Considerations on the Calculation of Multifocal Duet Implantation in a Monovision Scenario for the Correction of Presbyopia – A Case Example

Überlegungen zur Berechnung einer multifokalen Duett-Implantation in einem darunter liegenden Monovisionsszenario zur Korrektur der Presbyopie – Veranschaulichung Anhand eines Fallbeispiels

Case

A 56-year-old male warehouse worker was referred for treatment of early cataract, presbyopia, and hyperopia. The patient stated a reliance on reading glasses for near-vision activities. However, the patient reported dissatisfaction with wearing progressive glasses and previous contact lens intolerance. Additionally, he reported dissatisfaction with nighttime vision, including driving, and difficulty with hobbies, including motorcycling and photography. His past medical history was notable for psoriasis, though he was not taking any systemic medications. The past ocular history was also unremarkable, and he reported no ocular pain or discomfort at the time of presentation.

Clinical exam findings, including refractive data, ancillary testing, and ocular biometry (IOLMaster700, Carl Zeiss Meditec, Jena AG, Germany) are summarized in ▶ **Table 1**. Slit lamp examination of the left eye (OS) revealed normal findings except for a few retinal pigment epithelium irregularities outside the upper vessel arc. Examination of both eyes revealed a cataract of lens opacities classification system III (LOCS III) grade: N2, C2, P0 [1]. Retinal nerve fiber analysis and macular optical coherence tomography (OCT) (Spectralis, Heidelberg Engineering, Heidelberg, Germany) showed no clinically relevant findings. Corneal endothelial cell counts (Perseus, CSO, Firenze, Italy) were within normal limits. Best-corrected visual distance acuity (BCVDA) was 0.1 logMAR in both eyes. Tomography maps (MS-39, CSO, Firenze, Italy) are displayed in ▶ **Fig. 1**.

▶ **Table 1** Preoperative biometry and refractive data.

	OD	OS
Subjective sphere (dpt)	+ 1.25	+ 1.25
Subjective cylinder (dpt)	− 0.25	− 0.25
UDVA (logMAR)	0.3	0.3
BCDVA (logMAR)	0.1	0.1
IOP (mmHg)	13	15
Pupillometry (mesopic) (mm)*	4.57	4.69
Endothelial cell count (cells/mm^2)***	2433	2461
Biometry**: AL (mm)	23.10	23.09
Biometry: K_{mean} (dpt)****	42.46	42.65
Biometry: astigmatism (dpt)	0.65	0.72
Biometry: axis	84°	175°
Biometry: ACD (mm)	3.02	3.02
Biometry: LT (mm)	4.6	4.7
Corneal spherical aberration* (µm) (6 mm)	0.29	0.36

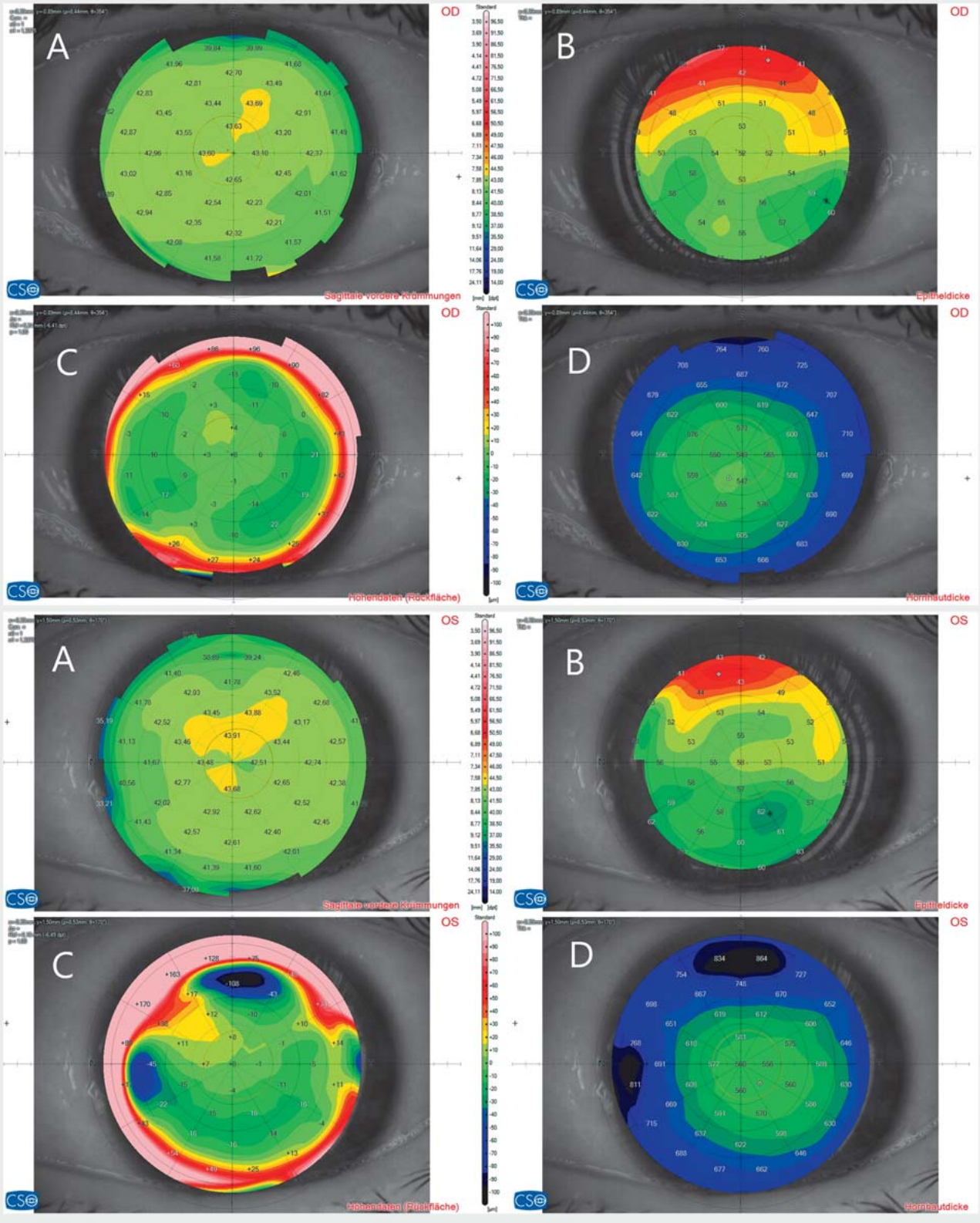
*Performed with MS-39 (CSO); **performed with IOLM700; ***CSO Perseus; ****keratometer index used: 1.332

Therapy

After discussing available treatment options, the patient chose to proceed with cataract surgery with trifocal intraocular lens (TFIOL) implantation. Benefits and risks of the procedure, including halos, lower contrast sensitivity, waxy vision, and dysphotopsias, were explained [2]. The patient expressed concerns about potential halos after the procedure as it might interfere with nighttime driving and his hobbies. Additionally, the patient desired spectacle independence if he became intolerant of the TFIOL. With these concerns in mind, we chose to pursue a myopic multifocal resp. trifocal duet implantation (TDI) in the nondominant eye and an emmetropic TDI in the dominant eye due to its potential reversibility and the resulting spectacle independency from pseudophakic monovision if explanted [3, 4]. To ensure that the patient would be satisfied with monovision in case of additional sulcus IOL removal, a monovision contact lens trial was performed for 1 week prior to surgery. The left eye (OS) was evaluated for far distance and the right eye (OD) for near distance using various defocus magnitudes. The patient responded positively to monovision and preferred a monovision of 1.5 dpt for everyday life, but still expressed his desire for a bilateral correction with TFIOL.

An aspheric ZCB00V IOL (Johnson & Johnson Surgical Vision, Inc., Jacksonville, Florida, USA) was chosen for implantation in the capsular bag. This IOL was chosen for several reasons:

1. Asphericity (SA [spherical aberration] correction: − 0.27 µm), given the pa-



▶ **Fig. 1** Tomography maps of the right eye (OD) and left eye (OS). Displayed is the sagittal anterior curvature (A), epithelial thickness (B), posterior corneal elevation (C), and corneal thickness (D). These show a rather homogeneous central corneal curvature, as well as inconspicuous elevation and pachymetry data and therefore no contraindication for a multifocal lens.

tient's corneal SA of 0.29 µm and 0.36 µm (▶ **Table 1**).

2. Availability of modern IOL constants [optimized for RMSE (root mean squared prediction error)] derived from a large database on a centralized repository website (IOLCON.org) (▶ **Fig. 2**).
3. Hydrophobicity, which decreases chances of IOL calcification, especially with multiple IOLs in the posterior chamber [5, 6].
4. Availability of a blue-violet light filter, which is available on the ZCB00V model of this IOL.

The additive sulcus IOL chosen was the Sulcoflex Trifocal 703F IOL (Rayner Intraocular Lenses, Ltd., Worthing, West Sussex, UK) [7, 8].

This IOL was chosen for the following reasons:

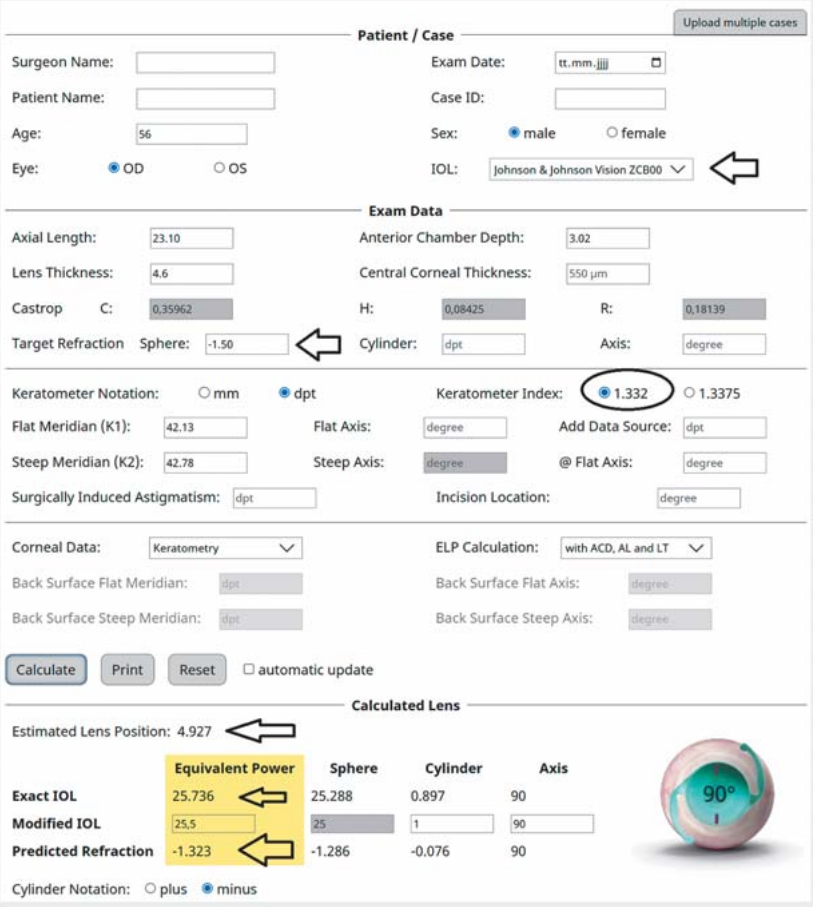
1. Good positional stability regarding tilt and decentration [9]
2. Good results are reported in the literature [10, 11]
3. Good light distribution profile [12]
4. Proven easy reversibility [3]

IOL Calculations

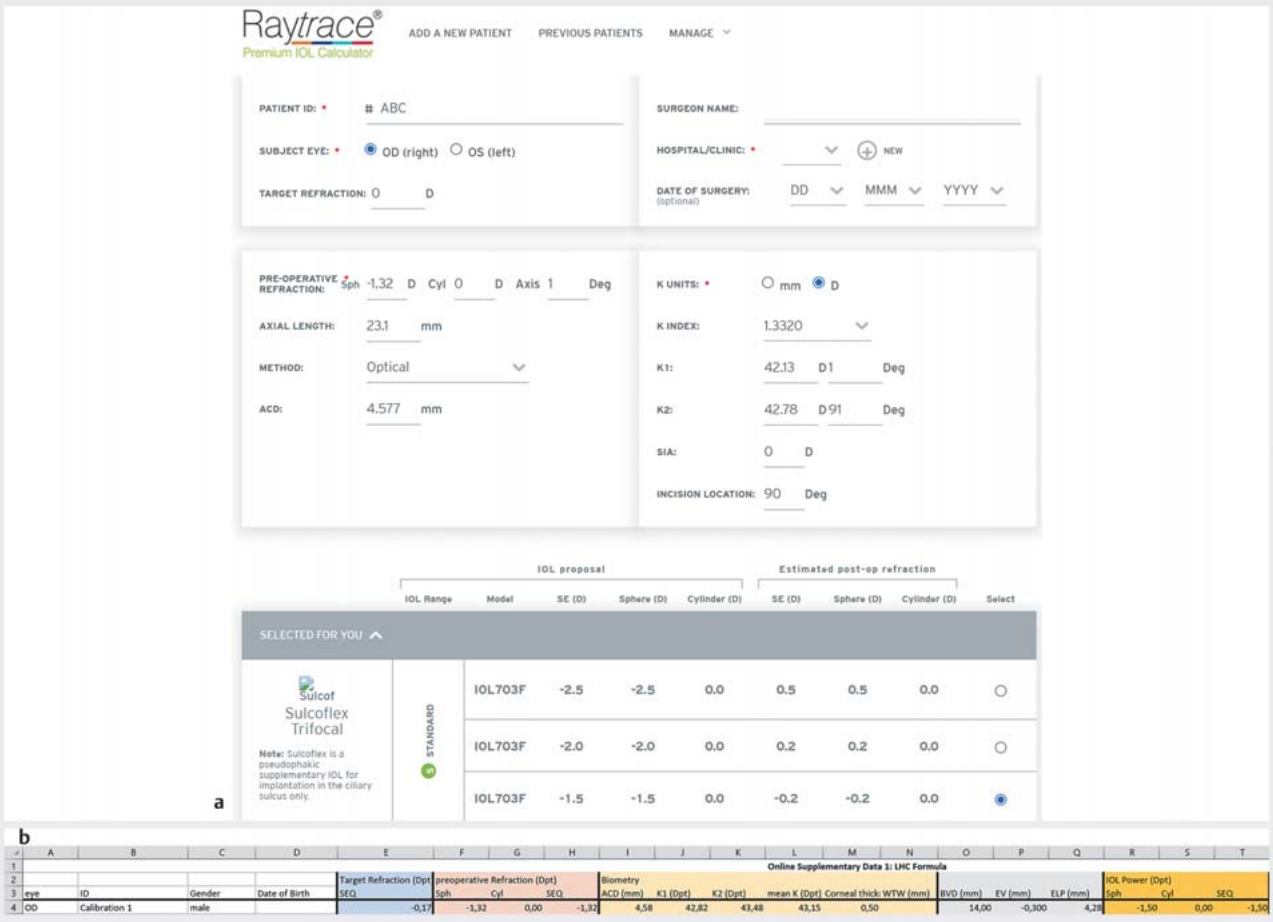
For the right eye, the intracapsular IOL power was calculated using the Castrop formula (target refraction: − 1.323 dpt) and validated using the EVO 2.0 formula (target refraction: − 1.37 dpt), resulting in an IOL power of 25.50 dpt. The intracapsular IOL power for the left eye was calculated using the Castrop formula (target refraction: + 0.038 dpt) and validated using the EVO 2.0 formula (target refraction: − 0.08 dpt), resulting in an IOL power of + 23.50 dpt.

Next, the power of the additive trifocal sulcus IOL for the right eye was determined based on the myopic target refraction of the intracapsular IOL. To calculate the sulcus additive IOL power, two methods were used: The manufacturer's calculation program Raytrace (Rayner; https://www.raytrace.rayner.com/) was validated with the LHC formula for additive phakic or pseudophakic sulcus IOLs (▶ **Fig. 3** and **Fig. 4**). The LHC formula, along with the readily-accessible spreadsheet, has been

▶ **Fig. 2** Accessing the "LPCM" (lens power calculation module) for the IOL power calculation on the IOLCON website.



▶ **Fig. 3** Entering data and extracting the wanted values from the Castrop formula.



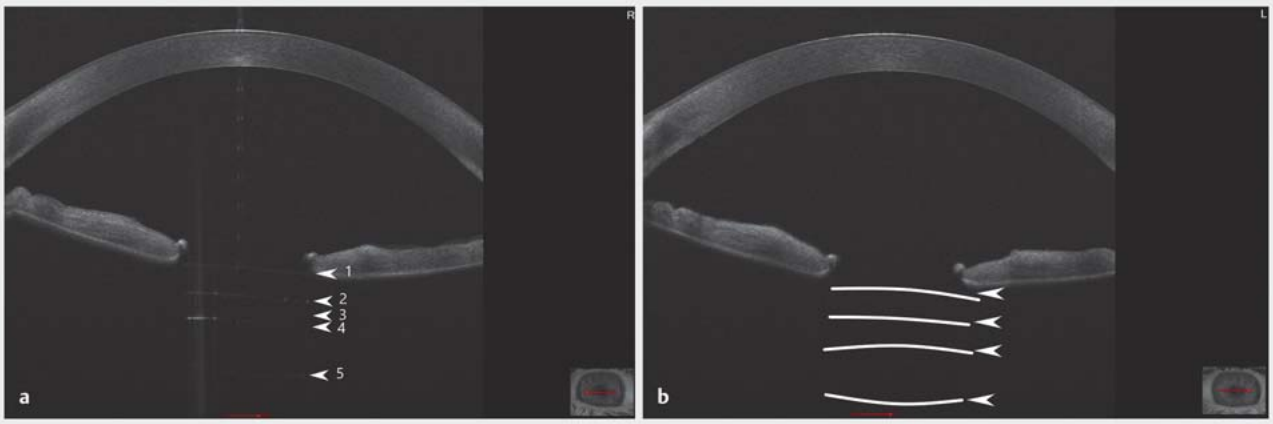
▶ **Fig. 4** **a** Displays IOL calculation of the additive IOL with the Rayner Raytrace application. Source: Raynor Intraocular Lenses Ltd., Worthing, United Kingdom. **b** Displays IOL calculation via LHC formula spreadsheet. An expected vault of − 0.300 mm was chosen. Target refraction for a − 1.50 dpt Sulcoflex IOL is − 0.17 dpt. Corneal power was converted from a keratometer index of 1.332 to a keratometer index of 1.3375.

previously published and is fully disclosed in the original source [13].

The relevant information [pseudophakic anterior chamber depth (ACD) and pseudophakic refraction] was considered for calculating an additive sulcus IOL with both methods. Usually, both values will be available in a pseudophakic patient before additive sulcus IOL implantation. In the case of planned TDI in this patient, this information could not be measured preoperatively due to the phakic state of both eyes. Therefore, in order to predict postoperative ACD, the effective lens position (ELP) prediction module of the Castrop formula (https://iolcon.org/lpcm.php) was used (▶ **Fig. 2** and **Fig. 3**). The Castrop formula ELP prediction mode was chosen, as it predicts the axial lens position as the distance from the corneal front surface to the IOL equator [14 – 16]. Hence, in order to accurately calculate the distance from the corneal front surface to the IOL front surface, the ELP prediction mode has to be corrected by half the central IOL thickness. This information was found in the manufacturer's information brochure, stating that a 20.0 Tecnis platform IOL has a central IOL thickness of 0.7 mm (https://www.jnjvisionpro.com/sites/us/files/public/surgical/IOLs/z311421e_b_tecnis_synergy_iols_dfu.pdf). Therefore, the pseudophakic ACD was calculated as Castrop ELP minus half the ZCB00V optic center thickness (0.7 mm/2 = 0.35 mm). Thus, the predicted postoperative pseudophakic ACD was 4.927 mm – 0.35 mm = 4.577 mm.

From previous cases, we measured a postoperative vaulting of around 300 µm in other eyes with TDI and therefore set the expected vault (EV) to − 0.300 mm for the LHC formula.

If surgically induced astigmatism (SIA) is known, it can be accounted for in the entered K values in the calculator. This makes sense primarily in the case of astigmatism correction with toric IOLs. Since we were dealing with rotationally symmetric IOLs, we did not account for SIA in our case. This resulted in an IOL power of − 1.5 dpt, with a target refraction of − 0.20 dpt and − 0.17 dpt in both calculation methods, respectively. For the left eye, the additive sulcus IOL power was similarly calculated and amounted to a neutral (0 dpt) IOL power.



▶ **Fig. 5** Postoperative OCT: both eyes show polypseudophakia. The vault between both IOLs is without any sign that the optics are touching each other. In ▶ **Fig. 5a**, arrows 1 and 2 display the anterior and posterior surface of the additive sulcus IOL. Arrow 3 displays the vault between both IOLs. Arrows 4 and 5 display the anterior and posterior surface of the ZCB00V. In ▶ **Fig. 5b**, all IOL surfaces are marked to make the ratio of both IOLs more visible.

Surgical Procedure

Surgery was first performed on the right eye. Intracapsular IOL implantation was performed after femtosecond laser-assisted capsulorhexis and lens fragmentation, manual phacoemulsification, and capsular bag polishing. The sulcus was then filled with an additional ophthalmic viscoelastic device (OVD), and the additive sulcus IOL was inserted. After removal of the OVD, all paracenteses were hydrated. A similar surgical procedure was performed in the left eye.

Postoperative Results

A postoperative evaluation was conducted 1 week and 1 month after surgery. Subjectively, the patient expressed satisfaction with the procedure and reported that he would do the same surgery again. The polypseudophakia is displayed in ▶ **Fig. 5**. The patient's uncorrected distance visual acuity (UDVA) was 0.1 logMAR OD and − 0.1 logMAR OS after 1 week and 0.05 logMAR OD and − 0.1 logMAR OS after 1 month. Additional postoperative refraction data is presented in ▶ **Table 2**.

▶ **Table 2** Postoperative refraction.

	OD	OS
1 week		
IOL vaulting	364 microns	465 microns
UDVA	0.1 logMAR	− 0.1 logMAR
BCDVA	0 logMAR	
Subj refraction (4 m)	SEQ − 0.75 dpt	SEQ 0 dpt
1 month		
UDVA	0.05 logMAR	− 0.1 logMAR
BCDVA	0 logMAR	
Subj refraction (4 m)	Sph: − 0.13 dpt; Cyl: − 0.75 dpt	Sph: + 0.25 dpt; Cyl: − 0.50 dpt

UDVA: uncorrected distance visual acuity; BCDVA: best-corrected distance visual acuity

Discussion

TDI allows for a potentially reversible surgical option to treat patients with presbyopia [3, 7]. The procedure offers significant advantages due to the implantation of the additive IOL to the ciliary sulcus rather than "piggybacking" both IOLs into the capsular bag [3, 5]. This technique notably reduces complications, including IOL decentration and interlenticular opacities resulting from dual acrylic intracapsular IOLs [5]. TDI may have additional advantages, as over time, the intracapsular IOL may undergo decentration, while the sulcus IOL has been reported to remain relatively well centered [9]. In cases where decentration or capsular bag reactions may be expected, an aberration-neutral intracapsular IOL could have some advantages. However, it is necessary to use IOLs that are specifically designed for implantation into the ciliary sulcus rather than IOLs designed for in-bag placement to avoid complications such as cystoid macular edema and IOL opacification [6].

Previous research has suggested the optical equivalency of using a two-IOL system (intracapsular aspheric monofocal IOL with trifocal sulcus IOL) compared to a single trifocal IOL, with minimal light loss [12]. A similar result was reported in a study comparing polypseudophakia using a monofocal IOL with a multifocal additive sulcus IOL compared to a conventional single multifocal IOL [17]. In a study examining

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clinical outcomes of the TDI procedure using trifocal supplementary IOLs, refractive outcomes for near, immediate, and far distances were comparable to capsular bag-fixated TFIOLs [10]. The strategy to consider the preexisting myopia in multifocal duet implantation or TDI and to implant the capsular bag-fixed IOL also with a myopic target refraction has also been pointed out by other authors [4]. These results suggest that the duet procedure can be utilized as an effective tool in the treatment of presbyopia. This solution of presbyopia correction can respond to potential later complications (such as ablatio retinae or severe courses of age-related macular degeneration) in which trifocal optics may be disadvantageous by removing the additive IOL [18].

While postoperative visual acuity is comparable between single TFIOL implantation and the duet procedure, other measures of visual performance have also suggested the utility of TDI. Liekfeld et al. reported no significant differences in reading speed and smallest print size when comparing additive lens placement to capsular bagged multifocal IOL fixation [17]. Supplementary, sulcus-fixated IOLs have also been indicated to correct refractive errors in pseudophakic eyes after keratoplasty, with little risk of graft rejection [19, 20]. While improvement of visual acuity and astigmatism are noted in this population, it is crucial to consider complications following supplementary IOL placement in post-keratoplasty eyes, specifically rotational repositioning [19, 21, 22]. However, this complication may be mitigated by using another additive sulcus IOL platform with four haptics, which has been associated with decreased mean absolute lens rotation and better lens positioning [23].

We offer several observations from this case that may be useful to other clinicians. First, we used the additive TFIOLs in a patient that demonstrated good tolerance of monovision before cataract surgery. However, the patient specifically desired a TDI to achieve a maximum of stereopsis in a single surgery while keeping the option to reverse the procedure if intractable pseudophakic photic symptoms occurred. The patient did not find the option of trying pseudophakic monovision first and implanting the additive IOLs in an eventual secondary procedure to be goal-directed. Second, while our patient tolerated the procedure well in the short term, our surgical strategy also offers late-term advantages should the patient desire reversibility for objective or subjective reasons. For example, the sulcus TFIOL can be safely removed in the future with iatrogenic disturbance of the capsule-zonule complex, leaving the patient with a good range of vision through monovision. Laser vision correction or a piggyback monofocal IOL can be considered to achieve bilateral distance vision should the patient not tolerate pseudophakic monovision in the future. Additionally, removing a ciliary sulcus TFIOL might incur fewer surgical risks than removing an intracapsular IOL, especially if a posterior capsulotomy has been performed. The aim of this paper is not to elaborate the superiority of one method, but to show the interested clinician how a duet implantation can be calculated using a paraxial vergence-based calculation approach. While the power of additive IOLs can also be converted using fixed factors from subjective refraction, a paraxial calculation based on a predictive model may have advantages in certain cases [13, 24, 25]. At the same time, the use of the LHC formula provides the opportunity to compare different additive sulcus lenses in studies independent of the undisclosed IOL-specific manufacturer calculation. Furthermore, understanding the calculation approach using Gaussian optics can help clinicians to understand where in the model to locate the error factor. Since the refractive power of additive IOLs is mostly low, the influence of ACD is usually not crucial. Thus, the introduction of the postoperative pseudophakic ACD into the manufacturer's calculation software had only a minimal effect on the prediction of the spherical equivalent in our case study as well but was noticeable in the prediction of the residual astigmatism. Thus, especially for (toric) IOLs with higher refractive power, the prediction of postoperative pseudophakic ACD may make sense [26]. Theoretically, a paraxial vergence calculation can additionally address total and meridional ocular image magnification in addition to just calculating the required lens power to incorporate aniseikonia into the selection of the appropriate IOL combination [27, 28]. In our case, the cornea was calculated as a thick lens. If the manufacturers provide enough information about the IOL geometry, both IOLs can also be calculated as a thick lens instead of a thin lens [29, 30]. Finally, we provided a detailed explanation of how we calculated the powers for all IOLs used, which may further guide clinicians in refining their surgical approaches. Notably, our case is limited to a single patient with short-term results. Future studies are needed to validate our observations.

We report our case of TDI with guidance on IOL power calculations to treat presbyopia with underlying monovision correction. We propose TDI with monovision can be advantageous in treating this patient population by offering the potential of later removing the additive IOL while preserving some form of spectacle independency.

Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki. As a single patient case report, regarding the international regulatory, approval by an ethics committee was not necessary and applicable.

Informed Consent Statement

Informed consent was obtained from the subject involved in the case report.

Conflict of Interest

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References

[1] Li H, Lim JH, Liu J et al. Towards automatic grading of nuclear cataract. Annu Int Conf IEEE Eng Med Biol Soc 2007; 2007: 4961–4964. doi:10.1109/IEMBS.2007.4353454

[2] de Vries NE, Webers CAB, Touwslager WRH et al. Dissatisfaction after implantation of multifocal intraocular lenses. J Cataract Refract Surg 2011; 37: 859–865. doi:10.1016/j.jcrs.2010.11.032

[3] Baur ID, Auffarth GU, Yildirim TM et al. Reversibility of the duet procedure: Bilateral exchange of a supplementary trifocal sulcus-fixated intraocular lens for correction of a postoperative refractive error. Am J Ophthalmol Case Rep 2020; 20: 100957. doi:10.1016/j.ajoc.2020.100957

[4] Feldhaus L, Mayer WJ, Siedlecki J et al. Myope multifokale Duett-Implantation zur Korrektur von Presbyopie und Myopie. Ophthalmologie 2023; 120: 759–762. doi:10.1007/s00347-022-01692-6

[5] Gayton JL, Apple DJ, Peng Q et al. Interlenticular opacification: clinicopathological correlation of a complication of posterior chamber piggyback intraocular lenses. J Cataract Refract Surg 2000; 26: 330–336. doi:10.1016/s0886-3350(99)00433-2

[6] Chang DF, Masket S, Miller KM et al. Complications of sulcus placement of single-piece acrylic intraocular lenses: recommendations for backup IOL implantation following posterior capsule rupture. J Cataract Refract Surg 2009; 35: 1445–1458. doi:10.1016/j.jcrs.2009.04.027

[7] Kahraman G, Amon M. New supplementary intraocular lens for refractive enhancement in pseudophakic patients. J Cataract Refract Surg 2010; 36: 1090–1094. doi:10.1016/j.jcrs.2009.12.045

[8] Khan MI, Muhtaseb M. Performance of the Sulcoflex piggyback intraocular lens in pseudophakic patients. J Refract Surg 2011; 27: 693–696. doi:10.3928/1081597X-20110512-01

[9] Prager F, Amon M, Wiesinger J et al. Capsular bag-fixated and ciliary sulcus-fixated intraocular lens centration after supplementary intraocular lens implantation in the same eye. J Cataract Refract Surg 2017; 43: 643–647. doi:10.1016/j.jcrs.2017.01.020

[10] Baur ID, Auffarth GU, Łabuz G et al. Clinical Outcomes in Patients After Duet Procedure for Reversible Trifocality Using a Supplementary Trifocal Intraocular Lens. Am J Ophthalmol 2022; 241: 217–226. doi:10.1016/j.ajo.2022.04.021

[11] Kahraman G, Dragostinoff N, Brezna W et al. Visual Outcomes and Patient Satisfaction After Bilateral Sequential Implantation of a Capsular Bag IOL and a Supplementary Sulcus-Fixated Trifocal IOL. J Refract Surg 2021; 37: 105–111. doi:10.3928/1081597X-20201215-01

[12] Łabuz G, Auffarth GU, Knorz MC et al. Trifocality Achieved Through Polypseudophakia: Optical Quality and Light Loss Compared With a Single Trifocal Intraocular Lens. J Refract Surg 2020; 36: 570–577. doi:10.3928/1081597X-20200715-01

[13] Wendelstein JA, Hinterberger S, Hoffmann PC et al. Evaluation of phakic intraocular lens power calculation using the new Linz-Homburg-Castrop formula and comparison with four conventional methods. J Cataract Refract Surg 2023; 49: 119–125. doi:10.1097/j.jcrs.0000000000001055

[14] Langenbucher A, Szentmáry N, Cayless A et al. Prediction of the axial lens position after cataract surgery using deep learning algorithms and multilinear regression. Acta Ophthalmol 2022; 100: e1378–e1384. doi:10.1111/aos.15108

[15] Langenbucher A, Szentmáry N, Cayless A et al. Considerations on the Castrop formula for calculation of intraocular lens power. PLoS One 2021; 16: e0252102. doi:10.1371/journal.pone.0252102

[16] Langenbucher A, Szentmáry N, Cayless A et al. The Castrop formula for calculation of toric intraocular lenses. Graefes Arch Clin Exp Ophthalmol 2021; 259: 3321–3331. doi:10.1007/s00417-021-05287-w

[17] Liekfeld A, Ehmer A, Schröter U. Visual function and reading speed after bilateral implantation of 2 types of diffractive multifocal intraocular lenses: Add-on versus capsular bag design. J Cataract Refract Surg 2015; 41: 2107–2114. doi:10.1016/j.jcrs.2015.10.055

[18] Khoramnia R, Yildirim TM, Son HS et al. Reversible Trifokalität durch das Duett-Verfahren. Ophthalmologe 2020; 117: 999–1004. doi:10.1007/s00347-020-01096-4

[19] Meyer JJ, McGhee CNJ. Supplementary, Sulcus-Fixated Intraocular Lens in the Treatment of Spherical and Astigmatic Refractive Errors in Pseudophakic Eyes After Keratoplasty. Cornea 2015; 34: 1052–1056. doi:10.1097/ICO.0000000000000506

[20] Srinivasan S, Ting DSJ, Lyall DAM. Implantation of a customized toric intraocular lens for correction of post-keratoplasty astigmatism. Eye (Lond) 2013; 27: 531–537. doi:10.1038/eye.2012.300

[21] Ferreira TB, Pinheiro J. Clinical results with a supplementary toric intraocular lens for the correction of astigmatism in pseudophakic patients. Eur J Ophthalmol 2015; 25: 302–308. doi:10.5301/ejo.5000564

[22] McLintock CA, McKelvie J, Gatzioufas Z et al. Outcomes of toric supplementary intraocular lenses for residual astigmatic refractive error in pseudophakic eyes. Int Ophthalmol 2019; 39: 1965–1972. doi:10.1007/s10792-018-1027-7

[23] Gundersen KG, Potvin R. Refractive and Visual Outcomes After Implantation of a Secondary Toric Sulcus Intraocular Lenses. Clin Oph-

thalmol 2020; 14: 1337–1342. doi:10.2147/OPTH.S255725

[24] Eppig T, Viestenz A, Seitz B et al. Berechnung pseudophaker torischer Intraokularlinsen. Klin Monbl Augenheilkd 2011; 228: 681–689. doi:10.1055/s-0029-1246046

[25] Holladay JT. Refractive power calculations for intraocular lenses in the phakic eye. Am J Ophthalmol 1993; 116: 63–66. doi:10.1016/s0002-9394(14)71745-3

[26] Langenbucher A, Viestenz A, Szentmáry N et al. Pseudophake und phake torische Linsen zur Korrektur des kornealen Astigmatismus – Theorie und klinische Aspekte. Klin Monbl Augenheilkd 2008; 225: 541–547. doi:10.1055/s-2008-1027502

[27] Langenbucher A, Szentmáry N, Cayless A et al. Prediction of ocular magnification and aniseikonia after cataract surgery. Acta Ophthalmol 2022; 100: e1675–e1684. doi:10.1111/aos.15190

[28] Langenbucher A, Hoffmann P, Cayless A et al. Meridional ocular magnification after cataract surgery with toric and non-toric intraocular lenses. Graefes Arch Clin Exp Ophthalmol 2022; 260: 3869–3882. doi:10.1007/s00417-022-05740-4

[29] Langenbucher A, Hoffmann P, Cayless A et al. Considerations of a thick lens formula for intraocular lens power calculation. Z Med Phys 2022. doi:10.1016/j.zemedi.2022.11.007

[30] Langenbucher A, Szentmáry N, Cayless A et al. Monte-Carlo simulation of a thick lens IOL power calculation. Acta Ophthalmol 2023. doi:10.1111/aos.15666

Bibliography

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