The Intersection of Optics and Neuro-Ophthalmology: The Enigma of Pseudophakic Dysphotopsia

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There is an expression "all that glitters is not gold." Disturbing glittering sensations of light following cataract surgery may actually originate from the intraocular lens (IOL). Visual complaints of "glittering" following cataract surgery have been the subject of numerous reports linking the cause to the optic edge design, material and shape of the IOL. Glittering (or shimmering) sensations and disturbing secondary images of light, producing rings, arcs, and central flashes, are commonly referred to as positive dysphotopsia as incoming light is internally reflected by the squared edges of the implant and projected onto the retinal surface. Off axis light striking the temporal cornea projects onto the nasal edge of the IOL and can create secondary images and disabling glare under scotopic conditions (1,2). Distinguishing the etiology of abnormal visual sensations derived from complex optical aberrations induced by the edge of the IOL from those visual symptoms produced by neurological pathology creates an interesting intersection of commonality between the anterior segment ophthalmic surgeon and the neuro-ophthalmologist.

CASE 1

A 57-year-old man had cataract surgery on the left eye. Immediately postoperatively, he complained of seeing a double broken circle with dots around it most of the time and secondary image. Light projected
F1 from the temporal field produced a secondary image nasally (Fig. 1A). Symptoms were worse at night when viewing a light source (Fig. 1B). The patient refused surgery in the opposite eye until the problem glare and secondary images was resolved in the left eye. A dilated examination was performed and appeared unremarkable. The patient was offered a second opinion with neuro-ophthalmology. Multiple tests were performed, including automated visual fields, macular optical coherence tomography, and multifocal electroretinography. All testing was normal. The patient was referred to another anterior segment specialist and an IOL exchange was performed with the insertion of an IOL with a round edge optic. Immediately following the IOL exchange, the quality of the symptoms improved slightly but his complaints have not totally resolved.

Visual dysfunction following implantation of an IOL after cataract surgery may also be manifested as a negative dysphotopsia. First described over 10 years ago (3), negative dysphotopsia appears as a tem-
F2 poral, dark, crescent-shaped shadow following in-the-bag posterior chamber IOL implantation (Fig. 2). Negative dysphotopsias have been linked to the square edge design of the IOL optic, shape of the IOL, high index of refraction, and the anterior capsule extending over the edge of the optic (1,2,4–7). Square truncated edges on many IOLs, originally designed to reduce posterior capsule opacification, may be the source of both positive and negative dysphotopsias. Negative pseudophakic dysphotopsias are caused by the absence of light in the extreme temporal field from the edge of the IOL causing a crescent shadow on the nasal retina where light would normally be transmitted by the crystalline lens of a phakic eye. Although articles demonstrating the crescent-shaped shadow with ray tracing studies are available and the clinical appearance of these symptoms has corresponded to the introduction of square edges, the topic is still debated (4,7). The circular IOL optic accounts for the crescent shape seen in positive and negative dysphotopsias.

Pseudophakic dysphotopsias are generally considered to be an annoyance of little functional significance. However, many patients become functionally or psychologically disabled from their

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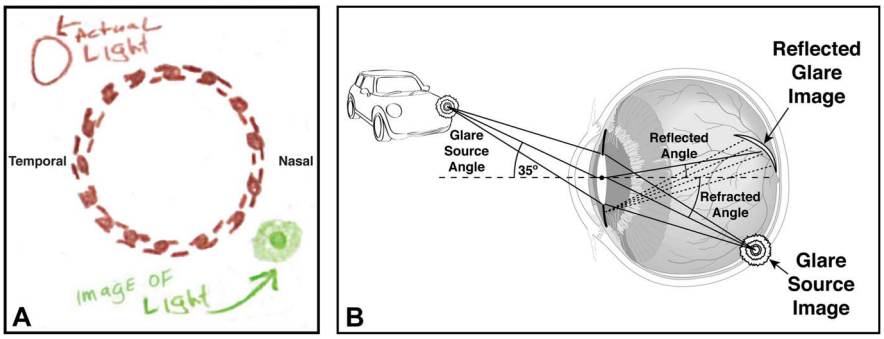

FIG. 1. Positive dysphotopsia. **A**. Patient drawing depicts a ring and secondary image (image of light) generated by a light source located at approximately 35° in the temporal visual field at a distance of 33 cm. The ring is probably produced from the edges of the intraocular lens. **B**. A glare source viewed by a pseudophakic eye will produce refracted and reflected images if light rays are able to reflect internally from the edge of the lens. The reflected glare imaged will appear as a thin crescent or partial ring on the side of the retina opposite the glare source [modified from Ref. (1)]. Adaptations are themselves works protected by copyright. So in order to publish this adaptation, authorization must be obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.

symptoms. These symptoms have a clear impact on daily visual function and generate the "unhappy 20/20 patient." It is not uncommon that many of these patients seek second opinions from other ophthalmologists and in fact may be referred to a neuro-ophthalmologist for extensive evaluation to rule out neurologic causes of their complaints. The differential diagnosis of pseudophakic dysphotopsias may include a host of neurological conditions with symptoms, including visual field loss, halos, flashes, and entoptic phenomenon such as visual auras, scintillations, and visual hallucinations.

Krista et al (8) reported in a study of normal pseudophakic patients without confounding ophthalmic diseases and with excellent visual acuity that a visual function questionnaire correlated strongly with patient dissatisfaction from pseudophakic dysphotopsia. This study revealed

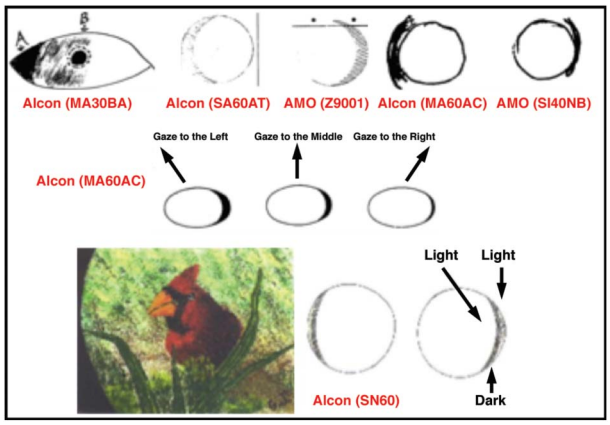

FIG. 2. Patient drawings of a variety of negative dysphotopsias and the model of intraocular lens implanted in each patient [modified from Ref. (1)]. Adaptations are themselves works protected by copyright. So in order to publish this adaptation, authorization must be obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.

that subjective visual function may indeed be compromised because of pseudophakic dysphotopsias in otherwise normal 20/20 pseudophakic eyes. Not only is vision of 20/20 considered normal but also the entire ophthalmic examination of the eye may appear to be normal. This places an increased burden on the ophthalmologist when examining symptomatic patients to correctly diagnose the symptoms because there are no objective tests to measure the severity of pseudophakic dysphotopsias. AU4

Despite bitter complaints about their vision, it is not uncommon for patients who easily read the 20/20 line on a Snellen acuity chart following cataract surgery to be told there is nothing wrong with their eye or their vision. Ophthalmologists may advise patients that their symptoms will disappear over time, suggesting neural adaption may suppress the severity of their awareness of their symptoms. Osher (9) reported negative dysphotopsias in 15.2% on the first postoperative day, 3.2% at 1 year, and 2.4% at 2–3 years. In contrast, after being told there is nothing wrong with their eyes, some patients may go years living with their symptoms without complaining.

An IOL exchange from a truncated edge design to a rounded edge design may relieve symptoms of patients with positive dysphotopsias. Several reports have demonstrated relief of symptoms from negative dysphotopsias following YAG laser of the anterior capsule (10,11), IOL exchange with a sulcus fixated IOL (12,13) or prolapsing the optic through the capsulorhexis into the anterior capsule (reverse optic capture), and piggyback IOL implantation into the ciliary sulcus (14).

CASE 2

A 71-year-old woman underwent uneventful phacoemulsification with IOLs in both eyes. Since surgery, she described a temporal "dark ring around both eyes" producing

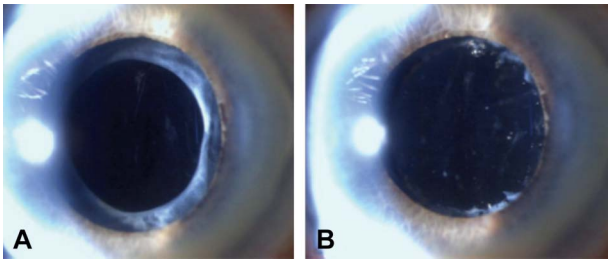

FIG. 3. Patient with negative dysphotopsia. **A**. There is fibrosis and opacification of the anterior capsule around the intraocular lens in the left eye. **B**. Following YAG laser anterior capsulotomy, the patient's symptoms resolved.

a sensation that she could not see and that she was going to step into a hole when she walked. She described "blinders and a dark spot" on the side of her vision as if she was looking through binoculars all of the time. Her symptoms were dismissed by 2 ophthalmologists and she was re-evaluated 8 months later. Visual acuity was 20/20 and J1 in each eye. On examination, there was extensive fibrosis of the anterior (not posterior) capsule extending over the anterior optic of the IOL by several millimeters. Bilateral YAG laser was performed to the anterior capsule allowing light to pass through the periphery of the lens optic, relieving the patient of her symptoms (Fig. 3). F3

In addition to the positive and negative dysphotopsias discussed above, there is another visual dysfunction commonly seen after cataract surgery following implantation of a multifocal IOL. Multifocal IOL intolerance not uncommonly results in patient dissatisfaction with the quality of vision despite having 20/20 eye in each eye. Referred to as "waxy" or "vaseline" vision, these patients may bitterly complain that they are unable to see clearly despite being able to read 20/20 high-contrast Snellen acuity. Concentric diffractive rings in multifocal IOLs create 2 simultaneous focal points and increase light scatter, resulting in reduced retinal image contrast. If the cornea has significant aberrations (>0.5 μm over a 6-mm zone) and is combined with the reduced retinal image contrast from the multifocal IOL, the result is poor quality of vision. Excessive corneal higher order aberrations of the Zernikie third-order and fourth-order (Z_3 + Z_4) terms have been statistically and clinically linked to multifocal lens intolerance and visual dysfunction (15). Light sources may also produce the presence of a halo (the simultaneously defocused image). Treatment options include refractive surgery to eliminate corneal higher order aberrations with limited success or an IOL exchange with a monofocal IOL.

The critical issue in arriving at the correct diagnosis of visual dysphotopsia is the temporal relationship of symptomatic onset after cataract surgery. Many patients complaining of undesired visual disturbances following cataract surgery may seek secondary and tertiary referrals for relief of their symptoms. 20/20 vision and a normal eye examination may pose a conundrum to the clinician to resolve these visual symptoms. All that glittering may not be gold, but it may be pseudophakic dysphotopsias.

REFERENCES

1. **Holladay JT,** Zhao H, Reisin CR. Negative dysphotopsia: the enigmatic penumbra. J Cataract Refract Surg. 2012;38:1251–1265.
2. **Holladay JT,** Lang A, Portney V. Analysis of edge glare phenomenon in intraocular lens designs. J Cataract Refract Surg. 1999;25:748–752.
3. **Davison JA**. Positive and negative dysphotopsia in patients with acrylic intraocular lenses. J Cataract Refract Surg. 2000;26:1346–1355.
4. **Holladay JT**. Reply: etiology of negative dysphotopsia. J Cataract Refract Surg. 2013;39:486.e1–486.e4.
5. **Trattler WB,** Whitsett JC, Simone PA. Negative dysphotopsia after intraocular lens implantation irrespective of design and material. J Cataract Refract Surg. 2005;31:841–845.
6. **Welch NR,** Gregori N, Zabriskie N, Olson RJ. Satisfaction and dysphotopsia in the pseudophakic patient. Can J Ophthalmol. 2010;45:140–143.
7. **Hong X,** Liu Y, Karakelle M, Masket S, Fram NR. Ray-tracing optical modeling of negative dysphotopsia. J Biomed Opt. 2011;16:125001.
8. **Krista K,** Jarstad A, Olson RJ. Correlation of visual quality with satisfaction and junction in a normal cohort of pseudophakic patients. J Cataract Refract Surg. 2013;39:590–597.
9. **Osher RH**. Negative dysphotopsia: a long-term study and possible explanation for transient symptoms. J Cataract Refract Surg. 2008:34:1699–1707.
10. **Folden DV**. Neodymium:YAG laser anterior capsulectomy: surgical option in the management of negative dysphotopsia. J Cataract Refract Surg. 2013;39:1110–1115.
11. **Cooke DL,** Kasko S, Platt LO. Resolution of negative dysphotopsia after laser anterior capsulotomy. J Cataract Refract Surg. 2013;39:1107–1109.
12. **Burke TR,** Benjamin L. Sulcus-fixated intraocular lens implantation for the management of negative dysphotopsia. J Cataract Refract Surg. 2015;41:478–479.
13. **Vámosi P,** Csákány B, Németh J. Intraocular lens exchange in patients with negative dysphotopsia symptoms. J Cataract Refract Surg. 2010;36:418–424.
14. **Masket S,** Fram NR. Pseudophakic negative dysphotopsia: surgical management and new theory of etiology. J Cataract Refract Surg. 2011;37:1199–1207.
15. **Michelson MA,** Myer RA. Corneal higher-order aberrations and visual dysfunction with multifocal IOLs. Paper presented at: American Society of Cataract and Refractive Surgery; April, 2012; Chicago, IL. AU5