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# Pseudophakic Dysphotopsia

*Emely Zoraida Karam Aguilar*

## Abstract

Pseudophakic dysphotopsia is an unwanted entoptic phenomenon caused by intraocular lenses. Dysphotopsias have been classified as positive (brightness, streaks, haze, or glare) and negative (temporal arc or half-moon crescent) in the visual field. These visual phenomena seem to be well tolerated cause in the case of positive dysphotopsia, but not as well in the negative cases that sometimes discomfort to the patient. The incidence of dysphotopsia ranges from 20% to 77.7%, and the prevalence seems not to be altered by the type of intraocular lens. Pseudophakic dysphotopsia continues to be enigmatic over time; however, many efforts are being made in order to resolve the mystery. In this chapter, the evolution of the dysphotopsia, possible causes, and proposed treatments will be described.

**Keywords:** pseudophakic dysphotopsia, negative dysphotopsia, positive dysphotopsia, dysphotopsia, half-moon crescent

## 1. Introduction

Cataract surgery has been one of the great ophthalmological contributions to the worldwide prevention and treatment of blindness.

The first cataract surgery was performed by an Indian surgeon, Sushruta, in the fifth century BC. [1–3]. Over time, improvements in cataract surgery led to many advances, such as the replacement of the opaque crystalline lens with an intraocular lens (IOL). The first IOL implant was performed by Sir Harold Ridley on November 29, 1949, at St. Thomas Hospital, London [4, 5]. Thanks to the contributions of many scientists and surgeons, techniques improved as well as IOL design. However, with the use of new technologies, complications or unwanted side effects may also arise. Dysphotopsia secondary to IOL [6, 7], is the reason for this chapter.

## 2. Pseudophakic dysphotopsia

Dysphotopsias are visual phenomena caused by light in phakic and pseudophakic patients. The term was introduced by Tester et al. [6] in the year 2000, and included all entoptic phenomena triggered by light (glare, halos, and dark arc). These phenomena frequently bother the patient, producing a certain degree of dissatisfaction, even in circumstances where there is good visual acuity (20/20 or better).

Dysphotopsia in phakic patients may improve with correction of the refractive error [8], special lenses [9], sunglasses [10], lenses with filters [11] and other techniques. In patients with significant cataracts, surgery is the option [6].

Before the advent of IOLs, aphakic patients (without IOL) who were placed in contact lenses reported glare phenomena [11]. The first report was by Koetting and Von Gunten in 1969 [12]. Subsequently, with the emergence of IOLs, patients with pseudophakia began to experience visual phenomena more emphatically than they did before surgery [13]. However, the benefit of improvement in visual acuity generally compensated for problems with dysphotopsia. A number of clinicians and researchers have tried to determine the causes of dysphotopsia [13].

Initial reports considered causes including the pupil, the intraocular lens, and the posterior capsule. This is reflected in one of the initial publications by Doden in 1984 [14]. This author studied the pupillary changes observed in 2500 eyes operated on cataract by extra capsular technique and phacoemulsification. He associated glare with the optical irregularity caused by the pseudophakia “per-se” or the opacities affecting the posterior capsule. Subsequently, sophisticated techniques were employed, refining the studies and reducing the number of causative factors to IOL as well as opacity of the posterior capsule [1, 12, 13, 15].

Between 1994 and 1995, the 6 mm and 5.5 mm acrylic IOL were introduced, which allowed patients to have calm eyes in the postoperative period, that is, with less chance of developing anterior uveitis and cystoid macular edema. They also found that these lenses caused less fibrosis and opacities of the posterior capsule, with lower capsular contraction, reduction of optical precipitates, and good optical centering [16]. Based on this, it was postulated that the square edge of the intraocular lens was the primary reason for the above findings [15, 17, 18]. In the laboratory, Nishi [15] confirmed that the edge of the IOL acted as a barrier to cell migration within the posterior capsule independent of the material. Unfortunately, the edge also caused a new undesirable visual phenomenon resulting from internal reflection due to the angle of incidence of oblique light. This was often referred to by the patient as a dark shadow in a half moon shape or an arc in the temporal field. The effect was more annoying than previously reported, proving even difficult to predict which patient could develop this symptomatology [15, 17, 19, 20].

Pseudophakic dysphotopsia was presented for the first time by Olson, MD, at the XVIth Congress of the European Society of Cataract & Refractive Surgeons, in Nice, France, on September 1998 [7]. Initially, it was thought that this visual phenomenon was transitory. Overtime the visual effect persisted as a source of visual complaints, resulting in a number of procedures to attempt to reduce or solve the problem. In 2000, Davidson [7] divided these dysphotopsia phenomena according to the symptoms into positive and negative.

### **3. Dysphotopsia classification**

#### **3.1 Positive dysphotopsia**

Positive dysphotopsia refers to the brilliant, lines or = stripes that emanate from a central point of a light source sometimes creating diffusion and strong glare, described by the author as “hazy glare.”

Few reports exist regarding positive dysphotopsia. Shambhu et al. [11] used a questionnaire to compare three different types of acrylic IOLs. In this study, 15 patients with severe dysphotopsia (negative and positive) were reported, but apparently, positive dysphotopsia (particularly the glare phenomena) was not severe enough to require the change of IOL. In a study conducted by Radford et al. [21], follow-up of 61 patients with Akreos Adapt and SN60-AT intraocular lenses

found that dysphotopsia declined by 8 weeks in 31.3% for positive dysphotopsia and 20.7% for negative ones.

Recently, publications showed in vitro evaluations that IOL designs with round optic edge curvature and full functional optics demonstrated the lowest level of glare-type photic phenomena. Clinical studies are necessary to demonstrate this observation [22].

My personal opinion is that positive dysphotopsia is caused by the wavelength of light as it interacts with the pseudophakic lens. Intraocular lens still permits significant transmission between 350 and 400 nm. Most intraocular lenses provide a reasonable imitation of the spectral characteristics of the natural lens, but probably, the exact balance to the natural lens has not been achieved [23, 24].

In relation to the type of dysphotopsia, it seems that positive dysphotopsias are better tolerated than negative ones; the reason is for this unknown. That's why conservative treatment or observation is generally recommended. However, some authors recommend correcting the refractive error with conventional or contact lenses, while also treating coexisting ocular pathology such as the opacity of the posterior capsule requiring it, and intraocular lens decentralization or large pupil size [25].

Chandramani A et al. relate positive dysphotopsia with the square edge of IOL. The authors reported that a patient with previous refractive surgery and persistent positive dysphotopsia after the insertion of a square-edge IOL responded well when they inserted a zero-power 3-piece silicone IOL in the sulcus, in order to maintain the refractive efficacy of the original IOL. It was thought that the symptoms decreased because the rounded edge of the silicone optic masked the aberrant reflections and refractions of the square edge of the acrylic IOL [25].

### 3.2 Negative dysphotopsia

Negative dysphotopsia is characterized by an arc-shaped shadow, usually located in the temporal field. Visible with or without frame lenses, the problem can be monocular or binocular and may affect near and far vision as well as occur in internal or external environments (lighting or gloom), mobile or not. Negative dysphotopsia generally appears 1-2 days postoperatively. Over time, some of them disappear and in others remain.

Various approaches to negative dysphotopsia were made in search for possible solutions [7, 13, 19, 20, 26–33] as reflected below:

#### 1. Related to the intraocular lens:

- Anterior and posterior lens surface
  - Reflections associated with the anterior and posterior surface of the lens due to the high refractive index of the lens material
  - Reflections generated by the high index of the bright optical edge material
- Intraocular lens edge
  - Straight or round
- Reflections generated by the high index of the bright and straight optical edge material

- Diameter
- Number of lens parts
  - One to three pieces

2. Manufacturing:

- Optical defect during the manufacturing process
- Central optical defect during the folding process

3. Surgeon:

- Incomplete capsulorhexis with optical overlap
- Reflection of the capsulotomy of the anterior border projected into the nasal peripheral retina
- Temporal clear corneal incision

4. Patient: visual system or psychological factors:

- Complex interaction of a predisposed and vulnerable pseudophakic visual system
- Dark irises
- Prominent eyeballs
- Deep orbits
- Post negative image phenomenon
- Neural adaptation

A program with a three-dimensional model eye was used to study the edges (straight or truncated and/or round) of IOL, through an analysis of ray tracing emanating from the light. The rays that reach the straight edge cause reflection of the light at an angle greater than 30 to 40–90° or more, maximizing the intensity of the reflexes, since they reach very close to each other and reflect on the opposite side of the peripheral retina as a dark shadow described by the patients as an arch or crescent (negative dysphotopsia). At the round edges, the rays cause significant dispersion and are reflected before 30°, not causing this temporary penumbra [7, 19, 20, 33].

It was shown that the round edge decreased the image in the form of an arc (negative dysphotopsia) by 87–91% in relation to the square edge [19]. Additional evidence of absence of positive dysphotopsia phenomena (light flashes) but not negative when the edges were compared with opaque lens was also found. Lenses with textured or opaque edges as a replacement or as a primary lens in the second eye suppose a decrease in the occurrence of positive and negative dysphotopsias. This type of design (textured or opaque border) creates the same type of light scattering as the nasal periphery of the translucent capsule, reduces the internal diffusion of

light from the straight edge by scattering, but still allows the presence of positive dysphotopsia and does not make the negative ones disappear [16, 30, 34].

The opaque edges of the AcrySof SA30 IOL were compared with the bright edges in the AcrySof MA30 BA (Alcon) and AcrySof MA60BM (Alcon) intraocular lens models [7], but the negative dysphotopsia did not disappear.

The diameter of the IOL does not significantly reduce the occurrence of dysphotopsia as Davidson reported when two types of lens diameters of 5.5 and 3.60 mm were compared; the occurrence of negative dysphotopsia was similar (80%) in both groups [7].

In relation with the lens material, Tester et al. compared two types of acrylic intraocular lenses of different diameters (5.5 and 6 mm) with a control group (no acrylic IOL); the authors found that acrylic lenses produce more dysphotopsia than nonacrylic IOL. The authors concluded that patients who received an acrylic IOL with flattened edges were at increased risk of experiencing images associated with edge reflections [6]. Holladay et al. found that only the square-edged design concentrated the light into a well-formed arc on the retina. Round-edge designs tended to disperse the stray light over a much larger portion of the retina, suggesting that its visual consequences fall below a perceptible threshold [13, 19].

Radford et al. compared two types of acrylic IOL (AcrySof SN60-AT IOL (Alcon) and the Akreos Adapt (Bausch & Lomb) IOL. The results of this study showed that patients with SN60-AT IOL reported more undesired images than patients with the Akreos Adapt IOL. It was more significant during the first week postsurgery, but at 8 weeks, the incidence of this negative dysphotopsia decreased in 20.7%; the cause of this phenomenon was not clarified by the authors [21].

The anterior surface of the AcrySof MA30 BA and AcrySof MA60 BA lenses with a 5.5 D curve was studied; the remaining power was found on the posterior surface. Because these surfaces are highly reflective, it could make lenticular reflections complex enough to cause negative dysphotopsia. The optical inversion or reversion of the anterior-posterior diopter surface (posterior surface flatter than the previous one) as observed in the AcrySof MA30 AA and AcrySof SA30 AL lenses did not solve the problem [7].

The incision in the temporal area of clear cornea has been implicated by Osher [35] as a cause of transient negative dysphotopsia due to a broad clear base and incisional edema in the cornea that interferes with the oblique light projected into the distant peripheral field; however, it does not explain permanent dysphotopsia. Nasal, upper, and lower incisions and scleral tunnel showed no difference between the presence of transient and permanent negative dysphotopsia [36].

One-piece lenses in a posterior chamber with horizontally placed haptics make the edge of the lens more peripheral when the “shoulder” of the haptic is inserted into the optics; this would imply that the “shadow” would move more previously, reflecting with less amplitude, but this proposal would have to be supported by the ray tracing program [29, 37, 38].

A manufacturing defect should be evident in other intraocular lenses of the same batch used in patients, but this did not occur [7].

The central optics could be altered by folding; when folding forceps are used, an irregular line is formed temporarily, since it disappears after the operation. However, if it persists permanently, it can create defects, but they do not specifically produce negative dysphotopsia. Nowadays, with the injectors used for lens folding, no alterations have been demonstrated, even when they have been studied due to intraocular lens change [7]. Incomplete capsulorhexis with its superimposition variable is quite common; this would not explain a temporary defect of the visual field [29, 34].

Individual predisposition with a certain constellation of factors in relation to ocular anatomy, including corneal curvature, new pseudophakic state, anterior

chamber depth, axial length, and intraocular lens power, can be particularly vulnerable, also be sensitive to aberration, and produce dysphotopsia. This peculiar interaction seems to vary from patient to patient [16, 33, 38].

Of all these studies, the design of the intraocular lens, specifically the edge, proved to be the source of negative pseudophakic dysphotopsia. The explanation of this enigmatic phenomenon has not been elucidated despite so many investigations [7, 34, 38].

In 2014, the author reported that the negative dysphotopsia was caused by a stimulation of the unpaired temporary crescent or “half moon” because the incidence of rays on the edge of the intraocular lenses refracts on the peripheral nasal retina outside 30° (location area of the temporary flood). The fact that some patients have it at 30° and others between 60 and 90° would explain why some patients may present them and others not, as well as unilateral or bilateral [39].

The disappearance or transientness of the negative dysphotopsia was explained by the opacification or translucency of the nasal sector of the capsule, later acting as a diffuser of the rays, in the first week or months following the surgery. The opacity of the posterior capsule causes diffusion of light and reduces contrast and retinal sensitivity. The anterior axial movement of the intraocular lens by contraction of the capsular bag maybe is another explanation that decreases the occurrence over time, since it reduces the axial space under the iris to 0.06 mm or less, causing a myopic change that is extremely rare. However, this has not made dysphotopsia disappear [38].

In relation to a persistent visual phenomenon, possible therapeutics arise such as the use of miotics [6, 21, 23, 29] but, contrary to expectations, it increases the problem and the pharmacological dilation seems to reduce it [34], anterior and posterior capsulotomies [6, 24, 34, 39, 40], smaller capsulorhexis [6, 31, 37], modifications of the intraocular lens [11, 30, 32, 34], change of intraocular lens [6, 13, 37, 40] do not solve the problem. The placement of another intraocular lens on the primary or “piggy bag” [29, 38] and reverse optical capture of the lens [34, 38] had partial or complete resolution of symptoms. The suture of the IOL-capsule complex iris bag [38] can decrease the visual phenomenon. The author used prism in the eye of dysphotopsia causing a displacement of the temporal crescent outside the visual field, with the disappearance of symptoms [39].

Henderson et al. [40] reported a 2.3-fold decrease in negative dysphotopsia symptoms early after cataract surgery when the nasal optic-haptic junction was oriented slightly super nasally (30° from horizontal) when compared with the haptic junction being oriented vertically. Henderson hypothesized that when the haptic junction was placed vertically, it exposed the nasal optic edge to reflections from temporal light. By placing the haptic junction relatively horizontal, the junction would then “block the light,” and the intraocular lens edge reflections and the resultant temporal negative dysphotopsia shadow would be avoided.

Erie et al. [41] with a ray-tracing software demonstrated how the horizontal haptic junction minimizes negative dysphotopsia.

The incidence of dysphotopsia phenomena in pseudophakic patients after uncomplicated cataract surgery varies, ranging from 20 to 77.7%, since there are only isolated reports as can be seen in the literature [6, 11, 30, 39, 42–49]; however, the prevalence does not seem to be altered with the type of intraocular lens [28].

#### **4. Conclusions**

Pseudophakic dysphotopsia is an entoptic phenomenon induced by intraocular lenses that cause discomfort to patients. Positive dysphotopsia manifested as glare is well tolerated by patients, and negative dysphotopsia reported from the

incorporation of intraocular lenses with square edges is a source of dissatisfaction in pseudophakia patients despite good visual acuity. After evaluating the different factors that could be responsible for it from the intraocular lens, manufacturing, surgical technique, surgeon, and patient, it was concluded that the square edge of the intraocular lens is responsible for the undesirable phenomenon. Multiple therapeutics have been proposed in order to solve the problem such as the use of miotic drops, piggy back, intraocular lens replacement textured or freezing lenses, etc. without finding the appropriate therapy. Additional studies with software or intraocular lens design program on schematic eye will be necessary to solve the problem.

### **Conflict of interest**

The author declares no conflict of interest.

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