A 68-year-old patient came to our clinic diagnosed with bilateral cataracts. Her medical history included diabetes mellitus on oral anti-diabetics. On ophthalmological examination, her distance corrected visual acuity (DCVA) in the right eye (OD) was (+2.75 −0.5 × 90 = 0.7), and in the left eye (OS) was (+3.00 D = 0.6). Anterior biomicroscopy revealed clear corneas, deep anterior chamber depth, and cataract OD: N3 C3 P4 and OS N4 C3 P4 (LOCS III). Intraocular pressure (IOP) in OD was 15 mmHg and in OS was 13 mmHg. Fundoscopy was normal in both eyes, with cup-to-disc ratio 0.4 in both eyes. In view of the clinical situation, cataract surgery was indicated with multifocal intraocular lens (MIOL) implantation in both eyes. The surgeries were performed sequentially one week apart, using standard ultrasound phacoemulsification with a 2.2 mm incision. There were no intra- or perioperative complications. The implant chosen was a hydrophobic acrylic non-apodized diffractive bifocal aspheric IOL, C-loop monoblock design, with near addition of +3.25 plano lens. The implant had a power of +24.0 diopters (D) in the OD and +24.5 D in the OS. There were no post-operative complications, and 3 months later the patient had spectacle corrected distance visual acuity (SCVA) of 1 (−0.25 −0. 5 × 160) in the OD and 1 (Plano −0.25 × 25) in the OS. She complained of nocturnal halos, but in particular of peripheral scotoma in the temporal visual fields of both eyes. The scotomas were dark, fixed and arc-shaped, and were more noticeable in photopic conditions. The biomicroscopy image at 3 months is shown in Figure 1; the visual field results are shown in Figure 2.

What is the most likely diagnosis?  
Differential diagnosis  
Why does it occur? Are there predisposing factors?  
Would you perform any further tests to confirm the diagnosis? If so, what would they add?  
How can it be prevented?  
How is it treated? Personal experience

This is a patient who underwent uncomplicated bilateral cataract surgery, who is now complaining of two types of post-operative symptoms. The first of these is nighttime halos, which are typical and present to a greater or lesser degree with all diffractive multifocal lenses. They are generally well tolerated in patients who have been previously warned about this possibility, and rarely require exchange for a monofocal lens, the only option to correct them.

The other symptom is consistent with negative dysphotopsias, a term coined by Davison. These refer to the perception by the patient of a dark shadow in the temporal field following uncomplicated phacoemulsification with an in-the-bag lens implant. They typically worsen in photopic conditions. They are rare, between 0.2% and 2.4%, but very bothersome for the patient due to their persistence.

The cause of this phenomenon has not been fully elucidated, and is probably multifactorial: the patient’s anatomical characteristics, type of material and index of refraction of the intraocular lens (IOL), square-edged lens, reflectivity of the lens surface, distance between the margin of the pupil and the anterior surface of the lens, and reflection between the capsulorhexis margin and the anterior surface of the lens.

Figure 1. Slit lamp biomicroscopy. Right eye (top) and left eye (bottom)
No predisposing factors have been demonstrated, and the only common factor is their appearance after uneventful phacoemulsification with lens implanted in the bag, with edges covered by the capsulorhexis. Although it has been suggested that it occurs more often with square-edged acrylic lenses, in fact it has been described with all types of lenses, but only when they are implanted in the bag.

This phenomenon appears in the first three days post-surgery, and the diagnosis is established by the patient’s description of the symptoms after uneventful surgery. Further tests do not add anything to the diagnosis, although ultrasound biomicroscopy (UBM) of the anterior segment may show an increased distance between pupil and lens.

Although it is a very obvious symptom that can alarm the patient, it is advisable to keep them under observation for at least 3 to 6 months. An improvement in symptoms has been described, with resolution of the incisional edema in temporal clear cornea incisions. Anterior capsule opacification is another factor that has been presented as a possible cause of spontaneous improvement. Finally, there is a certain degree of “neuroadaptation” by the patient.

Brimonidine eye drops may be applied during the observation period, but their efficacy is very limited. If the symptoms persist for more than 3-6 months, surgical treatment can be assessed. The recommendation would be IOL exchange for a three-piece multifocal lens implanted in the sulcus. It would be advisable to perform endothelial microscopy to ensure that the endothelium is not damaged, and to thoroughly discuss possible complications derived from a lens exchange with the patient, including loss of corrected visual acuity. A lower risk alternative would be reverse optic capture through the capsulorhexis. In any case, it is important not to perform YAG posterior capsulotomy previously, which would not improve symptoms and could complicate lens exchange.

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Jorge Castanera, MD
Barcelona, Spain
This is a typical case of predominantly negative dysphotopsia. Negative dysphotopsia, as reported by this patient, consists of the visual perception of a dark shadow in the temporal visual field after uneventful cataract surgery and in-the-bag intraocular lens (IOL) implantation. It can be disabling for some patients and the risk increases threefold with multifocal compared to monofocal IOLs. The patient also complains of some positive dysphotopsia, a disturbance of vision that includes light phenomena such as halos. Thus, overall, this patient suffers from pseudophakic dysphotopsia.

Although the patient’s presentation is quite self-explanatory, any loss of a temporal crescent in the visual field can occur with diseases involving the peripheral retina or optic nerve sheath, meningeval diseases, and anterior infarction of the contralateral primary visual cortex (absolute crescentic defects are strongly suggestive of an anterior V1 infarct from occlusion of a branch of the distal posterior cerebral artery). If the peripheral field loss is symmetrical, it is characteristic of vigabatrin (anti-epileptic medication) toxicity, but it is also seen with fatigue. Lastly, positive dysphotopsia can be included in the differential diagnosis of light flashes, which can be broken down into three basic mechanisms that alter the retina: mechanical, inflammatory or vascular. However, when the presentation is bilateral, one should think of vascular effects on the cerebral cortex (migraine), medication-related side effects (digitalis, quetiapine, paclitaxel, quinine, and quinidine among others), and bilateral retinopathies (hereditary tapetoretinal degenerations and paraneoplastic autoimmune retinopathies).

Negative dysphotopsia only occurs with “lens in the bag” and is thought to be mainly related to the square-edge shape of the implanted IOL. However, a patient can still have negative dysphotopsia even if a round-edged IOL is implanted, due to light coming into the pupil from the temporal field of vision. When light hits the square edge of the IOL on the nasal side of the optic, the edge acts like a plano mirror, reflecting light off it. This light then bounces back to the temporal side of the retina, causing one of several positive dysphotopsias, and cannot pass through the edge to illuminate a patch of nasal retina, thus casting an arc-shaped shadow over the area.

Although there is no strong evidence, it seems to occur more in women in their 50s, and the pattern is an observant patient with a more technical and engineer-like profile. Conversely, it has never been described in extremely short eyes (highly hyperopic or children) and negative dysphotopsia has never been reported in a sulcus-placed lens or with an anterior chamber lens.

Since negative dysphotopsia may fade away, either because of neuroadaptation or because of epithelial cell growth at the IOL edge, it is wise to wait a minimum of 3 months, but ideally 6 months to a year, before attempting anything surgically. During that period, having the patient wear thick-framed glasses might alleviate the symptoms.

Treatment consists ultimately of reverse optic capture (ROC); although the patient must be taken back to the operating theater, it does not require IOL exchange or addition, and can be a definitive solution to resolve the problem. In my experience, IOL exchange with another C-loop IOL is not as useful as ROC in these cases. However, a plate haptic IOL oriented horizontally may be a very good choice since the optic is continuous with the haptic, so there is no longer a lens edge to cause the problem. Some success has also been reported by inserting a “piggyback” IOL.

The ROC technique entails making two opposite paracenteses: one to grab the capsulorhexis edge (ideally with a micrograsp forceps) and the other to enter either a Sinsky hook or a viscoelastic (cohesive) cannula to separate the IOL optic from the anterior capsulorhexis. In addition, if the haptic-optic junctions are located on the horizontal meridian, rotating the lens clockwise 90 degrees apart (so that they become placed on the vertical meridian) is also helpful. The latter makes the reverse optic capture more efficient towards the nasal and temporal areas. The optic edge is finally placed over the capsulorhexis edge so that it approaches a plane that is closer to the back of the iris and thus, the undesirable “optic edge phenomena” diminishes or completely disappears.

Miguel Maldonado, MD
Valladolid, Spain

The symptoms and clinical data appear to indicate that the patient has pseudophakic negative dysphotopsia. The term dysphotopsia describes any ectopic phenomena triggered by light (glare, halos, arcs or half-moons) that take place in pseudophakic patients and cause discomfort, distress and dissatisfaction, even when they have excellent visual acuity. These dysphotopic phenomena can be divided according to their form of presentation into positive and negative dysphotopsias. The term “positive dysphotopsias” refers to brightness, streaks or rays around a central point source of light, creating diffusion, halos and glare. In contrast, negative dysphotopsias are characterized by the presence of an arc-shaped shadow, generally located in the temporal field of vision. Both types of dysphotopsias can occur with multifocal or multifocal lenses, although they are more common in the latter case.

Negative pseudophakic dysphotopsia is an undesirable visual phenomenon which, although its causes have not been fully established, appears to be related with the design of some intraocular lens. This seems to occur particularly with the truncated or square edge of some lenses, which reflect the incident light on the straight edge to over 30 degrees on the nasal retina, causing stimulation of the unpaired temporal crescent. The squared edge of the intraocular lens acts as a barrier to cell migration within the posterior capsule, making its opacification difficult, but unfortunately it also causes this undesirable visual phenomenon, a result of the
internal reflection by incident light obliquely, reported by the patient as a shadow or darkness in the form of a half-moon or arc in the temporal field. Other factors that can influence its onset are a high index of refraction of the lens material, a large distance between the posterior side of the iris and the anterior side of the IOL, more anterior location of the ora serrata and therefore the functional nasal retina, and nasal location of the pupil.

This entoptic phenomenon is independent of the degree of visual acuity, the state of the visual field and the presence (or not) of associated ophthalmological conditions, so it is impossible to predict which patients will develop these symptoms. Negative dysphotopsias can be perceived both with and without optical correction, and affect distance and near vision equally. They can be binocular or affect one eye only, and present inside and outside, in good lighting or in darkness. They appear early in the post-operative period, and sometimes disappear in the early weeks or months, but in other cases they persist. In this latter case, some patients eventually become accustomed to it, while others do not. Automated visual field tests cannot show the defect, as the scotoma is not seen on perimetry.

The incidence of these types of disturbances is greater when multifocal lenses are implanted, especially if they are acrylic, since the high material index of refraction can also have an effect in this phenomenon, affecting up to 25% of patients in some series. The predominance of this dysphotopic phenomenon in diffractive multifocal IOLs seems to be because the concentric rings of the lens diffract or redirect the incoming light in a way similar to the square edge already mentioned. The likelihood of these disturbances occurring in patients with these types of implants probably depends on individual predisposition associated with a host of factors related with the eye anatomy, corneal curvature, the new pseudophakic state, anterior chamber depth, axial length and power of the IOL.

Management of these situations will depend on the severity of symptoms and on the patient’s personality and circumstances. It is first necessary to confirm that no organic factors (residual refractive defect, alteration in the ocular surface, lens centering, position and size of the pupil, state of the lens and posterior capsule) could be affecting the optical performance of the lens. Once these have been ruled out and the visual phenomena attributed to the presence and design of the multifocal lens, it is recommended to wait a while until the patient adapts to their new optical situation. It is common for symptoms to disappear within 6 months. Neuroadaptation and the fact that constant, repetitive visual stimuli unconsciously end up being suppressed, together with the dedication and time that should be accorded to the patient, explaining the situation and benefits of the implanted lens to them, eventually play an important role in their tolerance. During this time, events may also appear that help the symptoms to fade, such as capsular contraction, which may reduce the dysphotopsia by slightly shifting the optics of the lens to the iris plane, or the opacification of the nasal sector of the anterior capsule weeks or months after the surgery. We can also look at whether the dysphotopsias improve with pupillary contraction, and if so, try miotic treatment. However, it is usually relatively ineffective, among other reasons because negative dysphotopsias seem to have more to do with small pupils than with large ones.

If the patient still remains dissatisfied or intolerant after a reasonable time, the possibility of explantation of the multifocal IOL should be proposed, replacing it with an IOL of a different design and material (silicone or PMMA), probably monofocal, always bearing in mind two aspects: do not perform early posterior capsulotomy with NdYag laser in an attempt to improve tolerance if there is not complete certainty that the state of the capsule could be responsible (it generally does not alleviate the symptoms), and do not delay the explantation excessively, so that the fibrosis and capsular fusion do not make it difficult to both extract the multifocal IOL and perform in-the-bag implantation of the new IOL. Always performing capsulorhexis that overlaps the optics of the IOL by 0.25-0.50 mm not only reduces the possibility of onset of some dysphotopsias, but facilitates subsequent maneuvers for dissection of the capsular bag, explantation of the IOL and in-the-bag implantation of a new one. The possibility has also been raised, instead of explanting the multifocal lens, of luxating it to the sulcus or performing a secondary piggyback in the sulcus, seeking the aforementioned effect of bringing the diffractive optic closer to the posterior side of the iris.

Prism adaptation as an effective therapeutic alternative in the treatment of negative dysphotopsias has recently been described, based on the fact that the use of prisms is usually of great help in the treatment of homonymous visual field defects. The reduction in the dysphotopic phenomenon was achieved with a prismatic value between 1 and 6 diopters (most patients with only 2 diopters) for distance vision, divided in bilateral cases between both eyes (half of the prismatic power for each eye), and only in the affected eye in monocular cases. Symptoms decreased in all patients with this correction. The explanation could lie in reorientation of the field, a shift in the dysphotopic phenomenon, or an improvement in the cortical adaptation.

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In this case, we must first differentiate the existence of photic phenomena (halos), which depend on the type of patient (pupillometry, eye surface) and the type of intraocular lens (IOL) (common in all diffractive lenses in the early months post-surgery), from the presence of negative dysphotopsia, which is what concerns us in this case.

The presence of a negative dysphotopsia (“a dark spot in the temporal field of vision”), which is what has happened in this case, moreover in a patient with “perfect” cataract surgery, is to begin with, very frustrating, both for the ophthalmologist and for the patient. This is as much because of precise lack of knowledge of its origin as for the multitude of different treatments proposed.

Weinstein\(^1\) published a list of 32 IOL explants for negative dysphotopsia (ND) symptoms, the vast majority of them square-edged hydrophobic acrylic lenses, almost all SN60WF IOL (ALCON), although it is true that other types of material and designs have also subsequently been involved. Holladay\(^2\) performed ray-tracing studies, showing that negative dysphotopsias have a relationship particularly with increased iris-IOL distance, IOLs with a high index of refraction and IOLs with smaller optics than normal. He also concluded that in the origin of negative dysphotopsias, more so than the increased iris-IOL distance, what really seems to be crucial is the presence of clear anterior capsular remains in the nasal sector of the IOL, which allows the formation of a dark spot (formed between the anterior side of the IOL and posterior vertex of the square edge) in the temporal sector of the retina, if this is functional. When the anterior capsule is no longer clear, the produced beam scatters and suppresses the dysphotopic image; this also occurs with the onset of posterior capsule opacification (PCO) and with anterior movement of the IOL due to capsular contraction.

Thus, the incidence of ND usually falls over time in accordance with the disappearance of the capsular transparency, as well as due to cerebral adaptation in many cases: 15% on the first postoperative day, 3.2% after one year and 2% after 3 years.

The treatment proposed is as follows, from lower to higher magnitude\(^3\):
- Anterior capsulectomy with YAG laser, from 1 to 6 o’clock in the nasal sector, which has a 50% cure rate according to Holladay\(^2\).
- Reverse optic capture (pass the optic in front of the capsulorhexis, leaving the haptics in the bag), proposed by Masket\(^3\).
- Sulcus placement of a secondary piggyback zero power IOL, the most widely used treatment in our experience, consistent with the effect produced: it minimizes the space between the iris and IOL.
- Explantation-exchange for a rounded-edge silicone IOL, which also has a lower refraction index, with which Weinstein obtained 90% resolution in his cases\(^1\).

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Javier Pascual, MD
Xátiva, Spain

The diagnosis in this case report is that of a ghost image secondary to an intraocular implant as characterized by the data provided, the absence of any other disease, and by the “almost” perfect and bilateral symmetry of symptoms.

The presence of optical phenomena in the use of optical additions in cataract surgery is nothing new. Before the advent of intraocular lenses (IOL), after in toto or extracapsular removal of the crystalline lens, we had to correct the ammetropia that resulted in most cases (except in pathological myopes) with high power lens, from +12 to +16D. This produced major optical aberrations and phenomena such as the so-called “Jacks-into-the-box”, which consisted of the disappearance of...
objects and images (sometimes considerably large) from the field of vision, with their subsequent reappearance with minimal changes in the axis of observation. This situation was due to the prismatic effect of these lenses when the transferred image was far away from the axial axis, resulting in an authentic negative scotoma (not perceived by the patient). This and other aberrative phenomena disappeared with the introduction of aphakic contact lenses, and have not been observed for many years now with the implantation of today's IOLs. Nevertheless, with new things come new experiences, not all of which are welcome.

Current IOLs have had a square-edged design to reduce cell migration for about 12 years. When the light hits axially or laterally, the result is an image on the retina, more or less sharp, but if the incidence is very lateral or the light is very intense, a phenomenon of internal reflection between the anterior and posterior sides of the lens occurs, until it reaches the edge of the lens; the subsequent visualization of this is perceived by the patient as a scotoma, in this case positive, unlike the one previously described (scattering). This phenomenon may be intensified by the prismatic diffraction of the rings of the diffractive lens and increases in high-power lenses. Patients with plate lenses do not usually describe this phenomenon, and if they do so, it is to a lesser extent. But why does a temporal and not a nasal or circular scotoma appear? The answer is simple: the orbital protection and presence of the nose mean that the incidence of very lateralized rays is smaller, so that this phenomenon does not occur in the nasal field of vision.

Would you perform any further tests to confirm the diagnosis? If so, what would they add?

When we have this clinical situation, it is important to focus on the anamnesis to confirm when it presents, in what circumstances, if it is always bilateral synchronically, etc. I do not consider it appropriate to perform further tests, except in the visual field (which has already been done) and the fundoscopy examination to check for the very rare presence of an alteration in the optic nerve or in the peripheral retina in a manner as similar and symmetrical. The problem with this clinical picture is that we cannot predict which patients will present it, but those with large pupils in photopic/mesopic conditions have a higher risk (in the case discussed it seems to present). The occupational factor is extremely important, the work station, lighting or light requirements, working with indirect artificial light, the open air, medium hyperopic and alpha patients present it more often.

The best treatment is to explain to the patient what is happening and why. In most cases, a correct explanation reduces anxiety and results in these phenomena eventually being assimilated by the patient. It also causes the intermittent positive relative scotoma to become negative by a process similar to that of neuroadaptation of diffractive multifocal lenses. In those cases in which I have already operated on one eye, and the patient has described this in the post-operative period, I try to position the lens of the contralateral eye horizontally and combine a capsular tension ring. I perform a somewhat smaller rhexis, and I am extremely careful not to touch or damage the iris sphincter. If it is possible, and I have implanted a lens with loops in the first eye, I use a plate lens positioned horizontally in the bag. It is not very effective, but in astigmatic surgeries and with the 2.2-mm entry that was made in the main incision in this case, it would not be a bad idea to place the lens at 4 o’clock. With these indications and maneuvers I have managed to resolve all my cases but an additional measure that can be applied is to instill 0.4% pilocarpine eye drops in an artificial teardrop, to be applied in the conditions and situations that the patient knows beforehand will cause discomfort. It is more likely, however, that they will end up abandoning treatment and become accustomed to this not serious, but not so uncommon problem.

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José Luis Rodríguez-Prats, MD
Alicante, Spain