Dysphotopsia-Unraveling the Enigma

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Abstract
Dysphotopsia is an aberrant optical phenomenon occurring after the implantation of an IOL (Intra-ocular lens). It has become a common problem after an otherwise uncomplicated, successful cataract surgery. It presents as unwanted images as flashes, arcs etc. as in positive dysphotopsia (PD) and as a dark shadow or a crescent in negative dysphotopsia (ND). The etiology of the condition remains speculative, and we are still unsure about how to prevent or effectively treat this frustrating side effect of cataract surgery. Patient counselling is important in its management. In case of persistence of symptoms, the surgeon needs to intervene surgically.

Keywords: dysphotopsia, IOL, cataract surgery

Introduction
Webster’s Medical Desk Dictionary defines photopsia as subjective perception of luminous rays or flashes of light. Newell1 states that dysphotopsias are subjective visual perceptions that arise in the absence of light stimuli. But the visual disturbances experienced by patients with IOLs are not purely subjective nor do they occur in the absence of light stimuli.2 In literature, terms such as Photopsia, Entoptic or Photic phenomena have been used. Photic phenomena after PCIOL implantation was first reported by Arnold in 1994.3 Tester coined the term Dysphotopsia in June 2000.4 It has been termed as enigmatic penumbra as it is has been an enigma of cause, prevention & treatment.5 Today cataract surgery aims to deliver 6/6 snellen’s visual acuity (VA) to the patient and patient expectations are also on the rise. Dysphotopsia, virtually unknown two decades ago, has become the leading problem following uneventful, cataract surgery with clear cornea and in the bag IOL. Once the patient’s thought process becomes fixated on it, it doesn’t disappear easily. These patients seek solution from many ophthalmologists and are often told that there’s nothing wrong with the surgery. Surgeons and patients both get frustrated, as there are no dependable remedies for this problem, although in many patients the symptoms resolve in a few weeks.6 It is very difficult to predict which patients will develop these symptoms.4 Also, patient’s perception and tolerance of symptoms may have a role to play. Prevalence of PD ranges from 1.5% to 67% in different studies with most studies showing 12% to 35%.1,4,7,8 in the immediate postoperative period decreasing to 0.2% to 2.2% over the next 12 months.9,10 ND is less prevalent occurring in 0.5% to 2.4% of patients.4,11,12 Tester et al4 showed that 49% of patients have some degree of ND or PD postoperatively. According to Bournas et al, 19.5% of cataract patients complained of dysphotopsia on the first postoperative day.13 Osher reported symptoms of ND on the first postoperative day in 15.2% of patients that decreased to 3.2%, one year after surgery.13

Positive Dysphotopsia
These are unwanted, extra images that the patient sees. They can be scintillating vision (caused by backscatter from the lens combined with microsaccades that tends to be exacerbated by higher refractive index lenses), arcs (patient sees the edge of the IOL, usually at night when the pupil dilates, tend to resolve over time, more so when the anterior capsule overlapping the IOL opacifies), flashes (central flashes occur when rays coming from periphery are reflected off the edge of IOL), haloes and rings which are more commonly seen with multifocal IOLs; and glares which occur due to high refractive index and reflectance of IOL or glistening formation in the IOL.

Figure 1: Mechanism of positive dysphotopsia

The nasal edge of the IOL is proposed to scatter light perceived as various images by the patient on the temporal side when the pupil is large enough for the incident ray to strike near the edge of the IOL, as occurs in low mesopic or scotopic conditions. This is blocked on the opposite side due to nose. An internal reflection from the posterior surface of the front of the IOL can also cause PD when angle of incidence exceeds the critical angle (CI). A glare source positioned around 35° off the visual axis creates an internal reflection within the IOL that is projected onto the temporal retina.15 (Figure 1) Refractive index (μ) of aqueous is 1.336, PMMA IOL 1.49, Acrylic Hydrophilic IOL1.43, Acrylic Hydrophobic IOL1.44-1.55, and Silicon IOL1.46. The critical angle for Acrylic, PMMA, and Silicon IOLs are 59.5, 63.7 & 66.2 degrees respectively. Critical angle of Acrylic is 6.7° < Silicon, so there is increased chance for internal reflection with acrylic (rays from 59.5 to 90.0°) compared to Silicon
Negative Dysphopsia

It is less understood and more debilitating than PD. It is perceived by the patient as a sickle-shaped, dark shadow/crescent that gives the impression of a shade over the temporal peripheral region of patients’ vision. First reported in 2000 by James Davison who likened this temporal darkness to “horseblinders”. It is perceived only in the temporal area as nose blocks the nasal part. As the light gets scattered by the nasal edge of IOL, it leads to a dark area on the retina on that side as no light reaches there and is perceived as a dark shadow by the patient. It typically manifests after perfect in-the-bag PCIOl implantation surgery. It has not been reported with decentred/ in the bag /sulcus placed PCIOLs or ACIOls. Stimulated with temporally placed light source, symptoms abate when light is removed but symptoms increase with bright light. The etiology of clinical riddle of ND has remained a mystery. Osher suggested that edema surrounding a temporal corneal incision could be responsible for the high early incidence of ND, but this theory may not be true, given that ND has been reported with superior cataract incisions.

Symptoms abate with pupil dilation. Causative factors of ND could be primary or secondary. Primary factors are small pupil, larger distance between the back of the iris and IOL sharp-edged design (edge radii ≤ 0.05 mm), anteriorly extending functional nasal retina and reflection of the anterior capsulotomy edge projected onto the nasal peripheral retina as suggested by Masket and Fram. This theory is supported by ray tracing model by Hong et al. ND shadow is easier to perceive with constricted pupils as pupillary constriction leads to increased contrast between the shadow and the rays adjacent to it, similar to the pinhole. Holladay et al. theorized that higher incidence of ND with acrylic IOLs was because of such higher distance (0.06-1.2 mm for acrylic vs 0.06 mm-0.62 mm for silicon foldable IOL).

Secondary factors can be high μ of optic material (lower μ of silicone compared with acrylic moves the anterior and the posterior border of shadow forward reducing the width of the shadow from 14.09° for acrylic to 2.3° for silicone), increased angle α (that causes the eye to turn temporally leading to the formation of ND because of the increased exposure of the nasal retina), nasal location of the pupil relative to the eye’s optical axis (if the pupil was displaced nasally by 2.6° (0.3 mm on the cornea), the pupil would be closer to the nasal edge of the IOL, again exposing more of the nasal retina), transparent vs translucent status of the peripheral nasal capsule, high plus lenses, idiosyncratic predisposition, cataract incision located temporally in clear cornea, brown irides, a prominent globe and a shallow orbit.

The most likely reason that the shadow is always temporal is that in the human eye, the retina reaches farther in the anterior nasal quadrants than in the temporal ones. Light entering an eye from the temporal periphery is reflected specularly off a flat or truncated edge. The eyebrow, nose, and cheek prevent light from entering the eye sufficiently obliquely from other directions.

The etiology and symptomatology of PD and ND differ, but there can be some crossover (Figure 2). The rays that form the PD on the temporal retina (reflected glare image) from the square or truncated edge optic would be absent from the refracted image of the light source (image of glare source). Moreover, both conditions can coexist in the same patient. In the first few weeks to several months after surgery, the factors would manifest itself clinically by the increased potential for patients to experience postoperative glare. Further work suggested that IOLs with anterior radius of curvature of 17 mm or less would minimize surface reflections. A decentered IOL causes PD from the edge of IOL and change in reflectance angle.

Figure 2: Positive and negative dysphotopsia
nasal capsule starts opacifying leading to spontaneous resolution of ND.\textsuperscript{31,34} Till the nasal capsule remains transparent, there is no light scattered into the shadow (Figure 3). However, when the nasal capsule becomes translucent (acts as a diffuser), the scattered rays enter the shadow and eliminate the ND.\textsuperscript{55} (Figure 4) Posterior capsule opacification (PCO) also causes light scatter, which reduces retinal contrast and threshold sensitivity.\textsuperscript{56} Anterior axial movement of the IOL from capsular bag contraction is also a possible reason for the decreasing incidence with passage of time because it could reduce the axial space behind the iris to 0.06 mm or less. Neuroadaptation plays a significant role in resolution of symptoms.

Negative dysphotopsia can be a) Transient (2 weeks in duration) – due to hydration of a temporarily placed clear corneal incision that gradually resolves in a few weeks as the incision area dehydrates, b) Temporary- (6 weeks-6 months)- caused by the projection of the optical void (penumbra) of a square-edged IOL on the nasal retina could gradually be lessened in time by the peripheral capsule opacification and neuroadaptation or c) Persistent- lingering cases that annoy patients, perplex surgeons and warrant treatment.

**Prevention**

No method guarantees absence from post-operative dysphotopsia, but certain measures can help reduce its effects. The use of 6mm optic (A smaller optic size of IOL leads to more edge related problems), uniform overlap by capsulorrhexis of 0.5 mm all around the optic by rhexis\textsuperscript{77,78} and horizontal orientation of haptics which reduce temporal stray light. The origin of the rays at the IOL edge would be moved laterally to the edge of the haptic, causing the retinal intercepts of the shadows to be more anterior and smaller in width. When operating the other eye of patient experiencing dysphotopsia in the previously operated eye, one should choose IOL with low \( \mu \), choose round-edge, 3-piece silicone IOL oriented with the haptics horizontally instead of a square-edged acrylic IOL oriented vertically.\textsuperscript{5}

The aim should not be to eliminate all unwanted images from every cataract patient’s vision as the phenomenon of central adaptation would eventually take care. The brain is adept at eliminating unwanted visual input from our perception; the most obvious example is blind spot. Others are front and backscatter off our natural lens, irregular pupils, and blood vessels in our retina that we can’t see through. By inserting a new lens, we’re just adding a new element to the equation. This natural process is an important part of resolving unwanted visual images after cataract surgery, and it’s a process over which we have some control.

**Management**

Non-surgical management includes counselling the patient. The patient should be advised to ignore the images as the symptoms resolve spontaneously over a period of 1-2 months. This is especially true for PD. Pupillary constriction can be tried with pilocarpine or brimonidine in patients having symptoms at night (due to pupillary dilatation). This also leads to disappearance of symptoms in a few weeks. It is helpful in PD but in ND it can worsen the problem, which then rather improves on pupillary dilatation. Thick frame spectacles can be helpful especially in ND, helping the brain to get trained in avoiding the shadow. Addressing other confounding issues is important like refractive error, dry eye etc. The refractive error should be eliminated with spectacles or contact lenses. The eye should be evaluated to determine if there are any corneal abnormalities such as epithelial basement membrane disease or microstriae due to previous LASIK. Yag capsulotomy of nasal anterior capsule can help resolve the symptoms as the anterior capsule could be responsible for the symptoms.\textsuperscript{39,40}

When patient’s symptoms do not resolve by 6 months on conservative management, then surgical approaches are tried. Fabrowitz et al\textsuperscript{41} advocates that an IOL with a smaller optic, high \( \mu \) with sharp edges should be replaced with an IOL with atleast 6mm optic size of a low \( \mu \) and rounded edges. IOL exchanges have been performed to change sharp-edged acrylic to round-edged silicone, shiny to frosted sharp-edged optics, and reverse-shape optics (posterior surface flatter than anterior surface). Exchanging sharp-edge acrylic to rounded-edge silicone may not necessarily eliminate the patient’s symptoms.\textsuperscript{4} However round optic edges while
ameliorating some types of pseudophakic dysphotopsia raise the possibility of an increased risk of PCO. Silicone moves the shadow anteriorly and significantly reduces its width; however, it still may be on the functional retina. Using a frosted (textured) edge optic for an exchange or as the primary IOL in the second eye lowers the incidence of both PD and ND. This type of design roughens the edge of the IOL optic to create the same type of light scatter as created by transluxation of the peripheral, nasal capsule. Frosting also reduces the internal light scatter from a sharp edge optic by dispersing the light that leads to positive dysphotopsia. IOL with characteristics (as described above) can be put in sulcus. This is especially helpful if the capsulorrhexis is large or eccentric which might be leading to edge effects causing the symptoms. Piggyback IOL in the sulcus is also proposed and reported to eliminate dysphotopsia. This procedure reduces or eliminates the space behind the iris; however, it must be less than 0.06 mm, which is not always the case. Pre requisites for piggyback IOL implantation are: Uncomplicated first IOL surgery with a well centered in the bag IOL, no evidence of zonulopathy or iris damage from earlier surgery, at least 1 mm space between the posterior iris and the existing IOL/bag complex in the ciliary sulcus. Reverse optic capture where the optic of the IOL is brought into the sulcus while the haptics remain in the bag, so that the capsulorrhexis does not overlap the haptic can be helpful. This can also be done prophyactically in the second eye of patient suffering from dysphotopsia. The edge of the optic is lifted with a spatula, an IOL dialer or a hook. The lifted edge of the optic is manipulated and placed above the anterior capsulorrhexis margin. In a one-piece IOL, it is difficult to place the entire 360° of the optic above the anterior capsular rim, yet the 180° opposite edges can be easily placed. Iris suture fixation of the capsule bag–IOL complex was suggested but is unsuccessful in eliminating symptom of ND as suturing the iris to the IOL complex moves the iris posteriorly but does not move the IOL anteriorly. Bag in the lens technique (BIL) was introduced by belgian ophthalmologist Marie-Jose Tassignon’s. The BIL procedure features a round-edged IOL that has a 5-mm optic surrounded by a peripheral groove and elliptical haptics to receive anterior and posterior capsular leaflets (Figure 5-a). Anti Dysphotopic IOL was introduced by Masket whose design concept is based on reverse optic capture. A peripheral groove is placed anteriorly to accept the anterior capsulotomy (Figure 5-b), and a lip of the optic overrides the anterior capsule. The Masket ND IOL (Morcher) received CE Mark approval in 2013, and a small number of patients have received the lens in a preliminary European clinical trial.

Reverse optic capture and piggyback IOL implantation in the sulcus-are the most successful approaches. This proves that symptoms depend on IOL coverage of the anterior capsule edge.

**Figure 5:** a) Bag-in-the lens technique b) anti-dysphotopic IOL (Masket)

**Conclusion**

Dysphotopsias represent a challenge to current-day cataract surgery that the ophthalmologists need to recognize, understand and address by alterations of surgical methods, IOL designs or both Recognition of the problem is extremely important to overcome it.

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