively investigated by Yusuf and colleagues for various SLO/OCT systems and different occlusive lens types.[3,5]

The following report expands the knowledge about black IOL implantation by showing the same human fundus pre- and postoperatively and by supplementing the imaging with OCT angiography (OCT-A) scans.

2. Case report

A 52-year-old man suffered a retinal central artery occlusion in his right eye during a neurosurgical intervention on a cerebral arteriovenous malformation. Visual function was reduced to the perception of a subjectively disturbing shimmer of light and did not recover further in the course of time. The left eye was not affected and maintained full visual acuity. Closing the eyelids or wearing an eye patch provided the patient with relief of symptoms, but occlusive contact lenses only insufficiently blocked the perception of light. The referral from the contact lens service was then made with the question whether the implantation of a black IOL could save the patient from wearing occluding eye patches. After the eye had remained free of neovascularizations for an observation period of twelve months, a cataract operation was performed with implantation of a single-piece black polymethyl methacrylate IOL (Morcher® 85F; Morcher GmbH, Stuttgart, Germany) (Fig. 1). The lens was placed in the sulcus with the intention that it could be

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https://doi.org/10.1016/j.ajoc.2020.100935
Received 15 June 2020; Received in revised form 23 August 2020; Accepted 13 September 2020
Available online 17 September 2020

easily explanted again if necessary for treatment.

With the consent of the informed patient, an identical series of apparatus examinations was performed immediately preoperatively and one week postoperatively: Slit lamp photography, fundus photography, SLO/OCT (Spectralis®, Heidelberg Engineering GmbH, Heidelberg, Germany) and OCT-A (Plex®Elite 9000, Carl Zeiss Meditec AG, Oberkochen, Germany) (Fig. 2). Postoperatively, the black IOL was centered, covered the pupil opening under all light conditions and prevented both biomicroscopic examination and photographic documentation of the fundus with visible light. In contrast, SLO and OCT images were possible as before and showed no loss of image quality compared to the preoperative images. Also, imaging of the microvasculature by means of OCT-A was still possible through the black IOL. The image quality of macular SLO/OCT and OCT-A en face recordings was objectively assessed with the Blind/Referenceless Image Spatial QUality Evaluator (BRISQUE) using MATLAB® (MathWorks, Natick, MA). The score values range from 0 to 100 (with lower values reflecting better perceptual image quality) and have been shown to correlate well with human judgement of quality.[6] The SLO/OCT scores were 40.63 before and 39.87 after implantation of the occlusive IOL, the corresponding OCT-A scores were 43.46 and 43.45, respectively.

Subjectively, the patient reported a complete elimination of the disturbing shimmer on the first postoperative day. After one week he had the impression that the perception of light was slowly coming back again and after one month the light perception was only a little weaker than preoperatively - with improvement by complete lid closure or by covering of the eye.

3. Discussion

The present case presented a clinical dilemma: How could the patient be able to benefit from a cosmetically elegant light blockage in form of a black IOL while fundus scans to detect potential neovascularization would still be possible ?

Based on the literature it could be assumed that a black occlusive IOL with a near-infrared window would still allow monitoring of the fundus. However, the corresponding investigations were carried out on artificial model eyes[3] and on a human eye for which no preoperative OCT images were available.[4] In the present case it was therefore reassuring to see that the SLO and OCT images of the same human eye before and after implantation of an occlusive IOL showed no discernible differences in quality (Fig. 2 E/F and Fig. 2 G/H, respectively). Furthermore, it was possible to visualize the chorioretinal microvasculature by means of OCT-A (Fig. 2 I/J, K/L). In principle, OCT-A in the context of a black IOL could be used for the same diagnostic questions as in the presence of a clear lens. However, clinical application is likely to be limited primarily to retinal vascular occlusion and diabetic retinopathy, i.e. pathologies that threaten the preservation of the eyeball through neovascularization. In contrast, diseases which only threaten visual acuity (e.g. macular degeneration, macular telangiectasia, central serous chorioretinopathy, choroidal neovascular membranes) may be of secondary interest due to the lack of consequences in this setting.

It should be noted that the OCT-A measurements had to be recorded several times until a sufficient recording quality could be achieved. This was on the one hand because the patient could not focus on the fixation target in the imaging aperture and on the other hand because of the prolonged exposure time (to image vascular flow, each B-Scan in the scan pattern is repeated more than once). An OCT-A measurement lasted between 10 and 20 seconds both before and after implantation of the black IOL. After implantation, the examiner had no view of the fundus, i.e. the measurement had to be performed without optical control. In addition, retinal tracking had to be switched off to start a measurement. For these two reasons the proportion of qualitatively useable images was only about 10%.

However, while a technical solution was now enabling continuous retinal surveillance through a black IOL, (i.e. eliminating the diagnostic problem), the therapeutic problem of incident light persisted to a certain degree. It appears that the persistent perception of light after implantation of a black IOL with a near-infrared window is not uncommon.[7] Possible reasons have been analyzed in detail, whereby the hypothesis of activation of long wavelength red cone photoreceptors by near-infrared light seems to be best supported.[8] By implanting black IOLs without transmission of near-infrared light,[5] either primary or as "double occlusion" in the sense of an add-on solution, this phenomenon could be avoided in the past.[9] However, the production of IOLs blocking near-infrared light such as the black Artisan® 201 (Ophtec BV, Groningen, The Nederlands) and the black MS 612 (formerly Dr. Schmidt GmbH, now HumanOptics AG, Erlangen, Germany) has been discontinued. The lens Ani II (Ophtec BV), manufactured on the same material as the Artisan® 201, is currently the only IOL on the market without a near-infrared window and has a mixed record of eliminating light perception.[10] Refractory light perception in the presence of an near-infrared light blocking IOL may be based on para-optical light leakage[11] or transmission of light through the intact sclera.[2] In the present case of a Morcher IOL with a near-infrared window, all three mechanisms discussed for light perception would be conceivable in principle. Initially, there was a clear benefit to the patient with no light perception through the black IOL. With time, however, the patient reported a partial recurrence of glare, which has not yet been reported in the literature.

We therefore hypothesize that we may have observed a light adaptation that occurred over a longer period of time in an eye with extremely low illumination levels, either at the level of the photoreceptor system that has been severely damaged by central artery occlusion or at a higher level of visual signal processing.

In summary, the presented case supports the view that retinal pathologies such as vascular occlusion are not an absolute obstacle to the implantation of occlusive IOLs, as instrumental monitoring of the retina is still possible. The before-and-after images of the present eye and the corresponding BRISQUE scores show that the image quality of SLO and OCT is not impaired by the implantation of such a lens and that even microvascular structures can be visualized by means of OCT-A. Before implantation of a black occlusive IOL, patients should be informed that the subjectively perceived light blockage may not be complete and may change over time.

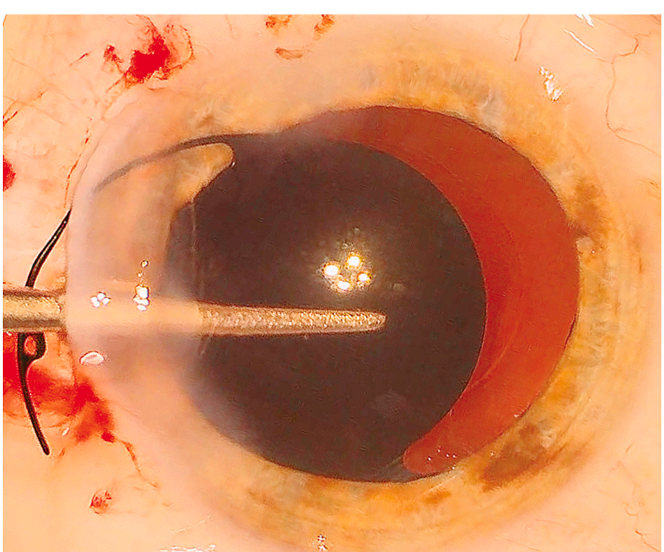

Fig. 1. Implantation of a black occlusive single-piece polymethyl methacrylate intraocular lens (Morcher® 85F) into the ciliary sulcus. A 7 mm incision is necessary to accommodate the rigid 6 mm optic.

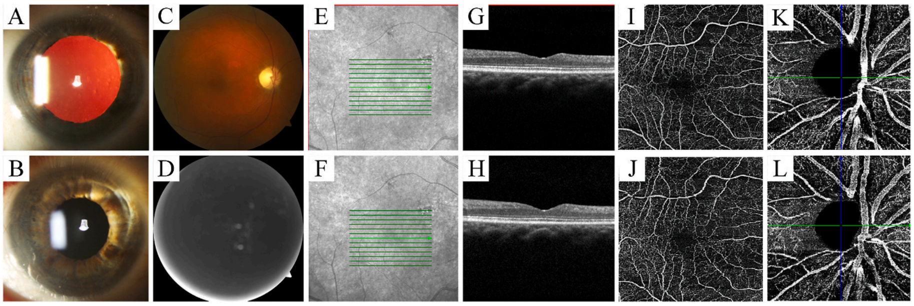

Fig. 2. Imaging of the same right eye before (upper row) and after (lower row) implantation of a black occlusive intraocular lens with a near-infrared window of transmission. Retroillumination slit lamp photographs (A, B) and fundus photographs (C, D) demonstrating the blockage of visible light. Confocal scanning laser ophthalmoscopy (E, F) combined with spectral-domain optical coherence tomography (G, H) revealing an unobstructed view of the fundus. En face optical coherence tomography angiography images of unaltered viewable macular (I, J) and peripapillary (K, L) vascular networks.

Patient consent

Written consent to publish the case report was not obtained. This report does not contain any personal information that could lead to the identification of the patient.

Disclosures

No funding or grant support.

The following authors have no financial disclosures: CK, PBB, OAP, KCI, OJ.

All authors attest that they meet the current ICMJE criteria for Authorship.

Acknowledgements

None.

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