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Research Article

Evaluation of the Quality of Visual Acuity, Stereoacuity, and Photic Phenomena After Bilateral Implantation of a Rotational Asymmetric Enhanced Depth of Focus Intraocular Lens in a Blended Vision Strategy

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Abstract

Purpose: To examine visual acuity (VA), stereoacuity, and the amount of halo and glare phenomena in patients with a blended vision (BV) implantation strategy using a rotational asymmetric enhanced depth of focus (EDOF) intraocular lens (IOL). The dominant eye was targeted for emmetropia and the non-dominant eye for -1.5 D.

Materials and Methods: In this retrospective analysis, 46 eyes of 23 patients (female/male: 58.33%/41.67%, mean age: 65.9 years) were implanted with a rotational asymmetric enhanced depth of focus intraocular lens the LENTIS Comfort LS-313 MF15 IOL (Teleon Surgical GmbH, Germany), in a BV strategy and underwent subjective refraction. Defocus curve was determined from 0 to -3.0 D. Stereoacuity was determined using the random dot stereoacuity test in 44 (91.3%) eyes. For measuring halo and glare phe-nomena, a group of 40 (87%) eyes matched photopsia through a simulation software assigning them to be "none", "mild", "moderate", or "severe".

Results: At all distances, a mean uncorrected VA (UVA) of 0.08 ± 0.12 logMAR was achieved. A mean stereoacuity of 0.15 ± 0.38 (min -0.18; max 1.12) logMAS was measured. In seven cases (35%) photic phenomena were assigned as "none", in eight cases (40%) patients described them as "mild", while five (25%) described them as "moderate". Nobody showed "severe" photic phenomena.

Conclusion: Postoperatively, the patients could drive, work at 60 - 80 cm distance, and read newspaper print without glasses. Stereoacuity was similar to that of healthy people without cataract. Halo and glare were comparable to extended depth of focus IOL. This BV strategy may constitute an alternative to trifocal IOL implantation, in patients who want to avoid severe photopic phenomena and accept a blended vision strategy.

Keywords: *Cataract Surgery; Blended Vision; Extended Depth of Focus; Stereoacuity*

Introduction

The age of individuals continues to rise globally because of better healthcare systems. Therefore, age-related illnesses such as the development of cataract affects more and more people.

The standard procedure to treat patients with cataracts is to replace the natural crystalline lens with an artificial intraocular lens (IOL) [1]. The IOL commonly used for standard cataract surgery is a monofocal aspheric lens [2]. Patients must decide preoperatively on which is the most important for them: near, intermediate, or distance vision. In this scenario, the patient usually needs spectacles after surgery.

Over the last couple of years, numerous IOL with different optical principles have been developed. They offer better individual solutions to minimize spectacle dependence after cataract surgery (CS) [3,4]. There are now more patients who ask for spectacle independence post-IOL implantation [5]. The desire to achieve good vision and better quality of life has increased as well.

Refractive or diffractive, bifocal or trifocal multifocal intraocular lenses (MIOL) offer a high degree of spectacle independence. However, they can cause patient dissatisfaction due to waxy vision, less contrast sensitivity, or photic phenomena which can lead to MIOL explantation [6-8]. IOL with an extended depth of focus (EDOF) are an additional option to improve spectacle independence. Their design creates an elongated focal point using refractive or diffractive low additions (equivalent to +1.0 D - +2.0 D) [9]. This enables patients to see better over a certain range. Therefore, they are superior to monofocal lenses in terms of range of vision [10-13]. This effectincreases with higher near additions (+3.0 D to +4.0 D) [14,15]. The physical optics of EDOF IOL induce less halo and glare, with less loss of contrast sensitivity than diffractive and refractive trifocal MIOL [16].

An emerging procedure over the last couple of years when treating presbyopia in patients with clear lenses is laser-blended vision (Presbyond, Carl Zeiss Meditec and PresbyMax, Schwind). Improved VA and range of vision can be achieved by creating an EDOF effect in the cornea. The improvement includes good distance, intermediate and near vision, and a high degree of patient satisfaction due to excellent contrast vision and only few photic phenomena in emmetropic, hyperopic and myopic populations [17-21]. These can be achieved by targeting the dominant eye for distance and intermediate vision and the non-dominant eye for intermediate and near vision (Figure 1). These principles inspired to combine the advantages of EDOF IOL with a BV strategy. By implanting the LENTIS Comfort LS-313 MF15 IOL (Teleon Surgical GmbH, Germany) with an addition of +1.5 D in a BV strategy, where the dominant eye targets for far and intermedi-ate distances (0.0 D) while the non-dominant eye is for near and intermediate vision (-1.5 D), we aimed to achieve a high visual acuity on postoperative uncorrected distance visual acuity (UDVA), intermediate visual acuity (UIVA) and near visual acuity (UNVA). This could result in a high degree of spectacle independence while obtaining a good quality of vision with less induction of halo and glare than with diffractive trifocal MIOL. Additionally, we wanted to investigate stereoacuity in this EDOF IOL based BV approach.

Figure 1: *In the low-add extended depth of focus blended vision strategy, the sensing dominant eye targets emmetropia for sharp vision from far to intermediate distance vision and the non-dominant eye for intermediate and near vision.*

Materials and Methods

We retrospectively analyzed 46 eyes in 23 patients (Table 1) after bilateral implantation of the LENTIS Comfort LS-313 MF15 (Teleon Surgical GmbH, Germany) using a BV approach in the course of our quality management. All surgeries were performed by the same surgeon (D.R.H. Breyer). The mean postoperative follow-up time was 308 ± 579 days.

Patient Demographics	
Parameter	**BV**
Patient (n)	23
Age (in years, mean)	65.9
Gender: female/male (n in %)	14/9 (58.33/41.67%)
CS/RLE (n in %)	21/2 (91.3/8.7%)
Days postoperative, mean (time frame)	308 (25-1813)

Table 1: *Demographics of patients.*

n= Number of Patients; BV= Blended Vision; CS= Cataract Surgery; RLE= Refractive Lens Exchange.

This study respected the tenets of Declaration of Helsinki. A prior ethical committee approval from Ethikkommission Medizinische Fakultät Heidelberg was obtained (S-392/2011). All patients signed a preoperative informed consent.

The inclusion criteria were patients at the age of 18 years and older, implanted with the LENTIS Comfort LS-313 MF15 binocularly using a BV approach without any ocular pathology. The exclusion criteria were irregular astigmatism, retinal disease, or other pre-existing ocular diseases, as well as dementia and pregnancy.

To determine the VA at different focal points, the patients underwent a subjective refraction with the addition of 0 up to -3.0 in 0.5 D increments to create a defocus curve. The values of the VA that were measured were subsequently converted to logMAR values. Furthermore, the defocus capacity was evaluated. It was represented and calculated by the area under the curve; this represents the VA over all distances [22].

We used the random dot stereoacuity test to measure stereopsis [23,24]. It can measure values between 800 and 40 seconds of arc. It consists of nine diamond-shaped arrangements of four concentric ring structures. In each of these arrangements, one out of the four inner ring structures is doubled and shifted. Hence, with the aid of spectacles with a polarization filter, two different pictures are generated. The patient receives the impression of an inner ring that is in front of the rest of the arrangement due to this disparity. The patient's stereoacuity can be defined by minimizing the disparity. It can then be converted into a logarithmic form [25]:

$$MAS = \frac{360°}{2\pi}\arctan\left(\frac{\Delta x}{D}\right) \; SA = \frac{1'}{MAS} \; logMAS = log_{10}\left(\frac{1}{10}\right)$$

For photic phenomena patients subjectively matched their postoperative halo and glare with a simulator (Carl Zeiss Meditech, USA). These were evaluated using a standardized strength formula (developed by Dr. P. Hagen., *et al*. Düsseldorf):

$$strength = \sqrt{size\ x\ intensity}$$

It classifies the halo and glare into four clinical categories: none (0 - 25%), mild (25 - 50%), moderate (50 - 75%) and severe (75 - 100%). Patients matched their vision to simulations of halo and glare as seen below (Figure 2).

Figure 2: *Simulation of different strengths of photic phenomena.*

Results

Out of 46 eyes, 42 eyes (91.3%) underwent CS while 4 (8.7%) received a refractive lens exchange.

Patients achieved a binocular UDVA of 0.05 ± 0.14 (min -0.2; max 0.5) logMAR, a UIVA at 75 cm of 0.04 ± 0.09 (min -0.1; max 0.26) logMAR, and a UNVA at 33 cm of 0.16 ± 0.11 (min -0.04; max 0.38) logMAR.

The defocus capacity (area under the curve) that represents the average VA over all distances shows that patients achieved 82% with correction and 84% without correction (Figure 3).

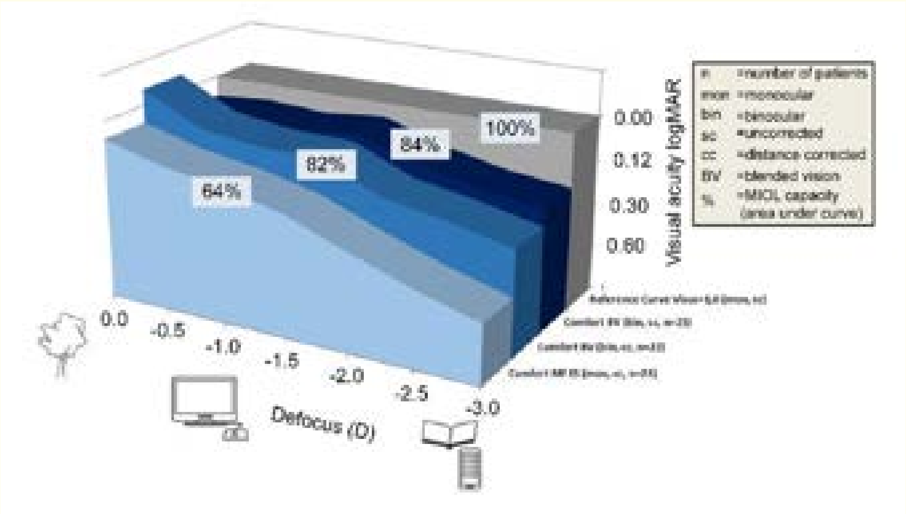

Figure 3: *Defocus curves in blended vision patients with binocular uncorrected (sc) and distance corrected (cc) and monocular distance corrected (cc) with the associated defocus capacities (area under the curve in %). D = diopters.*

The evaluation of stereoacuity in 22 patients showed a mean stereoacuity of 0.14 ± 0.39 (min -0.18; max 1.12) logMAS that was achieved with a median of 0.00 logMAS (Figure 4).

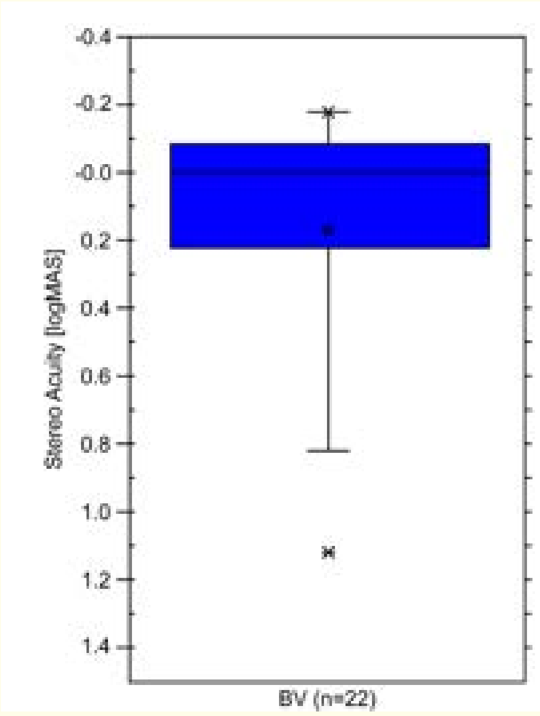

Figure 4: *Stereo acuity of blended vision (BV) patients in logMAS.*

Halo and glare phenomena among the 20 patients who underwent the BV procedure and the photic phenomena simulator showed the following results: seven (35%) perceived "none", while eight (40%) had "mild" phenomena. Only five (25%) patients perceived the phenomena with "moderate" intensity, while none had "severe" problems (Figure 5).

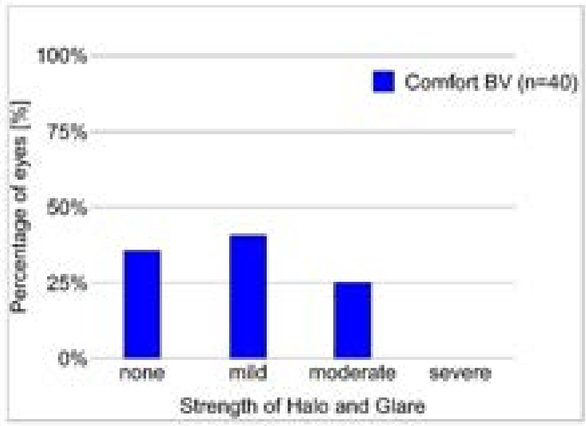

Figure 5: *Strength of photic phenomena of blended vision patients.*

Discussion

To our knowledge this is the first analysis of the visual outcomes of an IOL-based BV strategy with this rotational asymmetric EDOF IOL. We showed that patients achieved comfortable VA at all distances while covering a range of 3 D in the IOL plane. This can result in a high degree of spectacle independence in everyday life and is comparable to the results that common trifocal IOL have achieved [26-28]. From our clinical experience and the previously mentioned VA data, most of the patients are completely independent from the use of spectacles, while few needed reading glasses for small print reading. This corresponds with the good visual outcomes that many laser-based BV strategies have shown over the last couple of years. In a recent study Nakajima., *et al*. evaluated the visual outcome following the implantation of LENTIS Comfort MF15 in a non-BV strategy. While UCDVA is similar to our results (0.05 ± 0.14 to 0.05 ± 0.13) the BV-strategy shows better results for UCIVA (0.04 ± 0.09 logMAR to 0.23 ± 0.17 logMAR), and a UCNVA (0.16 ± 0.11 to 0.52 ± 0.20 logMAR) [29]. This shows not only the superiority at intermediate and near distance vision but also the non-inferiority at distance vision. These advantages of the BV-strategy are also shown compared to the results of Oshika., *et al*. [30].

A comparison to trifocal IOL show similar results in VA at all distances. Marques., *et al*. showed that using the AT Lisa tri 839 MP a UDVA of 0.08 ± 0.12, a DCIVA of 0.18 ± 0.18 logMAR and a DCNVA of 0.11 ± 0.08 logMAR can be achieved [31].

Therefore, the evaluated patients achieved a range of clear vision comparable to trifocal IOL with less commonly occurring side effects such as the perception of photic phenomena like halo and glare, waxy vision, and contrast sensitivity [32]. The lower disturbance due to photic phenomena in rotational asymmetric EDOF compared to diffractive MIOL has already been shown in previous literature and is consistent with our results [33,34]. EDOF IOL also showed fewer halo effects than low-add bifocal IOL and was similar to monofocal IOL [34]. So EDOF IOL seem to be the preferable option for patients with cataract requiring high levels of visual acuity while only tolerating low levels of positive dysphotopsia due to halo [35].

From our clinical experience a big advantage of the BV implantation strategy is that it offers more postoperative retreatment options than in trifocal IOL. Unsatisfied patients who underwent BV still have other opportunities like contact lenses and eyeglasses or touch up procedures like laser vision correction or the implantation of an add-on IOL to modulate the monovision effect. This offers higher safety and comfort to patients being unhappy about the side effects of trifocal IOL like reduced light permeability or photic phenomena or dissatisfaction in laptop or computer distance reading that might make a lens exchange in trifocal MIOL unavoidable [7,36].

Although no case is as straightforward as it initially seems, selecting the correct individual strategy for the patient can increase the chances of providing truly remarkable postoperative outcomes and a high degree of patient satisfaction.

The most important limitations of this study are the risk of bias inherent to the retrospective design, the small sample size, and the inability to generalize the results and findings to different populations. Hence, further studies should be done with more patients using a prospective study design.

In accordance with Teleon, the rotational asymmetric EDOF IOL BV strategy with LENTIS Comfort LS-313 MF15 IOL will now be called "The Duesseldorf Strategy". We recommend this strategy for patients with a high demand for spectacle independence and low tolerance for photic phenomena or reduced contrast sensitivity [37].

Conclusion

We can conclude that the BV principle offers a safe and individualized approach on correcting presbyopia in cataract patients when compared to trifocal MIOL. On the other hand, we still use trifocal MIOL in patients who prefer the highest degree of independence from glasses over the perception of photic phenomena. In the future, we look forward into evaluating more patients who underwent the BV approach not only using the LENTIS Comfort LS-313 MF15 IOL but different EDOF IOL as well.

Conflict of Interest

Detlev Breyer is a consultant to Teleon Surgical GmbH and gets travel grants from Teleon Surgical GmbH. The co-authors report no other conflicts of interest in this work.

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