CASE REPORT

Bilateral sequential implantation of a monofocal IOL and a pseudophakic sulcus-placed trifocal IOL in a young adult with posterior microphthalmos

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An 18-year-old man enquired about the possibility of refractive surgery due to increasing difficulty performing near tasks. Corrected distance visual acuity was 20/25 with +10.00 −1.00 ×40 degrees right eye and 20/25 with +11.00 −1.00 ×120 degrees left eye. Corrected near visual acuity was Jaeger (J) 4. Optical biometry and corneal tomography revealed posterior microphthalmos with estimated intraocular lens (IOL) power >45.0 diopters (D) right eye and >47.0 D left eye. Considering the normal anterior segment morphology and the patient's high motivation for improving refractive error, refractive lens exchange was performed with monofocal +45.0 D IOLs. The residual refractive error was corrected by secondary bilateral implantation of a supplementary sulcus-placed trifocal IOL. One week after the second implant, uncorrected distance visual acuity was 20/25 right eye and 20/30 left eye, whereas the uncorrected near visual acuity improved to J2. Visual stability was verified at the third postoperative month with a residual refractive error of −0.50 × 120 degrees right eye and +1.50 −1.25 ×150 left eye.

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The management of high hyperopia is clinically challenging because of the inherent risks for amblyopia and strabismus. To achieve satisfactory visual development, early detection and prescription of full cycloplegic refraction is necessary. From an early age, these patients are visually dependent on inaesthetic spectacles with thick lenses, which may not fully satisfy visual requirements due to inherent optical aberrations. For older patients seeking to ameliorate their refractive status, this condition is particularly worsened when associated with abnormal eye morphologies such as nanophthalmos/posterior microphthalmos as the very short axial length resulting in very high hyperopia and the frequently associated high keratometric values contraindicate laser vision correction. Additionally, the possibility of a crowded anterior chamber makes them unsuitable candidates for phakic intraocular lenses (IOLs).[1,2] Therefore, for patients unable to tolerate contact lenses and desiring spectacle independence, the only possible solution may be refractive lens exchange (RLE). Nevertheless, the procedure is technically difficult because of IOL calculations often yielding results in the >40.0 diopter (D) power range, leading to a compromising solution, which is to place a secondary IOL as a "piggyback" add-on lens to obtain the intended refractive power. The ideal placement of such secondary IOL was somewhat controversial because of the possibility of adverse events such as interlenticular opacification or iris pigment dispersion.[3,4] Fortunately, IOL design technology evolved with new models specifically designed to be implanted in the ciliary sulcus as a supplementary IOL. In this regard, we report a case of a young patient with bilateral high hyperopia associated with posterior microphthalmos, which underwent RLE by sequential implantation of a +45.0 D monofocal IOL in the capsular bag and a secondary IOL specifically designed for implantation in the ciliary sulcus and with diffractive trifocal optics (Sulcoflex Trifocal, Rayner Intraocular Lenses Limited) to achieve a complete refractive correction with a high level of spectacle independence.[5]

CASE REPORT

An 18-year-old man presented to our department for poor visual quality with 2 different spectacles he had been

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prescribed in the previous 2 years. More specifically, the patient complained that he had good distance vision with monofocal lenses with +10.00 −1.00 × 40 right eye and +11.00 −1.00 × 120 left eye, but required a magnifying glass for writing and reading comfortably; he also had tried progressive lenses with +10.50 −1.00 × 40 right eye and +12.00 −1.00 × 120 left eye, with +1.00 addition for near, but with this latter correction, despite obtaining a comfortable near vision, the patient reported intolerable image distortion in distance vision, causing dizziness, and thus, he preferred to wear the monofocals with a magnifying glass for near tasks. The patient had previously tried contact lens fitting with no success due to intolerable ocular foreign body sensation. To the patient's knowledge, there was no family history of high refractive errors or other significant ocular diseases. Medical history was relevant only for allergies (mainly in the form of allergic rhinitis) and daily medication with levocetirizine. Because of increasing difficulty in successfully performing daily tasks, such as studying and writing assignments, the patient enquired about the possibility of refractive surgery, with the expectation of at least significantly reducing the refractive error.

Ophthalmological examination revealed a corrected distance visual acuity (CDVA) of 20/25 with +10.50 D right eye and 20/25 with +11.75 −0.75 × 120 left eye, with +1.00 D addition in both eyes for a comfortable Jaeger (J) 1 reading. No ocular motility abnormalities were verified with the cover–uncover test. Slitlamp examination revealed a normal anterior segment with clear lens and wide angle. Fundus examination was unremarkable. Intraocular pressure by Goldmann applanation tonometry was 15.0 mm Hg in both eyes. The patient had further examination with corneal tomography (Pentacam HR, Oculus Optikgeräte GmbH) and optical biometry (IOLMaster 700, Carl Zeiss Meditec AG). Results revealed very steep corneas, normal anterior chamber angle, no evidence of corneal ectasia, and acceptable angle α profiles (Figure 1). Optical biometry revealed very short axial lengths (16.78 mm right eye; 16.58 mm left eye) and suggested that IOL power ranged between 45.0 D (Holladay 2) and 49.5 D (Hoffer Q) right eye and 47.0 (Holladay 2) and 50.50 (Hoffer Q) left eye.[6,7] These combined results confirmed very high axial hyperopia compatible with posterior microphthalmos. Because of the anatomical specificities of the case, the results were explained to both the patient and the parents regarding the possible risks and benefits of RLE. The patient's very high motivation to improve refractive error and the normal anterior segment morphology prompted the decision to advance with simultaneous bilateral RLE with the goal of achieving spectacle independence. To achieve such goal, considering the young age of the patient, a trifocal IOL was preferred, but available models provide a maximum spherical correction of 32.0 to 35.0 D, which would lead to unacceptable residual error. Therefore, we decided to procure a monofocal IOL providing the highest possible spherical correction, and if possible, the residual error would be further corrected by secondary implantation of a sulcus-placed trifocal IOL.

As planned, the patient had bilateral simultaneous RLE with monofocal +45.0 D IOLs (Zeiss CT SPHERIS) implanted in the capsular bag. The main incisions (2.4 mm blade) were placed in the steepest corneal meridian (120 degrees right eye and 45 degrees left eye), and a contralateral corneal incision was made at the end of the case to reduce corneal astigmatism. Special care was placed on creating a large round and centered capsulorhexis, and exhaustive anterior and posterior capsular bag cortical cleanup was performed. Postoperative medication consisted of ofloxacin 4 times a day, dexamethasone every 2 hours, and bromfenac eyedrops in both eyes 2 times a day.

At the fifth postoperative day, a residual error of +1.50 right eye and +3.00 −1.25 × 140 left eye was verified, and binocular uncorrected distance visual acuity (UDVA) was 20/40. Repeated corneal tomography revealed a marked increase in anterior chamber angles, allowing safe implantation of a secondary sulcus trifocal IOL (Figure 2). Using the online Raytrace IOL calculator (https://www.raytrace.rayner.com/), we verified an expected spherical equivalent of −0.20 D right eye and +0.90 D left eye, with a +2.5 Sulcoflex Trifocal IOL. The supplier suggested a +3.0 D Sulcoflex Trifocal IOL for the left eye, as the ideal multifocal toric IOL (+2.50, + 2.00) would not be available until late 2019. The patient had bilateral surgery 6 days later with implantation of the trifocal IOLs (+2.50 right eye and +3.00 left eye). As routine in our department in the case of multifocal IOLs, complete aspiration of ophthalmic viscosurgical device from behind the IOLs was performed, and centration of the inner diffractive ring with the coaxial corneal light reflex was observed.[8]

At the 1 week postoperative visit, UDVA was 20/25 right eye and 20/30 left eye, and comfortable J2 reading was verified. IOP was 17 mm Hg right eye and 20 mm Hg left eye. At the first postoperative month, UDVA was 20/25 right eye and 20/30 left eye, improving in the latter to 20/25 with +1.50 −1.25 × 150, and uncorrected near visual acuity was J2, whereas comfortable J1 was achieved with over-the-counter +1.25 monofocal IOLs. During the postoperative period, corticosteroid drops were slowly tapered over the course of 4 weeks, and no significant anterior segment inflammation or pigment dispersion was verified (Figure 3). At the second month of follow-up, mild bilateral cystoid macular edema (CME) was detected on routine optical coherence tomography, the patient was asymptomatic, and there were no signs of ocular surface or anterior segment inflammation. Treatment with nepafenac 0.1% 3 times a day, prednisolone 1% 4 times a day, and brinzolamide 1% 2 times a day was initiated, and complete CME resolution was verified 15 days later. At the third month of follow-up, UDVA (20/25 right eye and 20/30 left eye) and uncorrected near visual acuity (Jaeger 2) were stable, and the patient maintained high satisfaction with the achieved spectacle independence, recurring to near-vision spectacles only for prolonged studying or use of smartphone applications.

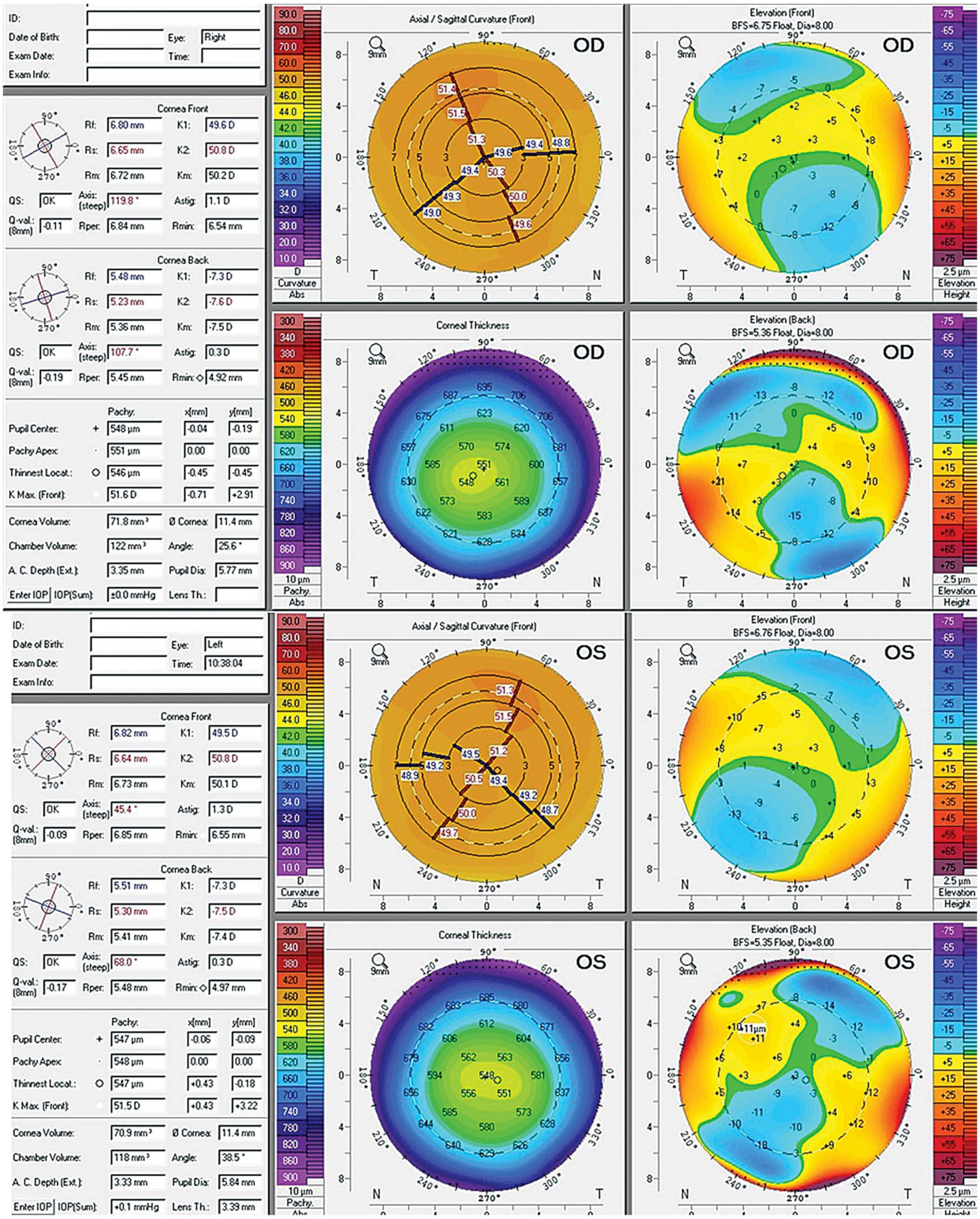

Figure 1. Anterior segment tomographic analysis revealed mild corneal astigmatism @ 119.8 in both eyes with enantiomorphic patterns; pachimetric maps were normal with thinnest point 546 μm right eye and 547 μm left eye. Anterior chamber depth was >3.30 mm in both eyes. Elevation maps were not indicative of corneal ectatic disorders.

DISCUSSION

This report describes surgical refractive correction of high hyperopia due to bilateral posterior microphthalmos, achieved by combining a very high power monofocal IOL (+45.0 D) with a novel supplementary IOL, specifically designed to be implanted in the ciliary sulcus with diffractive trifocal optics. Currently, the term *microphthalmos* is used to define a development disorder of the eye characterized by an axial length smaller than 2 standard deviations below the normal range for the age group.[9] In this case, there were no other ocular malformations; the anterior chamber depth, the anterior chamber angle, and corneal diameter were within normal ranges, but the very short axial lengths indicated the rare condition of posterior microphthalmos resulting in high hyperopia with significant hindering of our patients' daily activities. Our proposed primary goal was to achieve a significant improvement in the refractive status of the eye, possibly allowing a high level of spectacle independence. Considering the young age of our patient, we believe that the choice of a trifocal IOL would have the highest probability of providing the most complete visual

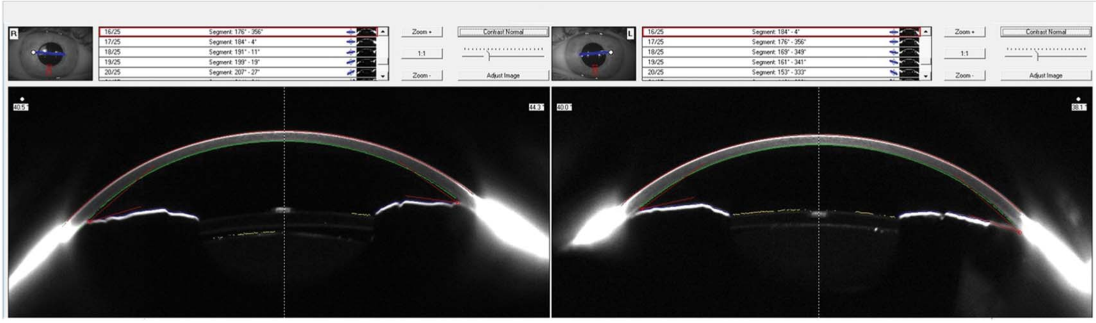

Figure 2. Repeated Pentacam HR analysis on the fifth postoperative day revealed a significant increase in the anterior chamber angle in both eyes and acceptable pupillary centration and diameter (<3.0 mm) for diffractive trifocal optics.

rehabilitation with spectacle independence, but currently available trifocal IOLs would not provide the necessary dioptric power, meaning that the only possible solution was to use a piggyback IOL configuration with a primary IOL in the capsular bag and a secondary IOL in the ciliary sulcus. We opted for the Sulcoflex IOL because it is specifically designed for implantation in the ciliary sulcus and available in monofocal, toric, and trifocal models. Such IOL range is characterized by a 6.5 mm diameter round-edged optic with a posterior concave surface and an overall length of 14.0 mm with 10-degree undulating haptics designed to minimize uveal contact and pigment dispersion syndrome. Considering this case had anterior chamber depth over 3.30 mm and endothelial cell density values above 3400 cell/mm^2, another option to consider would be implanting a phakic IOL. The advantage of this option would be that it would maintain the natural accommodation for near vision while avoiding the possibility of significant dysphotopsia for distance vision. Nevertheless, the 2 well-known phakic IOL models available in Portugal would only allow a power range of up to +12.0 D, which according to the refraction of the left eye would prove insufficient to achieve emmetropia. In addition, the difficulty of reliable IOL calculations in this extreme of axial length and the possibility of varying corneal shape, lens thickness, and axial length with age would mean that even if emmeptropia was achieved, the refractive correction would be more susceptible to the effect of age in the visual system when comparing with RLE for a similar risk profile.[10,11] The only other possible alternative would have been to choose the monofocal aspheric Sulcoflex IOL, aiming for −1.25 D in the nondominant eye to achieve monovision. Considering the young age of the patient and predominant use of near tasks such as studying, writing, and using a wide range of digital devices, such as a personal computer, laptop, tablet, and smartphone, choosing the monovision solution would probably still require progressive or at least near–mid distance IOLs to achieve comfortable prolonged near vision. It is also important to consider that to ensure successful monovision, usually a trial period with contact lenses is recommended, but contact lens fitting was not possible in this case. In addition, considering the anatomical specificities of the nanopthalmic eye and challenging optical biometry results, it would be difficult to aim for the intended residual refractive error in the nondominant eye, particularly in the setting of a piggyback solution. This latter point could also apply to the decision of implanting the Sulcoflex trifocal, but the +1.00 residual error verified in the right eye after the +45.0 D monofocal IOL implantation, although with few days of follow-up, provided a strong feedback that emmetropia could be achieved in this eye with a +2.5 D trifocal IOL. The left eye would theoretically be slightly hyperopic (at most +0.9 D), but the expected refraction was acceptable for trifocal optics (<1.25 D of residual cylinder), and in our opinion, the benefit of trifocal optics would be superior and lead to higher spectacle independence than aiming for monovision plus progressive spectacles for prolonged near–intermediate vision.[12–15] It is important to consider the potential problems of dysphotopsia with diffractive IOLs, but the literature provides evidence that increasing age is a significant factor for ocular straylight, thereby younger patients are expected to obtain better visual quality, which adding to the better neuroplasticity will favor efficient neuroadaptation

Figure 3. A: Slitlamp digital photography at the first postoperative week of bilateral trifocal IOL implantation. Pupils were round, reactive, and centered, and there were signs of ocular surface or anterior chamber inflammation. B: After application of tropicamide, pupillary dilation revealed optimum centration of the IOL diffractive rings, with the central ring aligned with the corneal light reflex.

Table 1. Optical biometry results.

	Right Eye	Left Eye
Axial length, mm	16.78	16.58
Anterior chamber depth, mm	3.31	3.26
Flat K	49.92 @ 35	49.43 @ 133
Steep K	50.78 @ 125	50.82 @ 43
White-to-white, mm	11.6	11.7
Lens thickness, mm	3.89	3.92
Suggested IOL power for emmetropia		
Hoffer Q	+49.50	+51.50
Haigis	+47.50	+49.50
Holladay 2	+45.00	+47.00

IOL = intraocular lens; K = keratometry

to diffractive optics.[16,17] Also, the acceptable angle α and aberration profiles suggested favorable outcomes by choosing a trifocal IOL. In addition, in the event of intolerable photic phenomena, it would be possible to perform exchange of the trifocal IOL for the aspheric monofocal IOL, aiming for emmetropia ensuring the best possible distance vision. Finally, it is important to consider the anatomical specificities of eyes with posterior microphthalmos, which may include an elevated papillomacular fold, chorioretinal folds, retinal pigmentary changes, crowded optic discs, and sclerochoroidal thickening.[5] The latter is particularly worrisome because it may predispose to uveal effusion due to increased venous outflow resistance. Although we did not obtain B-scan ultrasonography, the absence of fundoscopic abnormalities alongside the normal anterior chamber morphology and normal intraocular pressure values were interpreted as indicators of lower risk for retinochoroidal complications occurring with lens surgery. In this regard, it is important to notice that a recent report on cataract surgery in small eyes (axial length < 21.0 mm) found choroidal effusion in only 3 of 103 eyes.[18] Other common reported complications include anterior uveitis and CME.[18–20] Although our case had no significant anterior segment inflammation, at the first postoperative month, asymptomatic CME was detected on routine optical coherence tomography, but a prompt clinical response was obtained with topical treatment. The current evidence seems to support the conclusion that modern phacoemulsification has contributed to increased safety in these traditionally considered high-risk eyes.[19,20] Regarding the Sulcoflex Trifocal IOL, it is a fairly new model, but it presents the same design specifications as the monofocal aspheric and toric IOLs, which have been available since 2010 with favorable reports toward its safety and effectiveness for correcting residual refractive error.[21–23] To our knowledge, there are still no published reports about the visual acuity outcomes with the Sulcoflex Trifocal IOL, but our experience with this challenging case seems to suggest that this IOL design may become a safe, effective, and predictive solution to provide spectacle independence to patients previously operated with monofocal IOLs.

WHAT WAS KNOWN

- Intraocular lens (IOL), surgery in eyes with very short axial length is technically challenging, as among other factors, limited availability of sufficiently powered IOLs often mandates the combination of 2 IOLs in a piggyback strategy.
- Newer IOL models specifically designed to be implanted in the ciliary sulcus have improved safety outcomes and refractive stability, but results with supplementary sulcus IOLs with trifocal optics had not been reported.

WHAT THIS PAPER ADDS

- The presence of a normal anterior segment morphology may indicate a favorable postsurgical clinical evolution in eyes with short axial lengths.
- Provided emmetropia is achievable, supplementary IOLs with trifocal optics may allow a functional level of spectacle independence even in extreme ranges of refractive error.

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