Neodymium:YAG laser anterior capsulectomy: Surgical option in the management of negative dysphotopsia

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This report describes 6 cases in which neodymium:YAG (Nd:YAG) laser anterior capsulectomy achieved limited success in treating negative dysphotopsia. In 5 eyes with the Akreos AO MI60L posterior chamber intraocular lens (PC IOL), the dysphotopsia symptoms resolved completely (3 eyes) and partially (2 eyes) depending on the extent of the Nd:YAG laser anterior capsulectomy. In 1 eye with the Acrysof IQ toric PC IOL, the symptoms did not improve. Success with this procedure in patients with the Akreos AO MI60L PC IOL supports the role of the anterior capsule in the etiology and mechanism of negative dysphotopsia. Because the anterior capsulectomy did not resolve the symptoms in the patient with the Acrysof IQ toric PC IOL, the anterior capsule should be considered an optical risk factor for negative dysphotopsia and important in the manifestation of symptoms in only some patients. Other primary optical factors that have been described can presumably manifest negative dysphotopsia symptoms independent of light scatter from the anterior capsule.

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Negative dysphotopsia manifests as a temporal crescent-shaped shadow following cataract surgery with in-the-bag posterior chamber intraocular lens (PC IOL) placement. The first reports of negative dysphotopsia were noted after widespread adoption of the square-edged-optic IOL design in the mid-1990s. Holladay et al. described a “Type 3 shadow” as the source of negative dysphotopsia and discussed several primary optical factors important in the mechanism of this condition. Sharp posterior-optic-edge design has been implicated as a critical and necessary final common pathway for symptoms and has been supported by ray-tracing models. Small pupil size, distance behind the pupil plane, high index of refraction optic, and the anterior extent of functional nasal retina have also been suggested as primary optical factors for negative dysphotopsia.

The mechanism of this disorder has been associated with IOLs confined to and beneath the anterior capsule. Based on these observations, therapeutic measures have included sulcus placement of the IOL (primarily or after IOL exchange), secondary sulcus-placed piggyback IOL implantation, and reverse optic capture of the IOL optic. Vámosi et al. report a series of patients whose negative dysphotopsia symptoms improved only if an IOL exchange involved placement of the IOL anterior to the edge of the capsule. Masket and Fram report a series that included 1 patient whose symptoms resolved following reverse optic capture of only the nasal edge of the PC IOL optic.

Surgical success through disruption of the continuous anterior capsule–PC IOL optic overlap was used as the basis for a novel, less invasive technique using the neodymium:YAG (Nd:YAG) laser to improve negative dysphotopsia symptoms. To my knowledge, this is the first report on the use and outcomes of Nd:YAG laser anterior capsulectomy for the treatment of negative dysphotopsia in the peer-reviewed literature.
CASE REPORTS

All cataract extractions were performed with topical anesthesia using 1.8 mm clear corneal self-sealing temporal incisions. The capsulorhexis diameter was 5.0 to 5.5 mm in all cases. In no case was the anterior capsule polished. The Akreos AO MI60L (Bausch & Lomb) PC IOL was inserted through the 1.8 mm temporal incision without extension and implanted in the capsular bag with a 360-degree anterior capsule overlap. This single-piece, neutrally aspheric, hydrophilic acrylic PC IOL has a partially rounded square-edged optic design. It has a 4-point haptic design with 10-degree angulation at the optic–haptic junction, vaulting the optic posteriorly and reinforcing contact with the posterior capsule. Consequently, a gap between the anterior capsule and the PC IOL optic is often observed postoperatively. The Acrysof IQ toric (Alcon Laboratories, Inc.) PC IOL was inserted through an enlarged 2.2 mm temporal incision following cataract extraction. This single-piece, negatively aspheric, hydrophobic acrylic PC IOL has a square truncated optic edge. It has a 2-point haptic design with zero-degree angulation at the optic–haptic junction and no vaulting of the optic.

The Nd:YAG laser anterior capsulotomies were intended to eliminate a sector along the nasal aspect of the anterior capsule overlying the PC IOL optic. All complete capsulotomies removed the annulus of anterior capsule overlying the anterior surface of the PC IOL and extended from the capsulorhexis edge to the capsule overlying the optic edge. The treatment created a sector void of anterior capsule, disrupting the 360-degree overlap of the capsulorhexis. No significant PC IOL optic damage or pitting occurred in any case. Prior to Nd:YAG laser treatment, patients were informally asked to confirm reduction of their symptoms following pharmaceutical mydriasis, which is characteristic of negative dysphotopsia.

Case 1

A 75-year-old white woman had uneventful cataract surgery in both eyes. A 28.0 diopter (D) Akreos AO MI60L PC IOL was implanted in the capsular bag bilaterally. Postoperatively, slitlamp examination revealed well-centered PC IOLs with 360-degree anterior capsule overlap and vertically oriented haptics bilaterally. The corrected distance visual acuity (CDVA) was 20/20 in the right eye and 20/25 in the left eye. The manifest refraction was plano and –1.00 + 2.00 × 93, respectively.

In the immediate postoperative period, the patient noted a dark temporal shadow in the left eye. Three months post-operatively, she remained symptomatic with the temporal shadow and also complained of progressive blurring of vision bilaterally. Slitlamp examination revealed uniform opacification of the posterior capsule bilaterally. The anterior capsules had a densely opacified fibrotic ring along the capsulorhexis margin with relative uniform opacification of the remaining anterior capsule extending to the edge of the PC IOL optic bilaterally. The left superior nasal haptic shoulder was oriented at approximately 152 degrees and the inferior nasal haptic, at approximately 217 degrees.

Neodymium:YAG laser posterior capsulotomies were performed in both eyes, improving the patient's visual acuity; however, she remained symptomatic with the temporal shadow in the left eye. Neodymium:YAG laser anterior capsulotomy was then performed in the left eye, creating a 2.5 mm sector along the nasal anterior capsule (Figure 1).

Figure 1. Creation of an anterior capsule sector along the nasal aspect of the capsulorhexis following Nd:YAG laser anterior capsulotomy, resulting in complete resolution of negative dysphotopsia symptoms.

The patient noted immediate and complete resolution of the temporal shadow.

Case 2

A 72-year-old white woman had uneventful cataract surgery in both eyes. A 17.0 D Akreos AO MI60L PC IOL was implanted in the capsular bag in the right eye. Two paired 30-degree limbal relaxing incisions (LRIs) were placed along the steep 94-degree corneal axis. An 18.5 D Akreos AO MI60L PC IOL was implanted in the capsular bag in the left eye. Two paired 25-degree LRIs were placed along the steep 90-degree corneal axis.

Postoperatively, slitlamp examination revealed well-centered PC IOLs with 360-degree anterior capsule overlap and vertically oriented haptics bilaterally. The CDVA was 20/20 bilaterally. The refractive goal was monovision, and manifest refraction was plano in the right eye and −1.75 + 0.50 × 80 in the left eye.

In the immediate postoperative period, the patient noted a dark temporal shadow in the left eye. Three months post-operatively, she remained symptomatic with the temporal shadow and also complained of poor reading quality with the left eye. Slitlamp examination revealed symmetrical-appearing anterior capsules with relatively uniform opacification extending from the capsulorhexis margin to the capsule overlying the edge of the PC IOL optic bilaterally. Slitlamp examination of the left eye also revealed uniform opacification of the posterior capsule. The left PC IOL superior nasal haptic shoulder was oriented at approximately 135 degrees and the inferior nasal haptic, at approximately 200 degrees.

Neodymium:YAG laser anterior capsulotomy and posterior capsulotomy were performed simultaneously in the left eye. The anterior capsulotomy created a 2.5 mm sector along the nasal anterior capsule. The patient noted improvement in her reading quality and complete resolution of the temporal shadow in the left eye.
Case 3

A 74-year-old white woman had uneventful cataract surgery in both eyes. An 18.5 D Akreos AO MI60L PC IOL was implanted in the capsular bag in the right eye, and a 20.5 D Akreos AO MI60L PC IOL was implanted in the capsular bag in the left eye.

Postoperatively, slitlamp examination revealed well-centered PC IOLs with 360-degree anterior capsule overlap and vertically oriented haptics bilaterally. The CDVA was 20/20 bilaterally. The refractive goal was monovision and manifest refraction was $-0.25 + 0.75 \times 015$ in the right eye and $-2.50$ sphere in the left eye.

In the immediate postoperative period, the patient noted a dark temporal shadow in the left eye. Six months postoperatively, she remained symptomatic with the temporal shadow and additionally described difficulty in neuroadaptating to the monovision. Slitlamp examination revealed anterior capsules with minimal and uniform opacification extending from the capsulorhexis margin to the anterior capsule overlying the edge of the PC IOL optic bilaterally. The left PC IOL superior nasal haptic shoulder was oriented at approximately 147 degrees and the inferior nasal haptic, at approximately 212 degrees.

The patient requested reversal of the monovision, and photorefractive keratectomy (PRK) was performed in the left eye to eliminate the myopic outcome. The negative dysphotopsia symptoms were unchanged following PRK, and 1 month later, Nd:YAG laser anterior capsulotomy was performed in the left eye. Radial incisions were created in the anterior capsule extending from the capsulorhexis margin to the capsule overlying the optic edge. The incisions created a flap of capsule that could not be completely amputated at its base (overlying the optic edge) secondary to poor pupil dilation. The anterior capsule flap was therefore trimmed and displaced, causing it to float above the capsulorhexis plane (Figure 2). The patient noted 85% symptomatic improvement and described the shadow as “less dense.”

Case 4

A 66-year-old white woman had uneventful cataract surgery in both eyes. A 19.5 D Akreos AO MI60L PC IOL was implanted in the capsular bag in the right eye and a 17.5 D Akreos AO MI60L PC IOL, in the capsular bag in the left eye. Two paired 35-degree LRIs were made along the steep 108-degree corneal axis in the left eye.

Postoperatively, slitlamp examination revealed well-centered PC IOLs with a 360-degree anterior capsule overlap and vertically oriented haptics bilaterally. The CDVA was 20/20 bilaterally. The refractive goal was monovision, and the manifest refraction was $-2.00 + 0.50 \times 10$ in the right eye and plano $+0.50 \times 150$ in the left eye.

In the immediate postoperative period, the patient noted a dark temporal fuzzy shadow in the left eye. Two months postoperatively, she remained symptomatic with the temporal shadow and slitlamp examination revealed anterior capsules with minimal opacification extending from the capsulorhexis margin to the capsule overlying the edge of the PC IOL optic bilaterally. The left PC IOL superior nasal haptic shoulder was oriented at approximately 155 degrees and the inferior nasal haptic, at approximately 220 degrees.

Neodymium:YAG laser anterior capsulotomy was performed in the left eye, creating a 2.5 mm sector along the nasal anterior capsule. The patient noted immediate and complete resolution of the temporal shadow and “brightening” of her vision.

Case 5

A 69-year-old white woman had uneventful cataract surgery in both eyes. A 19.5 D Akreos AO MI60L PC IOL was implanted in the capsular bag in the right eye and a 20.0 D Akreos AO MI60L PC IOL, in the capsular bag in the left eye.

Postoperatively, slitlamp examination revealed well-centered PC IOLs with 360-degree anterior capsule overlap bilaterally. Haptics were oriented vertically in the right eye and obliquely at approximately 145 degrees in the left eye. The CDVA was 20/20 bilaterally and manifest refraction, $-0.50 + 0.50 \times 14$ in the right eye and $-0.25 + 0.25 \times 157$ in the left eye.

In the immediate postoperative period, the patient noted a temporal “sliver of a moon/arc” opacity obstructing the peripheral vision in the left eye. She described a distracting “white” quality to the opacity but did not describe brightness, streaks, or rays characteristic of positive dysphotopsia. One year postoperatively, the patient remained symptomatic with the temporal arc, which she thought was contributing to an uneasiness and loss of balance. Slitlamp examination of the right eye revealed a well-centered PC IOL with an open posterior capsule (posterior capsulotomy performed 3 months postoperatively) and a relatively transparent 360-degree overlapping anterior capsule. Slitlamp examination of the left eye revealed a well-centered PC IOL with a densely opacified 360-degree overlapping anterior capsule extending from the capsulorhexis margin to the capsule overlying the edge of the PC IOL optic (Figure 3). Uniform posterior capsule opacification was also noted in the left eye but was not visually significant to the patient. The left PC IOL superior nasal haptic shoulder was oriented at approximately 176 degrees and the inferior nasal haptic, at approximately 241 degrees.

Neodymium:YAG laser anterior capsulotomy was performed in the left eye at the 1-year follow-up, creating a 2.5 mm sector along the nasal anterior capsule. A small...
tag of anterior capsule could not be removed along the superior border of the capsulectomy edge overlying the optic–haptic junction (Figure 4). The patient noted immediate and approximate 90% resolution of the temporal opacity and some improvement in her balance. She did, however, note also seeing the inferior border of the previous arc and a small residual “dot-like” shadow in the inferotemporal periphery.

A secondary Nd:YAG laser anterior capsulectomy was performed to remove the residual anterior capsule tag (Figure 5), but no additional superior extension of the anterior capsulectomy was performed. The patient noted resolution of the “dot-like” shadow following the secondary Nd:YAG laser treatment, although she continued to see the inferior border of the previous arc. Two months after the secondary Nd:YAG laser anterior capsulectomy, the patient was satisfied and noted resolution of her imbalance and rarely noticed what she described as the small inferior border of the previous arc with a “shadow-like” quality.

Case 6

A 65-year-old white woman had uneventful cataract surgery in both eyes. A 22.0 D Acrysof IQ toric PC IOL was implanted in the capsular bag in the right eye and a 26.5 D Acrysof IQ toric PC IOL, in the capsular bag in the left eye.

In the immediate postoperative period, the patient recognized dark temporal shadows bilaterally. The symptom was less bothersome in the right eye and was described as a faint temporal shadow in the inferior temporal periphery. The patient described a prominent dark temporal shadow (“rim”) extending throughout the temporal periphery in the left eye.

Three months postoperatively, slitlamp examination of the right eye revealed a well-centered PC IOL with 360-degree anterior capsule overlap. Uniform opacification was noted throughout the anterior capsule (overlying the anterior surface of the PC IOL optic), with faint clearing of the anterior capsule nasally and adjacent to the optic–haptic junction. The IOL axis was at 10 degrees with haptics oriented horizontally. The superior border of the left nasal optic–haptic junction extended to approximately 145 degrees, and the inferior border of the nasal optic–haptic junction was oriented at approximately 193 degrees. The CDVA was 20/30 (limited by mild amblyopia) and the manifest refraction, −0.50 + 0.50 × 15.

Neodymium:YAG laser anterior capsulectomy was performed in the left eye. The capsulectomy created a 3.5 mm sector along the nasal anterior capsule (Figure 6), although the patient noted no improvement in symptoms following the treatment.

**DISCUSSION**

Holladay et al.2,3 implicated sharp posterior-optic-edge design as a critical and necessary final common pathway for negative dysphotopsia symptoms. Small pupil size, distance behind the pupil plane, high index of refraction optic, and the anterior extent of functional nasal retina were also shown to be primary optical factors for negative dysphotopsia. Masket and Fram5 reported negative dysphotopsia could be alleviated if the anterior capsule edge were covered by the IOL optic, even if only the nasal edge were involved. They implicated the anterior capsulorhexis as causal and suggested that the induction of negative dysphotopsia likely occurs at the interface of the anterior capsulorhexis and the front surface of the PC IOL.

The nasal anterior capsule annulus overlying the anterior surface of the PC IOL optic (with varying degrees of translucency) scatters light, creating a new path for incident light to reach the sharp posterior edge.
nasal PC IOL optic edge, thus manifesting the Type 3 shadow and negative dysphotopsia symptoms discussed in Holladay’s reply to Masket and Fram. Although opacification of the capsule peripheral to the PC IOL optic edge appears responsible for the transient nature and spontaneous resolution of negative dysphotopsia, opacification of the anterior capsule is a necessary feature and contributes to the mechanism of negative dysphotopsia in some patients. During the first few postoperative days, swollen epithelial cells create a frosted cellophane-tape-like quality to the anterior capsule, resulting in early light scatter. Back-scattered light that the clinician observes and grades versus forward-scattered light affecting the patient’s vision are not equal in character or amount. What looks like a clear capsule to the clinician is not necessarily without light scatter for the patient. Weeks later, differentiation into myofibroblasts allows the opacification to persist or intensify, as seen in capsules with a white fibrotic appearance. In this report, Case 4 had minimal opacification of the anterior capsule and Case 5 progressed to a densely opacified anterior capsule. Both cases, however, allowed light transmission and scatter through the body of the nasal anterior capsule annulus, facilitating negative dysphotopsia symptoms. The cases in this report demonstrate that removing a nasal sector of the anterior capsule overriding the IOL optic can eliminate this source of light scatter and improve negative dysphotopsia symptoms in some patients.

In the 5 eyes with the Akreos AO MI60L PC IOL, complete resolution of symptoms occurred in 3 eyes and partial resolution in 2 eyes, depending on the extent of the Nd:YAG laser anterior nasal capsulotomy. The intent of this report was to remove a small sector of the nasal anterior capsule, disrupting the potential for light reflection or refraction as a path to the square-edged design of the Akreos optic. The unique design of the Akreos vaults the optic 10 degrees posteriorly, reinforcing contact against the posterior capsule. A gap between the anterior capsule and the PC IOL optic is typically established and noted postoperatively, creating a unique anterior capsule-optic relationship. Depending on the diameter of the capsular bag and the extent and direction of capsular contractile forces, separation between the anterior capsule and optic can persist indefinitely to varying degrees. Because of this unique relationship, the role of the anterior capsule in patients receiving the Akreos PC IOL may be important in the mechanism of negative dysphotopsia and therefore may be particularly responsive to Nd:YAG laser anterior capsulotomy. When a complete sector of anterior capsule was cleanly removed, symptoms entirely resolved. When a sector of anterior capsule was incompletely removed, symptoms improved but did not completely resolve. Case 3 resulted in an anterior capsule that could not be amputated at its base (overlying the optic edge) because of poor pupil dilation. Consequently, the anterior capsule was trimmed and displaced, causing it to float above the capsulorhexis plane (Figure 2). This patient noted 85% symptomatic improvement and described the shadow as “less dense.” Case 5 resulted in an anterior capsulotomy that had a persistent...
tag of anterior capsule that had not been cleanly amputated beyond the edge of the optic. The patient reported 90% symptomatic improvement but continued to see the inferior border of the previous arc and an associated “dot-like” shadow. The “dot-like” opacity appeared to correlate with the tag of anterior capsule that had not been cleanly amputated along the superior border of the capsulectomy edge (Figure 4). After a second Nd:YAG treatment, the tag was eliminated (Figure 5) and the “dot-like” shadow completely resolved. The patient continued to notice the lower border of the previous arc, which may have been eliminated if the anterior capsulectomy had been extended superiorly.

Success with this procedure supports the role of the anterior capsule as an important optical risk factor for negative dysphotopsia in patients receiving the Akreos AO MI60L PC IOL. Because the symptoms in the patient receiving an Acrysoft IQ toric PC IOL (Case 6) remained unchanged after the nasal anterior capsule was removed using the Nd:YAG laser (Figure 6), other primary optical factors including the PC IOL optic and edge design, pupil size, distance behind the pupil plane, PC IOL index of refraction, and the anterior extent of functional nasal retina can presumably manifest negative dysphotopsia symptoms independent of light scatter from the anterior capsule.

To my knowledge, this is the first report to describe limited success using Nd:YAG laser anterior capsulectomy for the treatment of negative dysphotopsia. Neodymium:YAG laser anterior capsulectomy provides a minimally invasive treatment option in patients with persistent intractable negative dysphotopsia and eliminates invasive intraocular manipulation and poorly tolerated pharmaceutical dilation. A sharp posterior-optic-edge design has been implicated as a critical and necessary final common pathway for negative dysphotopsia symptoms, which has been supported by ray-tracing models and correlates historically with the preponderance of case reports following widespread adoption of the square-edged optic design in the mid-1990s.

The present report suggests that the anterior capsule is an important risk factor for negative dysphotopsia and therefore responsive to Nd:YAG laser anterior capsulectomy in some patients. Since Case 6 remained symptomatic after treatment, the report also supports the role of other previously described primary optical factors (independent of the anterior capsule) as vital in this multifactorial phenomenon. Limitations of the report include its small sample size, dependence on subjective patient response, and absence of objective measures for negative dysphotopsia symptoms.

REFERENCES


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