

# Monofocal intraocular lens with enhanced intermediate function as substitute for multifocal intraocular lens in positive dysphotopsia

Tadas Naujokaitis, Ling Zhao, Debora Scharf, Ramin Khoramnia, Gerd U. Auffarth\*

International Vision Correction Research Centre (IVCRC), Department of Ophthalmology, University of Heidelberg, Heidelberg, Germany

## ARTICLE INFO

### Keywords:

IOL  
Depth of focus  
Monofocal  
Multifocal  
IOL exchange  
Positive dysphotopsia

## ABSTRACT

**Purpose:** To present a case of a 62-year-old patient implanted with multifocal intraocular lenses (IOLs) who underwent a bilateral IOL exchange due to positive dysphotopsia. In an attempt to reduce the symptoms and compensate for the loss of multifocality, we implanted an aspheric monofocal IOL with enhanced intermediate function in one eye and a spherical monofocal IOL in the other eye.

**Observations:** The patient presented with complaints of halo and glare, measured with a simulator, following the implantation of segmented multifocal IOLs two years earlier. The uncorrected distance visual acuity (UDVA) was 20/20 in both eyes. Before presentation at our clinic, a laser capsulotomy had been performed on the right eye. We proceeded with a bilateral IOL exchange. Because of capsular insufficiency in the right eye, we implanted a spherical monofocal three-piece IOL in the ciliary sulcus with optic capture. In the left eye, we used a monofocal IOL with an enhanced intermediate function. Two weeks postoperatively, UDVA (monocularly) was 20/20 in OD and OS, the uncorrected intermediate visual acuity (UIVA) was 20/32, and the uncorrected near visual acuity (UNVA) was 20/50. Binocularly, UDVA was 20/20, UIVA was 20/25 and UNVA was 20/25. The patient reported a marked decrease in halos and glare.

**Conclusions and importance:** When planning IOL exchange surgery, in cases of intolerance to multifocal IOLs, the clinician should consider the dilemma of loss of multifocality. Recent developments in monofocal IOL technology present new options to improve visual function in cases of multifocal IOL explantation.

## 1. Introduction

Patient satisfaction following the implantation of multifocal intraocular lenses (IOLs) is generally high.<sup>1,2</sup> However, some patients are disturbed by photic phenomena such as halos and glare, and IOL exchange is the only reasonable solution.<sup>3-5</sup> Typically, the multifocal IOL is replaced with a monofocal IOL.<sup>4,6</sup> However, this results in only partial restoration of visual function as patients lose multifocality.

One option to overcome this predicament is to use a monofocal IOL with enhanced intermediate function. The ICB00 TECNIS Eyhance IOL (Johnson & Johnson Surgical Vision, Inc., Santa Ana, CA, USA) is similarly to a standard monofocal IOL associated with lowered halo and glare but unlike it in providing an improved intermediate vision.<sup>7-9</sup> This makes it suitable for IOL exchange surgery in patients experiencing photic phenomena with multifocal IOLs. To our best knowledge, the use of the ICB00 to substitute a multifocal IOL due to photic phenomena has

not been reported before.

In cases where capsular bag implantation is no longer feasible, a three-piece IOL will be required for an implantation in the ciliary sulcus. Such IOLs exist with a spherical optic design which can also add an improved depth of focus due to remaining positive spherical aberration.<sup>10</sup>

We present a case in which implantation of the aspheric monofocal IOL with enhanced intermediate function ICB00 was combined with a spherical monofocal AR40e IOL (Johnson & Johnson Surgical Vision, Inc., Santa Ana, CA, USA) following the explantation of multifocal IOLs in a patient suffering from positive dysphotopsia.

## 2. Case report

A 62-year-old male patient presented to our clinic complaining of halos and glare while driving as well as difficulty adapting between

\* Corresponding author. International Vision Correction Research Centre (IVCRC), Dept. of Ophthalmology, Univ. of Heidelberg, INF 400, 69120, Heidelberg, Germany.

E-mail addresses: [Tadas.Naujokaitis@med.uni-heidelberg.de](mailto:Tadas.Naujokaitis@med.uni-heidelberg.de) (T. Naujokaitis), [Ling.Zhao@med.uni-heidelberg.de](mailto:Ling.Zhao@med.uni-heidelberg.de) (L. Zhao), [Debora.Scharf@med.uni-heidelberg.de](mailto:Debora.Scharf@med.uni-heidelberg.de) (D. Scharf), [Ramin.Khoramnia@med.uni-heidelberg.de](mailto:Ramin.Khoramnia@med.uni-heidelberg.de) (R. Khoramnia), [Gerd.Auffarth@med.uni-heidelberg.de](mailto:Gerd.Auffarth@med.uni-heidelberg.de) (G.U. Auffarth).

<https://doi.org/10.1016/j.ajoc.2022.101511>

Received 2 March 2022; Received in revised form 23 March 2022; Accepted 2 April 2022

Available online 10 April 2022

2451-9936/© 2022 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

bright and dim lighting conditions. Two years previously, he had undergone cataract surgery with implantation of LENTIS MPlus MF30 multifocal IOLs (Oculentis, Eerbeek, Netherlands) in both eyes, performed in another clinic. Before the initial presentation in our clinic, a neodymium-doped yttrium aluminum garnet (Nd:YAG) laser capsulotomy had been performed in the right eye. The uncorrected distance visual acuity (UDVA) was 20/20 in both eyes and the manifest refraction was  $-0.25 -0.25 \times 120^\circ$  in the right eye and  $0.00 -0.25 \times 100^\circ$  in the left eye. Apart from the capsulotomy in the right eye, the slit lamp examination findings of anterior and posterior segments were unremarkable. The Halo & Glare Simulator (Eyeland Design Network GmbH, Vreden, Germany) was used to quantify the subjective photic phenomena perception. The patient selected the halo type H1 (single ring-shaped halo), halo size 20 out of 100, and halo intensity 64 out of 100, as well as the glare type G1 (diffuse round glare), glare size 64 out of 100, and glare intensity 86 out of 100 (Fig. 1).

To address the dysphotopsia, a bilateral IOL exchange was offered to the patient. Aiming to compensate for the loss of multifocality while minimizing the possibility of positive dysphotopsia, we considered the use of a spherical AR40e IOL and an aspheric monofocal IOL with enhanced intermediate function ICB00.

The biometry measurements were obtained with the IOLMaster 700 (Carl Zeiss Meditec, Jena, Germany). For the right eye, to avoid potential problems due to a large posterior capsulotomy, we selected the three-piece AR40e IOL for the implantation in the ciliary sulcus with optic capture. For the left eye, we selected the ICB00 IOL since the posterior capsule was intact.

Both surgeries were performed by an experienced surgeon (GUA) with the patient under general anesthesia.

During the surgery of the right eye, a clear-cornea incision of approximately 4 mm was created. Ophthalmic viscosurgical device (OVD) was injected both anterior and posterior to the IOL to create space and to prevent the vitreous prolapse through the opening in the posterior capsule. The adhesions between the capsule and the anterior surface of the IOL were then separated using a spatula.

The plate haptics of the MF30 IOL were relocated into the anterior chamber using the Bonn iris hook, while stabilizing the capsule with a spatula. The IOL was then rotated by  $90^\circ$  to place one haptic next to the main incision and the whole lens was removed using forceps, which was possible due to the deformable nature of the hydrophilic material of the MF30 IOL. The AR40e IOL was implanted in the ciliary sulcus with optic capture after an anterior vitrectomy was performed (Fig. 2). On the first day postoperatively, UDVA in the right eye was 20/40.

The surgery of the left eye was less complicated because the posterior

capsule was intact. The IOL was removed using the same technique as previously described. The ICB00 IOL was implanted into the capsular bag and an adequate centration could be achieved. On the first day postoperatively, UDVA in the left eye was 20/25.

Two weeks postoperatively, monocular UDVA in the right and the left eye was 20/20, the uncorrected intermediate visual acuity (UIVA) at 0.8 m distance was 20/32, and the uncorrected near visual acuity (UNVA) at 0.4 m distance was 20/50. Binocularly, UDVA was 20/20, UIVA was 20/25 and UNVA was 20/25.

The defocus curve was performed 11 weeks postoperatively with the manifest refraction of  $+0.25$  diopters sphere in the right eye and no correction in the left eye. In the left eye, implanted with ICB00 IOL, the defocus curve was wider compared to the right eye, implanted with the AR40e IOL (Fig. 3). Binocular vision was considerably better than monocular vision at the defocus of  $-2.0$  D (0.20 logMAR binocularly vs. 0.50 logMAR in the right eye and 0.36 logMAR in the left eye).

The assessment of positive dysphotopsia perception using the Halo & Glare Simulator at 11 weeks postoperatively revealed a marked improvement compared to the preoperative results. The patient selected the halo type H1, halo size 16, and halo intensity 15, as well as the glare type G1, glare size 8, and glare intensity 12 (Fig. 4).

### 3. Discussion

Although visual acuity is an important measure of the quality of vision, it is only one of multiple factors determining visual function and patient satisfaction. One of the complaints of multifocal IOL patients is the presence of halos and glare.<sup>11,12</sup> The dysphotopsia perception is influenced by neuronal processing of light distribution and some patients develop a tolerance to it during the process of neural adaptation.<sup>13</sup> Nevertheless, some patients remain disturbed by the photic phenomena.

Postoperative refractive error and corneal irregularities have been associated with positive dysphotopsia in multifocal IOL patients.<sup>14</sup> The refractive error can be corrected using spectacles, contact lenses, as well as surgical methods such as supplementary IOLs and corneal laser surgery.<sup>15,16</sup> The conventional laser-assisted in situ keratomileusis (LASIK) is known to induce corneal higher-order aberrations, which could negatively affect the vision in multifocal IOL patients.<sup>17,18</sup> To avoid this effect, a wavefront-guided LASIK and a topography-guided LASIK have been attempted in this patient group, with generally favorable outcomes in reducing the refractive error.<sup>17,19,20</sup> In terms of higher-order aberrations, the outcomes of the wavefront-guided LASIK were inconsistent, likely due to wavefront-measurement errors prior the treatment.<sup>19</sup> In a more recent study, Shin et al. investigated the topography-guided



Fig. 1. The patient's subjective perception of photic phenomena measured using the Halo & Glare Simulator before the IOL exchange. The patient adjusted the settings of the simulator to create an image representing his visual impression.

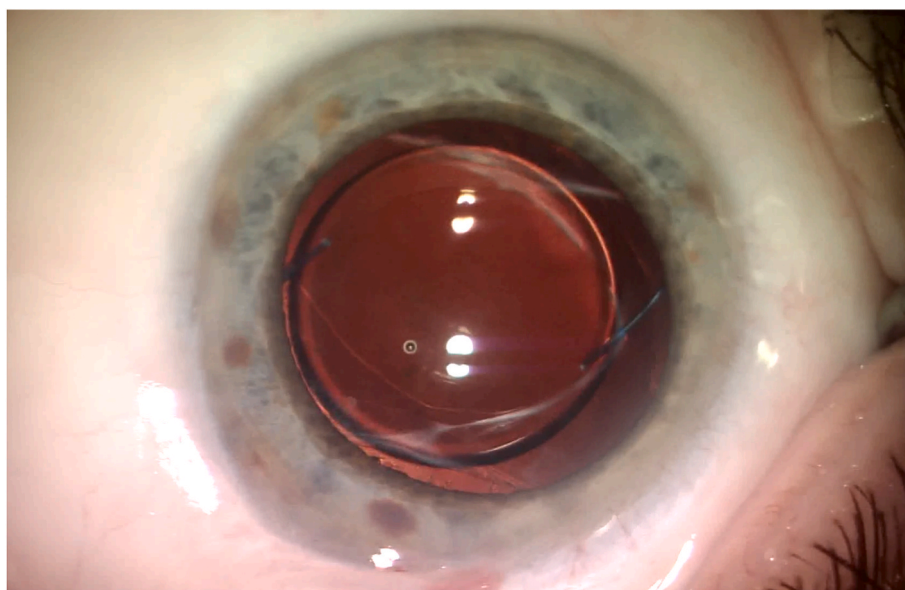


Fig. 2. Intraoperative image of the AR40e IOL implanted in the ciliary sulcus with optic capture.

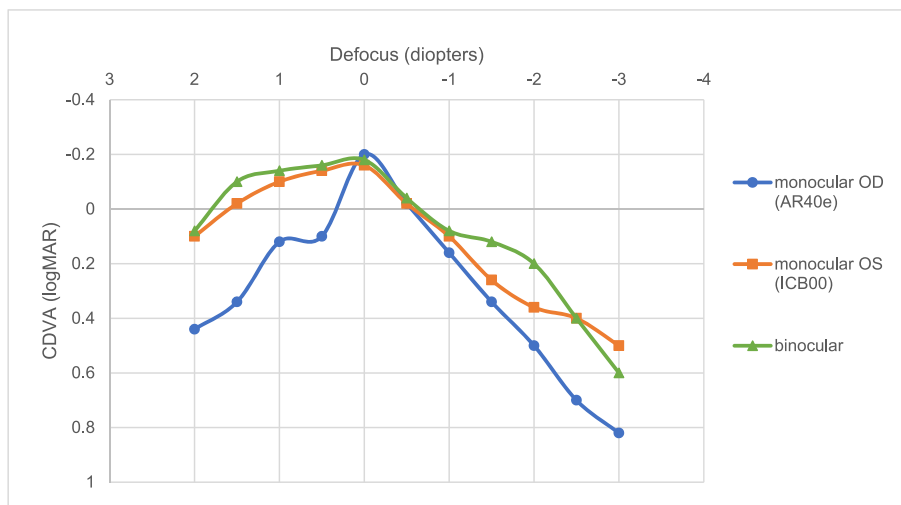


Fig. 3. Monocular and binocular defocus curves performed at 11 weeks postoperatively.

femtosecond LASIK after multifocal IOL implantation and reported a decrease in higher-order aberrations as well as an improvement in CDVA.<sup>17</sup> By decreasing the corneal higher-order aberrations, topography-guided treatments could potentially reduce positive dysphotopsia in some multifocal IOL patients with significant corneal higher-order aberrations, and further research is needed to confirm this.

When no significant refractive error or corneal irregularities are identified on clinical examination as in our case, then IOL exchange surgery is the only option to improve the quality of vision. This indication of intolerance to positive dysphotopsia accounts for 7–11% of all IOL exchange surgeries and a third of multifocal IOL exchange surgeries.<sup>5,6,21</sup> The procedure presents multiple challenges to the surgeon which include the choice of the replacement IOL, advanced surgical techniques and high expectations of multifocal IOL patients.

In IOL exchange surgeries, a suboptimal fixation of the lens and some amount of decentration cannot always be avoided. This can affect the selection of the IOL. Monofocal lenses were demonstrated to have a higher tolerance to decentration when compared to multifocal ones.<sup>22</sup> They are also less likely to cause noticeable positive dysphotopsia. Thus the prevailing view in IOL exchange because of photic intolerance is to

replace the multifocal lens not with another multifocal but with a monofocal.<sup>23</sup> However, these patients are accustomed to spectacle independence and the implantation of a monofocal IOL presents the dilemma of only partial visual function restoration due to the loss of multifocality.

When selecting the IOL model for the IOL exchange surgery, it is also important to identify the individual needs of the patient and set realistic expectations. In our case, the patient had an active professional life which involved a lot of night time driving. We needed a safe option to provide a good distance vision while driving while minimizing positive dysphotopsia. We also aimed to preserve some amount of his spectacle independence. To compensate for the loss of multifocality, we used two approaches: an aspheric monofocal lens with enhanced intermediate function and a spherical monofocal lens.

For the left eye, we selected the ICB00 because it combined the advantages of a monofocal IOL with an enhanced intermediate function. It uses a higher order aspheric optic to enhance the intermediate vision. To keep straylight and photic phenomena to the same level as a standard aspheric monofocal IOL, the lens design is based on a continuous refractive optical surface.<sup>24</sup> Indeed, clinical studies have reported that





Fig. 4. Postoperative results using Halo & Glare Simulator revealed a low level of photic phenomena after the IOL exchange.

photic phenomena and contrast sensitivity is similar to a standard monofocal IOL but giving improved UIVA and DCIVA.<sup>7–9</sup> Despite the enhanced intermediate VA, the ICB00 IOL is not classified as an extended depth of focus (EDOF) IOL by the United States Food and Drug Administration (FDA).<sup>25,26</sup> The ICB00 is therefore referred to as a monofocal IOL with enhanced intermediate function.<sup>7</sup> Nevertheless, the ICB00 may still provide similar intermediate vision to EDOF IOLs. A recent study by Corbelli et al. compared the ICB00 with a diffractive IOL TECNIS Symphony ZXR00 (Johnson & Johnson Surgical Vision, Inc.), which is labelled by the FDA as an EDOF lens.<sup>27</sup> The authors found that the patients with the ICB00 had a similar intermediate distance visual outcome and spectacle independence but lower subjective perception of halos and glare than the patients with the Symphony ZXR00. Similar findings were reported by two other studies.<sup>28,29</sup> The other FDA-approved EDOF IOLs AcrySof IQ Vivity (Alcon Laboratories, Inc., Fort Worth, TX, USA) and Clareon Vivity (Alcon Laboratories, Inc.), which use a wavefront-shaping technology to extend the depth of focus, have not yet been directly compared with the ICB00.<sup>30,31</sup> A practical aspect that differentiates EDOF IOLs from monofocal IOLs is that the term “EDOF-IOL” implies the spectacle independence at far to intermediate distances. As the ICB00 is currently not classified as an EDOF IOL, the patients should be prepared to wear spectacles if needed.

In the right eye with a large posterior capsulotomy, we decided against the IOL implantation in the capsular bag. While it was technically possible, it could have resulted in IOL dislocation and a requirement for subsequent pars plana vitrectomy. To limit the risk of complications, we selected the spherical monofocal AR40e three-piece IOL and aimed for fixation in the ciliary sulcus. Optic capture technique was used to prevent decentration of the sulcus IOL.<sup>32</sup> The spherical design of the AR40e IOL potentially also offers a slightly increased depth of focus, when compared to aspheric monofocal IOLs.<sup>10</sup>

The IOL exchange requires advanced surgical skills to prevent damage to the capsular bag and the zonules, which is important in order to achieve adequate fixation of the IOL. After the OVD is injected both anterior and posterior to the IOL, adhesions are carefully separated using a blunt spatula and the IOL can be then luxated into the anterior chamber and subsequently removed. Hydrophilic IOLs can be explanted in one piece due to the deformable nature of the hydrophilic material. However, in case of a hydrophobic IOL, the recommendation is to use microscissors to intraocularly divide the IOL into two or more fragments.<sup>6,33,34</sup>

Our case also illustrates the importance of considering the consequences before performing Nd:YAG laser capsulotomy. In clinical practice, it is not uncommon to offer such treatment to a pseudophakic patient with vision complaints even when the posterior capsule

opacification is mild. A retrospective study on IOL exchange surgery found that in approximately half of the cases, when the IOL exchange surgery was performed due to intolerance of a multifocal IOL, the posterior capsule was open.<sup>21</sup> While Nd:YAG laser capsulotomy is safe, fast and inexpensive, it can considerably complicate any subsequent IOL exchange surgery, if such is needed. Leysen et al. reported that preoperative Nd:YAG laser capsulotomy was strongly correlated with vitreous loss during an IOL exchange surgery.<sup>35</sup> Therefore, the indication for Nd:YAG laser capsulotomy should always be carefully evaluated. In cases when the patient complaints are most likely related to the IOL itself, the Nd:YAG laser capsulotomy should be deferred as long as possible.<sup>4</sup>

Ideally, in the first place, potential side effects should be identified and addressed before implanting a multifocal IOL. The patient selection plays a crucial role. The surgeon has to consider the needs and the lifestyle of a patient. The decision should be taken together with the patient after considering the importance of the spectacle independence as well as the readiness to accept the potential side effects of multifocal optics. In cases when the visual lifestyle is dominated by intermediate and far distances, the EDOF IOLs may be a better fitting solution, as they aim to minimize positive dysphotopsia while providing spectacle independence for far to intermediate distance.<sup>36–38</sup> Standard monofocal IOLs as well as monofocal IOLs with enhanced intermediate function are reasonable options for patients who are uncomfortable with the risk of positive dysphotopsia and are willing to wear spectacles. To aid the IOL selection, a wearable device to collect objective visual behavioral data, the Vivior Monitor (Vivior, Zürich, Switzerland) was recently developed. It allows the physician to objectively analyze the viewing distances of a particular patient and use this information when discussing the IOL options with the patient.<sup>39</sup> Personality is another important factor to consider, as it affects patient satisfaction with a multifocal IOL. It has been demonstrated that those patients with conscientiousness and agreeableness as dominant personality traits are the ones who are the most satisfied with the postoperative results after a multifocal IOL implantation.<sup>40</sup>

However, due to the subjective nature of the perception of dysphotopsia, it is not always possible to predict how pronounced and disturbing the photic phenomena are going to be for each patient.<sup>13</sup> Studies have reported good visual outcomes and high patient satisfaction with the LENTIS MPlus MF30 segmental refractive multifocal IOL, the lens which was implanted in our patient.<sup>2,41–43</sup> Despite that, the patient experienced extreme halos and glare, which significantly affected his quality of life. In cases of uncertainty regarding the patient's tolerance of multifocal optics, the Duet procedure could be an alternative because it can offer reversible trifocality by implanting a monofocal IOL in the capsular bag and a supplementary trifocal IOL in the ciliary sulcus,

which can be relatively easily removed or exchanged afterwards.<sup>44–46</sup>

#### 4. Conclusions

The IOL selection for the IOL exchange surgery carries no less importance than the IOL selection for the initial surgery. In patients with intolerance of multifocal IOLs, not only it is important to minimize the risk of positive dysphotopsia, but also to anticipate the predicament of losing multifocality. Recent developments in monofocal IOL technology present new options to improve visual function in cases of multifocal IOL explantation.

#### Patient consent

Written consent to analyze and publish the data was obtained from the patient. This report does not contain any personal identifying information. Retrospective review of this case was done in accordance with the Declaration of Helsinki.

#### Funding

Partially funded by a research grant from Klaus Tschira Foundation (KTS), Heidelberg, Germany.

#### Authorship

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

#### Declaration of competing interest

G.U. Auffarth reports grants, personal fees, non-financial support and consulting fees from Johnson&Johnson and Alcon, grants, personal fees and non-financial support from Carl Zeiss Meditec, Hoya, Kowa, Oculentis/Teleon, Rayner, Santen, and Sifi. R. Khoramnia reports grants, personal fees and non-financial support from Alcon, Johnson&Johnson, Hoya, Physiol, and Rayner, personal fees and non-financial support from Kowa, Oculentis/Teleon, Santen, and Acufocus. T. Naujokaitis, L. Zhao, D. Scharf have nothing to disclose.

#### Acknowledgements

Donald J. Munro contributed to the review of the pre-publication report.

#### References

- Rosen E, Alió JL, Dick HB, et al. Efficacy and safety of multifocal intraocular lenses following cataract and refractive lens exchange: metaanalysis of peer-reviewed publications. *J Cataract Refract Surg.* 2016 Feb;42(2):310–328.
- Venter JA, Pelousova M, Collins BM, et al. Visual outcomes and patient satisfaction in 9366 eyes using a refractive segmented multifocal intraocular lens. *J Cataract Refract Surg.* 2013 Oct;39(10):1477–1484.
- Gibbons A, Ali TK, Waren DP, Donaldson KE. Causes and correction of dissatisfaction after implantation of presbyopia-correcting intraocular lenses. *Clin Ophthalmol.* 2016 Oct 11;10:1965–1970.
- Galor A, Gonzalez M, Goldman D, O'Brien TP. Intraocular lens exchange surgery in dissatisfied patients with refractive intraocular lenses. *J Cataract Refract Surg.* 2009 Oct;35(10):1706–1710.
- Kamiya K, Hayashi K, Shimizu K, et al. Multifocal intraocular lens explantation: a case series of 50 eyes. *Am J Ophthalmol.* 2014 Aug;158(2):215–220.e1.
- Jones JJ, Jones YJ, Jin GJ. Indications and outcomes of intraocular lens exchange during a recent 5-year period. *Am J Ophthalmol.* 2014 Jan;157(1):154–162.e1.
- Auffarth GU, Gerl M, Tsai L, et al. Clinical evaluation of a new monofocal intraocular lens with enhanced intermediate function in cataract patients. *J Cataract Refract Surg.* 2020 Sep 3.
- Unsal U, Sabur H. Comparison of new monofocal innovative and standard monofocal intraocular lens after phacoemulsification. *Int Ophthalmol.* 2021 Jan;41(1):273–282.
- Mencucci R, Cennamo M, Venturi D, et al. Visual outcome, optical quality, and patient satisfaction with a new monofocal IOL, enhanced for intermediate vision: preliminary results. *J Cataract Refract Surg.* 2020 Mar; 10;46(3):378–387.
- Steinwender G, Strini S, Glatz W, et al. Depth of focus after implantation of spherical or aspheric intraocular lenses in hyperopic and emmetropic patients. *J Cataract Refract Surg.* 2017 Nov;43(11):1413–1419.
- Woodward MA, Randleman JB, Stulting RD. Dissatisfaction after multifocal intraocular lens implantation. *J Cataract Refract Surg.* 2009 Jun;35(6):992–997.
- Mamalis N, Brubaker J, Davis D, et al. Complications of foldable intraocular lenses requiring explantation or secondary intervention-2007 survey update. *J Cataract Refract Surg.* 2008;34:1584–1591.
- Breyer DRH, Kaymak H, Ax T, et al. Multifocal intraocular lenses and extended depth of focus intraocular lenses. *Asia Pac J Ophthalmol (Phila).* 2017 Jul-Aug;6(4): 339–349.
- Dick HB, Krummenauer F, Schwenn O, et al. Objective and subjective evaluation of photic phenomena after monofocal and multifocal intraocular lens implantation. *Ophthalmology.* 1999 Oct;106(10):1878–1886.
- Basarir B, Kaya V, Altan C, et al. The use of a supplemental sulcus fixated IOL (HumanOptics Add-On IOL) to correct pseudophakic refractive errors. *Eur J Ophthalmol.* 2012 Nov-Dec;22(6):898–903.
- Piñero DR, Ayala Espinosa MJ, Alió JL. LASIK outcomes following multifocal and monofocal intraocular lens implantation. *J Refract Surg.* 2010 Aug;26(8):569–577.
- Shin E, Yoo YS, Choi SH, et al. Clinical outcomes of topography-guided femtosecond laser-assisted in situ keratomileusis after multifocal intraocular lens implantation. *Sci Rep.* 2020 Jun 30;10(1), 10666.
- Yamane N, Miyata K, Samejima T, et al. Ocular higher-order aberrations and contrast sensitivity after conventional laser in situ keratomileusis. *Invest Ophthalmol Vis Sci.* 2004 Nov;45(11):3986–3990.
- Jendritza BB, Knorz MC, Morton S. Wavefront-guided excimer laser vision correction after multifocal IOL implantation. *J Refract Surg.* 2008 Mar;24(3): 274–279.
- Seiler TG, Wegner A, Senft T, Seiler T. Dissatisfaction after trifocal IOL implantation and its improvement by selective wavefront-guided LASIK. *J Refract Surg.* 2019 Jun 1;35(6):346–352.
- Davies EC, Pineda 2nd R. Intraocular lens exchange surgery at a tertiary referral center: indications, complications, and visual outcomes. *J Cataract Refract Surg.* 2016 Sep;42(9):1262–1267.
- Tandogan T, Son HS, Choi CY, et al. Laboratory evaluation of the influence of decentration and pupil size on the optical performance of a monofocal, bifocal, and trifocal intraocular lens. *J Refract Surg.* 2017 Dec 1;33(12):808–812.
- Khandelwal SS, Jun JJ, Mak S, et al. Effectiveness of multifocal and monofocal intraocular lenses for cataract surgery and lens replacement: a systematic review and meta-analysis. *Graefes Arch Clin Exp Ophthalmol.* 2019 May;257(5):863–875.
- Alarcon A, Cánovas C, Koopman B, et al. Enhancing the intermediate vision of monofocal intraocular lenses using a higher order aspheric optic. *J Refract Surg.* 2020 Aug 1;36(8):520–527.
- U.S. Food and Drug Administration. Product classification. Available at <https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpdc/classification.cfm?id=4571>. Accessed March 21, 2022.
- U.S. Food and Drug Administration. Premarket approval (PMA). Available at <https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpma/pma.cfm?ID=P980040517>. Accessed March 21, 2022.
- Corbelli E, Iuliano L, Bandello F, Pasce F. Comparative analysis of visual outcome with 3 intraocular lenses: monofocal, enhanced monofocal, and extended depth of focus. *J Cataract Refract Surg.* 2022 Jan 1;48(1):67–74.
- Jeon YJ, Yoon Y, Kim TI, Koh K. Comparison between an intraocular lens with extended depth of focus (Tecnis Symphony ZXR00) and a new monofocal intraocular lens with enhanced intermediate vision (Tecnis eyhance ICB00). *Asia Pac J Ophthalmol (Phila).* 2021 Oct 1;10(6):542–547.
- Lee JH, Moon SY, Chung HS, et al. Clinical outcomes of a monofocal intraocular lens with enhanced intermediate function compared with an extended depth-of-focus intraocular lens. *J Cataract Refract Surg.* 2022 Jan 1;48(1):61–66.
- U.S. Food and Drug Administration. TPLC - total product life cycle. Available at [https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cftplc/tplc.cfm?id=4571&min\\_report\\_year=2007](https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cftplc/tplc.cfm?id=4571&min_report_year=2007). Accessed March 21, 2022.
- Kohnen T, Petermann K, Böhm M, et al. Nondiffractive wavefront-shaping extended depth-of-focus intraocular lens: visual performance and patient-reported outcomes. *J Cataract Refract Surg.* 2022 Feb 1;48(2):144–150.
- Kemp PS, Oetting TA. Stability and safety of MA50 intraocular lens placed in the sulcus. *Eye (Lond).* 2015 Nov;29(11):1438–1441.
- Karamaounas N, Kourkoutas D, Prekates C. Surgical technique for small-incision intraocular lens exchange. *J Cataract Refract Surg.* 2009 Jul;35(7):1146–1149.
- Por YM, Chee SP. Trisection technique: a 2-snip approach to intraocular lens explantation. *J Cataract Refract Surg.* 2007 Jul;33(7):1151–1154.
- Leyens I, Bartholomeeusen E, Coeckelbergh T, Tassignon MJ. Surgical outcomes of intraocular lens exchange: five-year study. *J Cataract Refract Surg.* 2009 Jun;35(6): 1013–1018.
- Baur I, Auffarth GU, Labuz G, Khoramnia R. Unilateral implantation of a new non-diffractive extended range-of-vision IOL in a young patient with Curschmann-Steiner myotonic dystrophy. *Am J Ophthalmol Case Rep.* 2021 Apr 17;22, 101109.
- Baur ID, Auffarth GU, Labuz G, et al. [Unilateral implantation of a new extended range of vision intraocular lens in a young patient]. *Ophthalmologe.* 2020 Dec 10.
- Lee Y, Labuz G, Son HS, et al. Assessment of the image quality of extended depth-of-focus intraocular lens models in polychromatic light. *J Cataract Refract Surg.* 2020 Jan;46(1):108–115.
- Zakharov P, Cummings A, Schwiegerling J, et al. Lifestyle match index - choosing the right lens for the right patient. *Invest Ophthalmol Vis Sci.* 2020;61(7):1692.
- Rudalevicius P, Lekaviciene R, Auffarth GU, et al. Relations between patient personality and patients' dissatisfaction after multifocal intraocular lenses

- implantation: clinical study based on the five factor inventory personality evaluation. *Eye (Lond)*. 2020 Apr;34(4):717–724.
41. Buckhurst PJ, Naroo SA, Davies LN, et al. Assessment of dysphotopsia in pseudophakic subjects with multifocal intraocular lenses. *BMJ Open Ophthalmol*. 2017 Jun 19;1(1), e000064.
  42. Khoramnia R, Auffarth GU, Rabsilber TM, Holzer MP. Implantation of a multifocal toric intraocular lens with a surface-embedded near segment after repeated LASIK treatments. *J Cataract Refract Surg*. 2012 Nov;38(11):2049–2052.
  43. Linz K, Attia MS, Khoramnia R, et al. Clinical evaluation of reading performance using the salzburg reading desk with a refractive rotational asymmetric multifocal intraocular lens. *J Refract Surg*. 2016 Aug 1;32(8):526–532.
  44. 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 Oct 10;20, 100957.
  45. Khoramnia R, Yildirim TM, Son HS, et al. [Duet procedure to achieve reversible trifocality]. *Ophthalmologe*. 2020 Oct;117(10):999–1004.
  46. Khoramnia R, Yildirim TM, Baur I, Auffarth GU. Duet procedure to achieve reversible trifocality in a young patient with hereditary hyperferritinemia-cataract syndrome. *Am J Ophthalmol Case Rep*. 2021 Feb 8;21, 101026.