Scientific Research Publishing

Open Journal of Ophthalmology, 2026, 16(3), 279-287
https://www.scirp.org/journal/ojoph
ISSN Online: 2165-7416
ISSN Print: 2165-7408

Surgical Approach to Decrease the Incidence of Negative Dysphotopsia after Intraocular Lens (IOL) Implantation

Omar Alabbasi[1], Abdulrahman Alahmadi[2], Waleed Alshehri[2], Fai Mahrous[2], Mubarak Alahmadi[2], Saud Khan[2], Sarah Alsharif[3], Wasayf Aljohani[4]

[1]Ophthalmology Department, King Salman Bin Abdulaziz Medical City, Medina, Saudi Arabia
[2]Ophthalmology Department, Ohud Hospital, Medina, Saudi Arabia
[3]Ophthalmology Department, Prince Sultan Military Medical City, Riyadh, Saudi Arabia
[4]Ophthalmology Department, King Fahad Armed Hospital, Jeddah, Saudi Arabia
Email: Fai.A.Mahrous@gmail.com

How to cite this paper: Alabbasi, O., Alahmadi, A., Alshehri, W., Mahrous, F., Alahmadi, M., Khan, S., Alsharif, S. and Aljohani, W. (2026) Surgical Approach to Decrease the Incidence of Negative Dysphotopsia after Intraocular Lens (IOL) Implantation. *Open Journal of Ophthalmology*, **16**, 279-287.
https://doi.org/10.4236/ojoph.2026.163024

Received: May 11, 2026
Accepted: August 2, 2026
Published: August 5, 2026

Abstract

Purpose: To evaluate the effectiveness of two surgical approaches—differing in incision site, operating surgeon, surgical center, and optic-haptic junction orientation—on the incidence of negative dysphotopsia (ND) after cataract surgery with intraocular lens (IOL) implantation. **Patients and Methods:** This prospective comparative study included 102 patients who underwent cataract surgery with IOL implantation, divided into two equal groups (51 patients each). Group 1 received a supratemporal incision with a vertical optic-haptic junction. Group 2 received a superior incision with an inferotemporal optic-haptic junction. Both groups received monofocal acrylic IOLs (RayOne and Alcon AcrySof IQ). The primary endpoint was ND incidence, defined as patient-reported dark shadows or curtains in the temporal visual field, assessed on postoperative day 1 (in-person), day 3 (phone call), and week 4 (phone call) using the question: "Do you experience dark, temporal arcing shadows or curtains in your vision?" Demographic characteristics, surgical parameters, and postoperative outcomes were recorded and analysed. **Results:** The overall ND incidence was 2.9% (3/102 patients): 3.9% (2/51) in Group 1 and 2.0% (1/51) in Group 2, with no statistically significant difference ($p = 0.558$). Among patients with ND, 66.7% (2/3) had a vertical optic-haptic junction and 33.3% (1/3) had an inferotemporal junction ($p = 0.558$). Symptoms worsened in bright light and improved in dim lighting in 50.0% of Group 1 patients and 100% of Group 2 patients with ND. The single affected Group 2 patient reported symptom improvement by week 4; no Group 1 patients did. **Conclusion:** The incidence of ND was low (2.9%). No statistically significant differ-

ence was detected between the two surgical approaches. Furthermore, only three ND events were documented, statistically reliable comparisons between groups cannot be established, Also, the underlying pathophysiology of ND is likely multifactorial with different variables that extend beyond the scope of the parameters examined in the present study.

Keywords

Cataract Surgery, Optic-Haptic Junction, Surgical Incision, Pseudophakia, Negative Dysphotopsia

1. Introduction

Cataract surgery is the most common eye surgery done worldwide. Even with an uncomplicated outcome, more than 70% of patients experience some form of dysphotopsia shortly after surgery [1]. Dysphotopsia falls into two broad categories: positive and negative. Positive dysphotopsia manifests as bright arcs, streaks, or halos at the center or mid-periphery of the retina [2]. Our study focuses on the less-understood phenomenon of negative dysphotopsia (ND), whose incidence reaches up to 15% of cataract surgery patients, with affected individuals perceiving a dark, arc- or crescent-shaped shadow in the temporal visual field [3].

ND was introduced to the literature by Davison et al. in 2000 [4]. Reported incidence ranges from 0.2% to 20% [1]. Although symptoms are resolved spontaneously in the majority of patients, [5] approximately one-fifth remain permanently symptomatic [6]. The aetiology of ND is currently the focus of debate; theoretical evidence suggests that light entering the eye inferotemporally and striking the edge of the implanted IOL creates a discontinuity among rays reaching the nasal retina, producing the perceived shadow [7]. Additional proposed mechanisms involve the positional relationship between the IOL, the anterior capsule, and the posterior iris surface, were recently reviewed by Henderson and Geneva [8].

Previous studies have reported varying incidence rates, attributable in part to differences in IOL type and surgical approach [2]. For example, inferotemporal positioning of the optic-haptic junction was associated with a 2.3-fold decrease in ND incidence [6]. Because the incision site, optic-haptic junction orientation, and operating surgeons were linked by center in this study, the present study compares two complete surgical approaches rather than isolating a single variable and aims to determine which approach is more effective in reducing ND incidence after IOL implantation.

2. Material and Methods

2.1. Study Design and Duration

This is a prospective comparative study conducted on 102 cataract patients across two surgical centers from 2023 to 2024. Because each group was treated at a single

dedicated center by a single dedicated surgeon, the surgical approach variables — center, surgeon, incision site, and optic-haptic junction orientation—were completely linked and cannot be analysed independently.

2.2. Study Population and Sampling

All patients listed for routine cataract surgery at both centers were considered for participation. Patients aged less than 18, uncooperative, or who have any coexisting eye diseases affecting their visual function (retinal pathology, glaucoma, or other optic neuropathies with visual field defects) were excluded from the study. Patients without a history of non-phacoemulsification cataract surgery and who developed intraoperative complications were also excluded.

Patients were approached consecutively on the first postoperative day, informed about the study, and invited to participate by completing a self-administered questionnaire. Participation was voluntary, and patients were free to withdraw at any time; patients who declined were not separately recorded. Completing and returning the questionnaire constituted consent to participate, to the extraction of surgical data from medical records, and to phone follow-up on day 3 and week 4. Data were kept confidential and accessible only to the primary and co-investigators. This study was ethically approved by the Institutional Review Board (IRB), General Directorate of Health Affairs in Madinah (IRB log No. 23-067).

The 102 enrolled patients were divided into two equal groups (51 per group) according to the center at which they were admitted. One surgeon performed all surgeries at Center A (Group 1: supratemporal incision, vertical optic-haptic junction), and a second surgeon performed all surgeries at Center B (Group 2: superior incision, inferotemporal optic-haptic junction). All procedures followed the standard phacoemulsification technique.

2.3. IOL Characteristics

Both groups received monofocal acrylic IOLs. Two models were used across the study population: RayOne Hydrophobic Aspheric BLF and Alcon AcrySof IQ. The distribution of IOL model across groups was not a study variable and was not recorded, so no conclusions regarding the effect of IOL model on ND incidence can be drawn from this study.

The RayOne Hydrophobic Aspheric BLF is a single-piece monofocal IOL made from hydrophobic acrylic with a blue-light-filtering chromophore. It features a 6 mm biconvex optic, a 360° enhanced square edge, an aberration-neutral posterior aspheric surface, 0° uniplanar haptic angulation, and a Cornerstone anti-vaulting haptic design. It is delivered through a 2.2 mm incision via a fully preloaded, single-use injector. Refractive index: 1.51; ABBE value: 43; UV cut-off: 385 nm.

The Alcon AcrySof IQ is a widely used single-piece monofocal IOL made from hydrophobic acrylic with a blue-light filter. It has a 6 mm optic, a square-edge design, and a posterior aspheric surface engineered to reduce spherical aberration. Refractive index: 1.55; designed for in-the-bag placement across a broad dioptric

range.

2.4. Primary Endpoint and Data Collection

The primary endpoint was ND incidence, defined as any patient-reported dark shadows or curtains in the temporal visual field, captured by the question: "Do you experience dark, temporal arcing shadows or curtains in your vision?" ND status was assessed on postoperative day 1 (in-person questionnaire), day 3 (phone call), and week 4 (phone call). A patient was classified as having ND if they reported the symptom at any of these time points.

The questionnaire comprised four sections: 1) responsible consultant details; 2) patient demographics (medical record number, age, gender); 3) medical and ocular history and ND symptom items; and 4) surgical data (incision site and location, IOL fixation site, optic-haptic junction location, and complications).

Participants' agreement to fill the questionnaire was considered as their consent to participate, and their data was kept confidential, accessible only to the primary investigator and co-investigators. Participation was voluntary, and participants had the right to withdraw from the study at any time.

2.5. Data Analysis

Data analysis was performed using SPSS version 27 (IBM Corp., Armonk, NY). Descriptive statistics summarised bio-demographic and surgical characteristics. Associations between categorical variables were assessed with the exact probability test. Variables examined included surgical technique versus bio-demographic characteristics (age, gender, comorbidities), surgical characteristics (operated eye, IOL fixation site, optic-haptic junction location), and ND prevalence and its associated factors. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. Demographic and Baseline Characteristics

The study included 102 patients with a mean age of 63.7 ± 9.8 years in Group 1 and 63.9 ± 10.4 years in Group 2 ($p = 0.924$). Gender distribution differed significantly between groups ($p = 0.001$), with more females in Group 1 (60.8% vs. 27.5%). Diabetes mellitus was the most common comorbidity in both groups (52.9% in Group 1 and 60.8% in Group 2), followed by hypertension.

3.2. Surgical Characteristics

As shown in Table 1, surgery was performed on the right eye in 62.7% of Group 1 patients and 49.0% of Group 2 patients ($p = 0.163$). Capsular bag fixation was used in 100% of Group 1 cases and 96.1% of Group 2 cases ($p = 0.153$). The main incision was done superiotemporal, with the optic-haptic junction vertical in all Group 1 cases and superior main incision with the optic-haptic junction inferotemporal in all Group 2 cases.

Table 1. Participants' surgical characteristics.

Characteristic	Supratemporal Incision (Group 1) n = 51	%	Superior Incision (Group 2) n = 51	%	Total n = 102	p-value
Operated Eye						
Right eye	32	62.7%	25	49.0%	57 (55.9%)	0.163
Left eye	19	37.3%	26	51.0%	45 (44.1%)	
IOL Fixation Site						
Capsular bag	51	100.0%	49	96.1%	100 (98.0%)	0.153
Ciliary sulcus	0	0.0%	2	3.9%	2 (2.0%)	
Optic-haptic Junction						
Vertical	51	100.0%	0	0.0%	51 (50.0%)	—
Inferotemporal	0	0.0%	51	100.0%	51 (50.0%)	—

3.3. Incidence of Negative Dysphotopsia

As shown in Table 2, the overall ND incidence (any report of dark shadows or curtains at day 1, day 3, or week 4) was 2.9% (3/102 patients): 3.9% (2/51) in Group 1 and 2.0% (1/51) in Group 2 (p = 0.558). Among patients with ND, 50.0% in Group 1 and 100% in Group 2 reported worsening in bright light and improvement in dim lighting (p = 0.386). By week 4, symptom improvement was reported by the single Group 2 patient (100%) but by none of the two Group 1 patients (0%; p = 0.083). With only three ND events in total, no stable between-group inference can be drawn from these observations.

Table 2. Negative dysphotopsia incidence and characteristics.

ND Symptom	Group 1 (n = 51) Count	%	Group 2 (n = 51) Count	%	Total (n = 102)	p
ND reported (dark shadows/curtains) — any of day 1, day 3, or week 4	2	3.9%	1	2.0%	3 (2.9%)	0.558
Worsens in bright light/ improves in dim light	1/2	50.0%	1/1	100.0%	2/3 (66.7%)	0.386
Symptom improvement by postoperative week 4	0/2	0.0%	1/1	100.0%	1/3 (33.3%)	0.083

3.4. Relationship between Optic-Haptic Junction Position and ND

As shown in Table 3, among patients who experienced ND, 66.7% (2/3) had a vertical optic-haptic junction and 33.3% (1/3) had an inferotemporal optic-haptic junction. Among patients who did not experience ND, 49.5% (49/99) had a vertical optic-haptic junction and 50.5% (50/99) had an inferotemporal optic-haptic junction. There was no statistically significant association between optic-haptic junction position and ND incidence (p = 0.558).

Table 3. Negative dysphotopsia and optic-haptic junction position.

Optic-haptic Junction	ND Yes Count	%	ND No Count	%	p
Vertical	2	66.7%	49	49.5%	0.558
Inferotemporal	1	33.3%	50	50.5%	

4. Discussion

4.1. Overview

The present study aimed to evaluate the effectiveness of different surgical strategies in reducing the incidence of ND after IOL implantation. Because center, surgeon, incision site, and optic-haptic junction orientation were inseparable within each group, the findings reflect differences between complete approaches rather than the independent effect of any single variable. This distinction is important when interpreting comparisons with studies that manipulated only one variable.

4.2. Incidence of ND

The overall ND incidence of 2.9% is lower than rates reported in several prior studies. Osher RH. reported that 15.2% of patients experienced ND on the first postoperative day, declining to 3.2% at one year and 2.4% at two to three years [3]. A study done by Davison JA. reported a range of 0.2% - 20% [4]. The relatively low rate observed here may reflect the surgical techniques used, the characteristics of the implanted IOLs, the timing of assessment, or a combination of these factors.

4.3. Comparison with Previous Studies

No statistically significant difference in ND incidence was found between the supratemporal-incision/vertical-junction approach (3.9%) and the superior-incision/inferotemporal-junction approach (2.0%) ($p = 0.558$). This is broadly consistent with a study done by Cooke DL., which demonstrated that ND could occur after both superior scleral tunnel and temporal corneal incisions [9]. Masket et al. suggested that temporal corneal incisions may contribute to early ND but also noted that symptoms can persist after lens exchange, indicating that the incision site is not the sole determinant [10].

Regarding optic-haptic junction orientation, Henderson et al. reported a 2.3-fold reduction in ND when the junction was placed inferotemporally versus vertically [6]. However, Safran (2017) noted that this reduction was apparent only on day 1 and week 1, not at 28 days [11]. Pamulapati et al. found a significant association between junction orientation and ND at four to six weeks in a randomised controlled trial, with the horizontal orientation performing best [12]. The absence of a significant difference in our study may be partly explained by the timing of assessment and by the very low absolute event count.

4.4. Mechanisms and Risk Factors

Several mechanisms have been proposed for ND. Holladay et al. attributed it to a

gap in rays traversing the lens edge [7], while Masket et al. emphasised light reflection from the IOL edge. Identified risk factors include small pupil size, large positive angle kappa, IOL geometry, and anterior capsule position were reported in different studies [13] [14].

4.5. Strengths and Limitations

Strengths of this study include its prospective design, equal group allocation, structured follow-up at three time points, and the use of a consistent IOL class (monofocal acrylic) across both groups. However, several limitations must be acknowledged. First, the sample size is relatively small (102 patients), yielding only three ND events; this severely limits statistical power and precludes stable between-group inference. Second, center, surgeon, incision site, and junction position were completely linked, so the independent contribution of each cannot be estimated. Third, important ND-related variables were not measured, including pupil size, angle kappa, anterior capsule overlap, and detailed IOL position; any of these factors may influence ND independently of the surgical approach and represent a relevant source of unmeasured confounding. Fourth, the follow-up period (four weeks) is relatively short for fully assessing long-term ND resolution.

For persistent ND cases, reported treatment options include bag-to-sulcus IOL exchange, reverse optic capture, secondary piggyback IOL, or nasal anterior capsulectomy [2] [8].

5. Conclusions

This prospective comparative study compared two surgical approaches—supratemporal incision with vertical optic-haptic junction (Group 1) and superior incision with inferotemporal optic-haptic junction (Group 2) with respect to ND incidence after cataract surgery. The overall ND incidence was low (2.9%), and no statistically significant difference between surgical approaches was detected ($p = 0.558$). With only three ND events observed, no stable between-group inference is possible, and the mechanism of ND likely involves multiple interacting factors beyond those captured in this study.

Future research should include larger, adequately powered studies with longer follow-up periods, independent variation of surgical variables, and systematic measurement of ND-related factors such as pupil size, angle kappa, anterior capsule overlap, and IOL position. Advanced imaging modalities such as anterior-segment optical coherence tomography may help elucidate the precise anatomical relationships underlying ND.

Disclosure

All authors have declared that no financial support was received from any organisation for this work. All authors have declared no financial relationships, at present or within the previous three years, with any organisation that might have an interest in the submitted work.

Acknowledgements

The authors would like to thank all patients who participated in this research, and both centers for their support and accessibility to patient data.

Author Contributions

All authors contributed substantially to all stages of this research. All authors participated in writing and revising the manuscript, including the preparation of the first and final drafts of the abstract and discussion sections. They critically reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work, including its accuracy and integrity.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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