

Cause of Monocular Diplopia Diagnosed by Combining Double-pass Retinal Image Assessment and Hartmann-Shack Aberrometry

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ABSTRACT

PURPOSE: To report an advanced optical procedure developed for the diagnosis of a particular case of diplopia.

METHODS: This approach combined the quantification of the level of intraocular scattering by using an Objective Scatter Index provided by a double-pass instrument (Optical Quality Analysis System) with the analysis of higher order aberrations using a Hartmann-Shack wavefront sensor.

RESULTS: The value of the Objective Scatter Index revealed increased intraocular scattering; the Hartmann-Shack images showed the existence of an optically differentiated area at the upper region of both crystalline lenses. Simulation of retinal images computed from the wavefront maps confirmed that, under low luminance conditions, this inhomogeneous region of the lens was included in the pupil, generating a secondary image and therefore the diplopia.

CONCLUSIONS: This report demonstrates the potential of combining two objective optical methods to show the presence of minor lens opacities that may severely degrade quality of vision. [*J Refract Surg.* 2010;26:301-304.] doi:10.3928/1081597X-20100218-05

The development of crystalline lens sclerosis imposes changes in the optics of the lens that, in some cases, can induce monocular polyopia,¹ which has been reported in patients with both nuclear² and cortical cataracts.³ In relation with this etiology, we present a patient with monocular diplopia in both eyes, which occurred only under low luminance conditions.

The combination of the objective diagnosis of a non age-related cataractous process by using a double-pass instrument⁴ and the analysis of the higher order aberrations by a Hartmann-Shack wavefront sensor⁵ determines the complete diagnosis of the cause of this diplopia.

In this report, only the results of the right eye are presented, as the same set of measurements on the left eye had equivalent results.

CASE REPORT

A 45-year-old woman complaining of monocular diplopia in both eyes was referred to the ophthalmology service of the Virgen de la Arrixaca Hospital. A specific examination was developed in collaboration with the Laboratorio de Óptica of the Universidad de Murcia by using state-of-the-art optical analysis technology. In the preliminary anamnesis, the patient reported a secondary image, which appeared to be displaced mainly vertically but also slightly horizontally from the primary image, but was only visible when the conditions of luminance were low.

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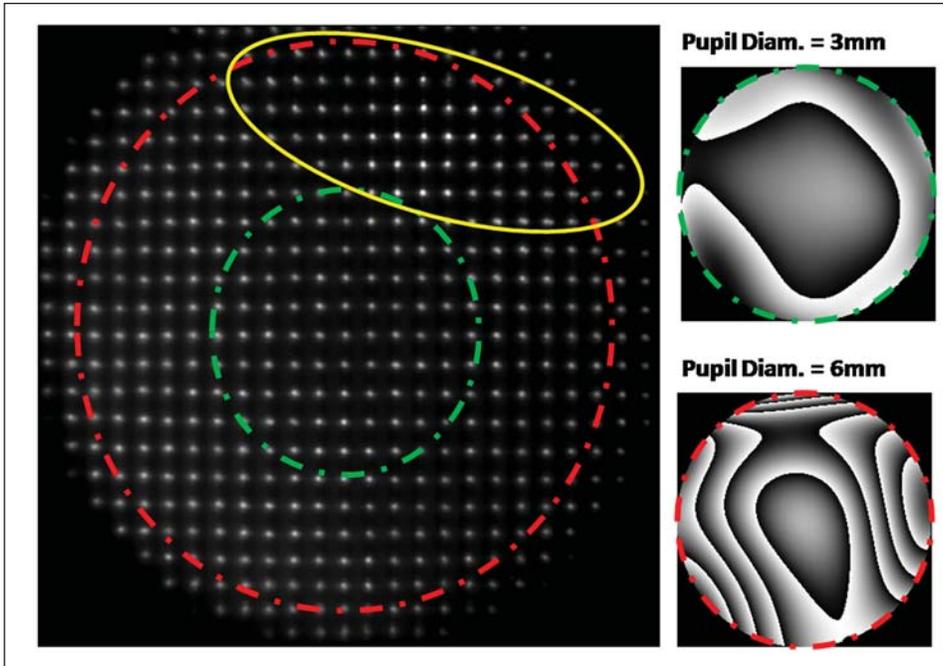


Figure 1. Spot pattern of the Hartmann-Shack image. The green circle corresponds with the 3-mm pupil diameter. The red circle defines the 6-mm pupil diameter. The inhomogeneous area at the upper-right quadrant of the image is defined by the yellow ellipse. The two wavefront maps computed under the corresponding pupil diameters are presented. The increased irregularity of the shape of the wavefront map under the 6-mm pupil reveals the contribution of this inhomogeneous area to the higher order aberrations.

Uncorrected visual acuity (UCVA) was 20/20 in both eyes even though the monocular diplopia under mesopic and scotopic luminance persisted. Before starting the ophthalmologic examination, two drops of tropicamide (1%) were instilled in both eyes to paralyze accommodation and to dilate the pupil. A slit-lamp examination was performed. Direct visualization of the slit-lamp images did not provide a definitive diagnosis, as these images only showed a small homogeneous opacity in both lenses.

A series of double-pass images were recorded using the Optical Quality Analysis System (OQAS; Visiometrics SL, Tarrasa, Spain) to determine the level of intraocular light scattering generated by the detected crystalline sclerosis. In both eyes, these measurements revealed a slightly increased value of the Objective Scatter Index, which is related to the level of intraocular scattering.⁶ The particular values obtained were 1.34 for the left eye and 1.42 for the right eye (as compared with values around 1 for normal transparent media).

Based on this objective diagnosis of an incipient non-age-related cataractous process, the higher order aberrations of the patient's eye were evaluated with the assumption that this irregular sclerosis would generate an irregular pattern of aberrations. A custom-made Hartmann-Shack sensor⁵ was used to measure wavefront aberrations for pupil diameters of 3 and 6 mm. For the 6-mm pupil, wavefront data revealed the existence of an optically differentiated area at the upper region of the pupil in both eyes (Fig 1). Simulated retinal images of a point source (point spread function [PSF]) and an object-test from the measured wavefront aber-

rations were calculated. The results presented in Figure 2 show the presence of double images (diplopia) for the large pupil.

Considering all available information, cataract surgery was recommended and successfully performed. Diplopia had resolved by the 1-week postoperative ophthalmologic examination.

DISCUSSION

Because the direct observation of the slit-lamp images did not reveal a recognizable cataract, the value of the Ocular Scatter Index parameter provided by the OQAS instrument, showing an increased value of intraocular scattering in both eyes, was the first objective indication useful to guide the diagnosis in the appropriate direction. By considering the values of the Ocular Scatter Index parameter reported for eyes with cataracts,⁶ the value of the Ocular Scatter Index measured for the patient would correspond approximately with a level NO2 according to the Lens Opacities Classification System (LOCS III). Therefore, an increased value of Ocular Scatter Index was the first indication of the existence of a lens sclerosis process, which led to the suspicion that the irregular irruption of a cataract process could be the underlying cause of diplopia.¹⁻³

As the study of higher order aberrations has been one of the most important trends in visual optics over the past decade, much is known about the normal characteristics of the aberrations⁷ and their influence on visual performance.⁸ This justifies the use of a wavefront sensor⁵ to provide a quantitative analysis of the higher order aberrations, and moreover, Hartmann-Shack

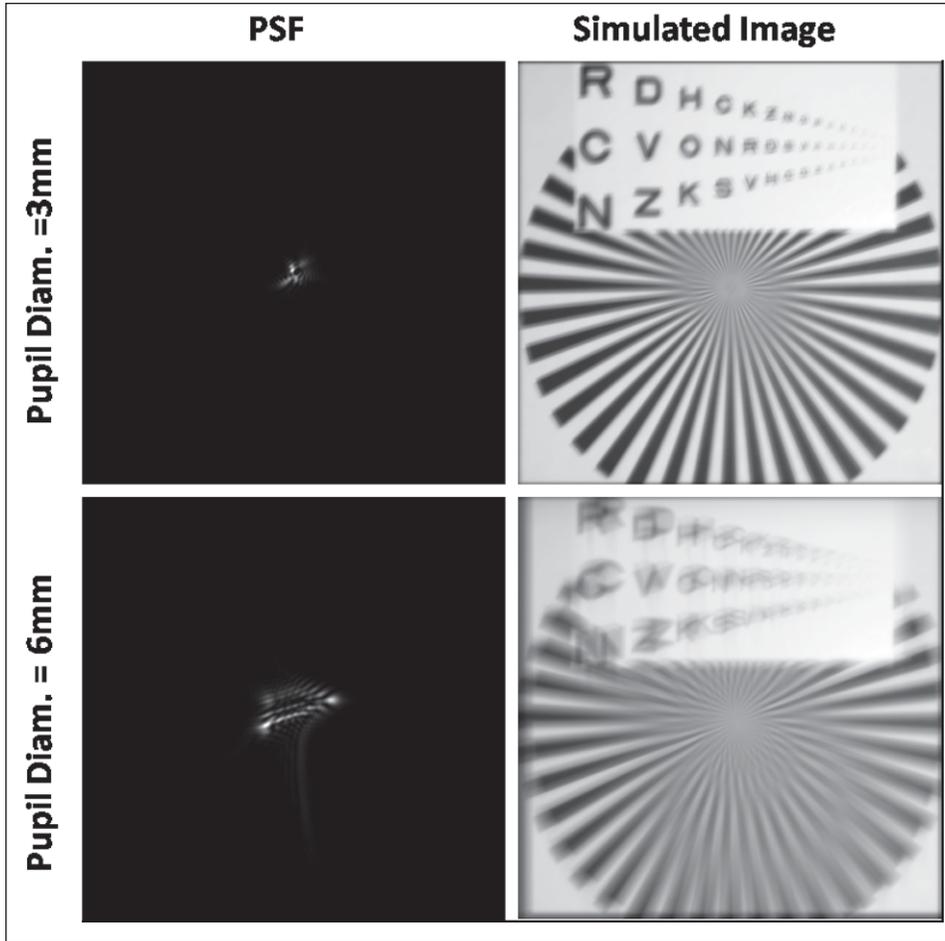


Figure 2. Point spread function (PSF) computed from the wavefront maps under the corresponding pupil diameters and simulation of the retinal image of an object-test seen through the corresponding PSFs. The incidence of the diplopia is evident on the simulated image under the 6-mm pupil.

imaging provides additional information, as it shows the pupil plane back-illuminated by the point source generated on the fundus of the eye. Therefore, this image can reveal the existence of inhomogeneities in the eye media, which would be noticeable as changes of the relative absorption among different areas of the pupil.

Bour and Apkarian⁹ showed that a slight degree of segmented refraction, which can be caused by the presence of irregular aberrations, could induce diplopia. In this case, the existence of the mentioned inhomogeneous area in the upper pupil affected the measured wavefront aberrations. To emphasize the effect of this higher order aberration pattern on the retinal image of the patient, we computed the retinal images of an object-test as was first suggested by Artal.¹⁰ The direct visualization of these images approaches the answer of how the vision of the patient was being affected by the optical inhomogeneity observed in the Hartmann-Shack images (see Fig 2). We used an object-test composed by a letter chart and a starburst test. The retinal image of this object-test for the larger pupil clearly reveals the existence of the diplopia. The direct visualization of these images resolves the diagnosis because

it makes evident that the vertical diplopia responds to the changes on the higher order aberration pattern due to the existence of this optically inhomogeneous area. The dependence of the double vision with the pupil diameter is also explained. The diplopia becomes evident only for the 6-mm pupil diameter because the responsible inhomogeneous area is localized in the upper part of the crystalline lens, which does not affect vision when the pupil diameter is smaller.

AUTHOR CONTRIBUTIONS

Study concept and design (G.M.P., J.M.M., P.A.); data collection (G.M.P., S.A., A.C., J.M.M., P.A.); analysis and interpretation of data (G.M.P., S.A., A.C., J.M.M., P.A.); drafting of the manuscript (G.M.P., S.A., A.C., J.M.M., P.A.); critical revision of the manuscript (G.M.P., S.A., A.C., J.M.M., P.A.); obtained funding (P.A.); administrative, technical, or material support (J.M.M., P.A.)

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