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# Light disturbance with multifocal contact lens and monovision for presbyopia☆

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ABSTRACT

Dysphotopsia affects a significant number of patients, particularly after visual correction with multifocal optical designs.

*Purpose:* Evaluate light distortion (LD) in two modalities of contact lens (CL) wear: multifocal (MF) and monofocal (MV).

*Methods:* This was a randomized, double-masked, crossover study involving 20 presbyopic patients. Patients were randomized first into either MF or MV for 15 days of use with a 1 week wash-out period between each lens type. The LD was evaluated with the Light Distortion Analyzer (LDA, University of Minho) under monocular and binocular conditions. The light distortion index (LDI, %), among other parameters were analyzed. Subjective quality of vision was assessed with the Quality of Vision (QoV).

*Results:* The LD showed an increase in all parameters in both CL modalities being significant for MV in the non-dominant eye ($p < 0.030$, for all LD parameters). For the MF, there was also a significant increase in LDI ($p = 0.016$) and in BFCrad ($p = 0.022$) in the non-dominant eye. After 15 days of MF lens wear, there was a significant decrease in all LD parameters ($p < 0.002$) in the dominant eye. Binocularly, a significant improvement from 1 to 15 days was observed for LDI ($p = 0.009$) and BFCrad ($p = 0.0013$) with MF. The QoV questionnaire showed no significant changes with neither CL. Conclusions. Adaptation to light disturbances induced by MF CL is more effective compared to MV. Practitioners will have greater success if they prepare their patients for the adaptation required as their vision will get better and have less of an issue with light disturbance.

## 1. Introduction

A consequence of the progressive ageing of the population is the significant growth in the ng number of contact lens (CL) wearers requiring presbyopic correction. The availability of multifocal CLs, the improved materials/wetting agents and generally better management of dry eyes, together with the improved marketing and familiarity of practitioners with the products, largely contribute to this growth [1,2]

Currently, patients have a variety of options for correcting presbyopia with CL, based on different principles: monovision, bifocal or trifocal alternating vision and multifocal simultaneous vision CLs. Within the multifocal lens category, two different types of designs are currently available: concentric spherical or progressive aspheric designs [3,4] Whereas in monovision one eye is corrected for distance and the other eye is enhanced for near vision, [5] multifocal designs of simultaneous vision provide clear vision at various distances, widening the depth of focus of the lens-eye system [3,6].

Monovision modality is independent of pupil size, and vision is lesser compromised in dim lighting or at low contrast [7–9]. On the other hand, the optical principle of multifocal contact lens is based on the formation of multiple images along different foci in each eye, which implies some compromise in visual performance, particularly under low-light conditions [10,11].

Although current multifocal strategies provide satisfactory distance, intermediate and near visual acuity, adverse subjective visual dysphotopic phenomena such as haloes, ghosting, or glare, are often reported by patients fitted with multifocal modalities [12–15].

Positive dysphotopsia is a photic light disturbance (LD) of vision that includes specific phenomena generally described in academic literature as glare, starburst, and haloes. Frequently might also involve hazy vision, monocular diplopia, polyopia, and defocus [16]. Glare refers to a bright and intense light source caused by scattered rays in the

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light path from media opacities and optical discontinuations. It can be divided into discomfort glare and disability glare [17]. The former is a subjective discomfort sensation induced by a bright light without causing significant losses in vision. Disability glare is associated to a significant loss in retinal image contrast due to an inappropriate distribution of light [18]. Halos and starburst, commonly referred as night visual disturbances, degrades the size and shape of the point source of light. Halos are perceived as circular shadows and starburst as a radial or regular scattering of light from a point source [19].

The measurement of these symptoms have been carried out with different methodologies beyond the use of subjective questionnaires and psychometric methods [20–25].

However, some of the commercially available techniques are limited in their ability to discriminate the light disturbance in all directions or do not measure the detailed shape and irregularity features. Previous studies showed an increase of about 15–23% in light distortion by multifocal intraocular lens (IOL) when compared to monofocal IOL implantation, with trifocal IOL inducing lower values of light distortion than extended depth of focus IOL [26] or bifocal IOLs.15 So far, few studies evaluated the perception of light disturbances in multifocal CL wearers. Besides, the contribution of dominance and the difference in optical design within the same multifocal CL, as well as the binocular summation effect are not completely known [27]. The quantification of such disturbances is relevant to a better understanding of complains and adaptation of simultaneous vision multifocal CL to avoid fitting failure and dropout.

This study aimed to evaluate how different presbyopic corrections with contact lenses affect the LD phenomena. For this purpose, the Light Distortion Analyzer (LDA, CEORLab, University of Minho, Braga, Portugal) [25,28] was used. This device allows measuring light disturbance under more realistic conditions, using hardware with physical LEDs designed to be able to quantify and analyze the size, shape and irregularity of positive dysphotopsia in multiple directions around a central source of glare, under laboratory conditions.

## 2. Methods

### 2.1. Sample

This was a randomized double-masked crossover study involving participants recruited from the staff of the University of Minho and performed at the Clinical and Experimental Optometry Research Lab (CEORLab). Following the tenets of the Declaration of Helsinki, all participants provided informed consent after they received an explanation of the nature, procedures, and consequences of the study. The inclusion criteria were: age between 45 and 65 years; lens opacities under grade II in LOCS III cataract grading scale; maximum spectacle astigmatism of 0.75 diopters (D) in either eye, best-corrected distance visual acuity (VA) of at least 0.00 logMAR in each eye. Patients could not have binocular vision anomaly, no ocular or systemic disease, and no need for medication that might interfere or contraindicate contact lens wear.

Macedo-de-Araújo et al. 29 reported that the induction of + 0.15 μm spherical aberration (SA) leads to an increase between 10 and 20% in light disturbance index (LDI). Considering that the mean induced SA by multifocal CL are in that order of magnitude, the sample size required was 18 subjects, to warrant an 80% power (type II error risk of 20%) and to detect 10% differences in LDI between follow-up visits, for a statistical significance level of $p = 0.05$ (type I error risk of 5%).

### 2.2. Outcome measures

After confirming subjects' suitability, a crossover study was conducted. Participants were randomized first into either multifocal or monovision for 15 days of wear for each modality with a 1 week washout period between each lens type.

For both modalities, the contact lens used were of silicone hydrogel material (Comfilcon A, Biofinity, Cooper Vision, Fairport, NY) with 48% of water content, 14.0 mm diameter and a base curve of 8.60 mm. Subjects were fitted with multifocal (Biofinity® Multifocal) contact lenses according to the manufacturer's fitting guidelines for the initial lens selection, and all participants received the same add power in both eyes; the near add power in the non-dominant eye for monovision also matched the add power of multifocal modality.

The Biofinity multifocal combine spherical and aspheric optics to yield a "center-distance" lens for the dominant eye. It comprises a spherical central zone (2.3-mm in diameter) for distance vision, surrounded by a 5.0-mm annular aspheric zone and an 8.5-mm spherical annular zone, both increasing in add power to emphasize distance vision. The "center-near" lens for the non-dominant eye (center-near design) has a 1.7-mm spherical central zone dedicated to near vision followed by a 5.0-mm aspheric annular zone and an 8.5-mm spherical annular zone, both with decreasing add. For monovision, the contact lens used was the single-vision lens (Biofinity) with an aspheric design.

Ocular dominance was identified using the sensory dominance method [30,31], and natural pupil size measured with the NeurOptics® VIP™-200 Pupillometer (Irvine, California, USA) in the same illumination conditions of light distortion measurements.

Once the fitting procedure was completed, subjects were dispensed with the first modality (multifocal or monovision, randomly assigned) and asked to return 14 days later for a follow-up visit to evaluate the fit, vision and comfort, and after a 1-week wash-out period for dispensing the other lens modality. Since the phenomenon of neuronal adaptation to dysphotopsia is unknown, and the time of wear of each lens was short, a 1-week washout seemed as the sufficient time to ensure that adaptive phenomena did not interfere between the different modalities.

All the clinical measurements of visual function were performed 45 min after finishing the fitting process (day 1) and 14 days after (day 15). Visual function analysis was measured using a high-contrast (100%) and low-contrast (10%) LogMAR chart (Precision Vision, USA). All VA values reported refer to high (HCDVA) or low (LCDVA) contrast distance VA while HCNVA and LCNVA refer to for high- and low-contrast near VA, respectively. Stereopsis (Stereo Fly SO-001, StereoOptical Co, Inc., Chicago, IL) and contrast sensitivity function (Vision Contrast Test System VCTS 6500, Vistech Consultants, Dayton, OH). Measurements were conducted monocularly and binocularly, under constant photopic (85 cd/m$^2$) illumination as previously described [7].

### 2.3. LDA measurements

Measurements of light disturbance were performed with an experimental device, Light Disturbance Analyzer (LDA, CEORLab, Portugal) [28]. It consists of central 5 mm white LED (glare source) surrounded by an array of 240 smaller LED (1 mm), distributed in twenty-four semi-meridians. These smaller LEDs have a linear separation of 10 mm to cover an angular field of 10° at the distance of 2 m. Fig. 1a to c represents the physical arrangement of the device. For technical specifications of the LEDs characteristics and examination procedures consult the previously published work [25,28]. In brief; in a darkened room, the instrument presents the central source of glare at maximum fixed intensity, while the peripheral LEDs are randomly presented at the different semi-meridians. Peripheral LEDs turn-on and turn-off sequentially around the central source of light using different sequences at random times (from 250 to 750 ms) and the semi-meridians explored in random order (Fig. 1c). The patient always fixates the central LED and gives feedback when sees the peripheral stimuli by clicking on a remote actuator. Then, the system automatically evaluates the following semi-meridian and examines each semi-meridian three times. If the standard deviation (SD) of these three measurements is above 20% of the mean value, the device automatically repeats the measurements in those semi-meridians until it reaches values of SD below 20% of the mean (Fig. 1b). After data collection and storage, a