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Evaluation of the efficacy of blue-light monofocal intraocular lenses in cataract surgery: a single-center observational study

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ABSTRACT

Aims: Blue-light filtering intraocular lenses (IOLs) have been introduced to reduce retinal exposure to short-wavelength light, potentially protecting against macular damage and enhancing visual function. This study aims to evaluate the clinical efficacy of the Acriva BB UD 613 blue-light filtering monofocal intraocular lens (IOL) in patients undergoing cataract surgery, focusing on visual acuity, contrast sensitivity, and postoperative outcomes.

Methods: This was a prospective, single-center observational study conducted at Erciyes University. Patients aged 50 years or older who underwent phacoemulsification with implantation of the Acriva BB UD 613 IOL were included. The sample size was determined based on the clinical volume of eligible patients meeting the inclusion criteria during the study period. Visual acuity, contrast sensitivity, and refractive outcomes were assessed at multiple postoperative time points (0-3 days, 7-14 days, 1-2 months, and 4-6 months). Statistical analyses included Wilcoxon signed ranks test and repeated measures analysis for longitudinal comparisons.

Results: A total of 64 patients (mean age: 66.18±10.27 years) were included. Uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA) significantly improved postoperatively ($p<0.05$). Contrast sensitivity remained stable at all follow-up visits, with no significant changes in color perception. No major complications were observed, and posterior capsular opacification incidence was low.

Conclusion: In this single-center observational study, the Acriva BB UD 613 blue-light filtering monofocal IOL demonstrated significant improvements in visual acuity and maintained contrast sensitivity, which are consistent with expected outcomes following routine crystalline lens extraction. These findings support its use as a safe and effective option for cataract surgery. Further long-term studies are needed to assess its impact on retinal health and potential protective effects against macular degeneration.

Keywords: Acriva BB UD 613, blue-light filtering intraocular lens, cataract surgery, contrast sensitivity, macular protection, phacoemulsification

INTRODUCTION

The macula, a specialized region of the retina, plays a critical role in central vision and color perception. Spanning approximately 5 mm in diameter, it contains carotenoid pigments like lutein and zeaxanthin, which naturally filter short-wavelength light such as blue and violet, protecting the retina from potential phototoxic damage.[1] Maintaining macular health is essential for clear vision, as diseases affecting this region, such as age-related macular degeneration (AMD), can cause significant vision loss.[2] AMD is a leading cause of blindness in older adults, with its prevalence rising sharply after the age of 50. While risk factors like genetics and smoking are well-established, the potential role of cumulative blue-light exposure in AMD progression remains a subject of scientific investigation.[3]

Blue-light filtering intraocular lenses (IOLs) have been introduced to reduce retinal exposure to short-wavelength light, aiming to mitigate phototoxic risks and enhance visual performance. These lenses, which incorporate yellow chromophores, selectively block blue light while maintaining overall light transmission.[4] They are particularly relevant in cataract surgery, where the natural crystalline lens is replaced with an artificial intraocular lens (IOL). While blue-light filtering IOLs offer potential benefits, such as protecting against macular damage and improving contrast sensitivity,

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concerns persist about their impact on circadian rhythms and color vision.[5]

The primary objective of this study is to evaluate the clinical efficacy of the Acriva BB UD 613 monofocal IOL in a real-world setting. The research focuses on patients who have undergone cataract removal via phacoemulsification and subsequently received this specific lens implant. By assessing critical outcomes, such as visual acuity and contrast sensitivity, the study aims to provide comprehensive evidence of the lens's performance in routine clinical practice, ultimately contributing to the enhancement of cataract patient care and surgical outcomes.

METHODS

Ehics

This was a prospective, single-center observational study designed to evaluate the safety and efficacy of the Acriva BB UD 613 monofocal IOL in patients undergoing cataract surgery. The study complied with the Declaration of Helsinki and was approved by the institutional ethics committee. All participants provided informed consent prior to inclusion in the study. It has been approved by the Erciyes University Clinical Researches Ethics Committee (Date: 19.03.2025, Decision No: 2025/150).

Study Population

The study included patients aged 50 years or older who underwent cataract removal through phacoemulsification. The sample size (n=64) was determined based on the total volume of eligible patients who met the specific inclusion and exclusion criteria during the designated study recruitment period. Eligibility criteria required the primary implantation of the Acriva BB UD 613 monofocal intraocular lens in one or both eyes. Participants were limited to those with cataracts graded below grade 4, as defined by CTCAE v5.0. Additional inclusion criteria included an axial length ranging between 21.0 mm and 26.0 mm and corneal astigmatism of less than 1.0 diopters for non-toric lenses.

Patients were excluded if they had a history of prior ocular surgeries or systemic or ocular conditions likely to impact surgical outcomes, such as advanced diabetes with retinopathy, amblyopia, or glaucoma. Individuals with irregular astigmatism, such as keratoconus, or those experiencing significant surgical complications, including vitreous loss, were also excluded.

Surgical Procedure

All cataract surgeries were performed by (two) experinced ophthalmic surgeons (MU vs FH) using the AMO Signature Whitestar Pro Phacoemulsification System. This advanced system incorporates elliptical ultrasound technology and precise fluidics to ensure efficient lens removal with minimal ocular disruption. The phacoemulsification process was carried out under balanced infusion and aspiration flow rates to maintain a stable anterior chamber. Surgery was initiated with a 2.8 mm clear corneal incision along the steep axis, creating a short tunnel for entry. After lens removal, the Acriva BB UD 613 intraocular lens was implanted through a corneal incision using a acrijetfly injection system, enabling accurate placement within the capsular bag with minimal tissue manipulation.

Technical Specifications of Acriva BB UD 613 IOL

The Acriva BB UD 613 intraocular lens is a monofocal, biconvex, and aspheric lens made from hydrophobic acrylic material with a water content of 25%. It has an optic diameter of 6.0 mm and an overall length of 13.0 mm. The lens features an asphericity value of -0.1 µm, which enhances visual performance by reducing spherical aberrations. It is designed to block ultraviolet and harmful short-wavelength visible light, with a spectral transmittance cut-off of <10% at 370 nm. The lens has a Refractive Index of 1.46 (measured at 546 nm) and offers a wide dioptric power range from 0.00 D to 32.00 D in 0.5 D increments. With an MTF value exceeding 0.6 at 20.00 D and 100 lp/mm, and an Abbe number of 58, the lens minimizes chromatic aberration while maintaining high image quality. Additionally, the yellow chromophore integrated into the lens selectively filters blue light, reducing retinal phototoxicity and supporting optimal visual clarity.

Outcome Measures

The primary outcomes of the study included best-corrected visual acuity (BCVA) and contrast sensitivity performance. These metrics were used to evaluate the efficacy of the Acriva BB UD 613 intraocular lens in improving postoperative visual function.

Secondary outcome included the incidence of posterior capsular opacification (PCO), which was monitored to assess the lens's long-term safety and stability.

Data Collection

Data were collected during scheduled preoperative and postoperative visits at 1-3 days, 7-10 days, 30-60 days, and 120-180 days. Evaluated parameters included uncorrected and corrected visual acuity, refractive error, and contrast sensitivity under photopic and mesopic conditions. Additionally, biomicroscopic evaluations were conducted to assess the position of the implanted lens and document any adverse effects.

Statistical Analysis

The collected data were analyzed using both descriptive and inferential statistical methods. Continuous variables were expressed as mean±standard deviation, while categorical variables were presented as frequencies and percentages. Non-parametric tests, such as the Wilcoxon signed ranks test, were used to compare preoperative and postoperative outcomes for non-normally distributed variables. For repeated measures across multiple time points, the Friedman test was employed to assess statistical significance in longitudinal changes. Analysis of variance (ANOVA) or Kruskal-Wallis tests were applied where appropriate to compare differences between groups, and pairwise comparisons were conducted with Bonferroni adjustments to control for multiple testing. Statistical significance was set at $p<0.05$ for all tests. Data were analyzed using SPSS version 21 software.

RESULTS

A total of 64 patients were evaluated, with a mean age of 66.18±10.27 years (range: 46-88). The majority of participants were female (68.8%, 44 females, and 20 males). The biometric parameters of the eyes are listed in Table 1. The mean axial length was 23.53±1.67 mm (range: 21.16-25.99 mm),

and the anterior chamber depth averaged 3.08±0.39 mm (range: 2.05-3.88 mm). The white-to-white (WTW) corneal diameter measured 11.74±0.41 mm (range: 10.80-12.63 mm). Additionally, the lens thickness (LT) was 4.15±0.39 mm (range: 2.84-5.12 mm), while the mean corneal thickness (pachymetry) was 538.52±47.58 µm (range: 465-682 µm).

Table 1. Biometric descriptives data of study population

Variables	Values
Age	66.18±10.27 (46-88)
Axial length	23.53±1.67 (21.16-25.99)
Anterior chamber depth	3.08±0.39 (2.05-3.88)
White to white	11.74±0.41 (10.80-12.63)
Lens thickness	4.15±0.39 (2.84-5.12)
Corneal thickness	538.52±47.58 (465.00-682.00)

The refractive error outcomes are listed in Table 2 and were evaluated across five time points; preoperatively, 0-3 days, 7-14 days, 1-2 months, and 4-6 months postoperatively. For spherical refractive error (S), the mean value improved from -1.75±4.50 preoperatively to 0.00±0.93 at 0-3 days, 0.05±0.90 at 7-14 days, 0.02±0.89 at 1-2 months, and remained stable at 0.02±0.90 at 4-6 months. Although there was a trend toward improvement, the changes were not statistically significant at any time point (p>0.05). The cylindrical refractive error (C) remained relatively consistent, with a mean of -1.23±0.89 preoperatively and -1.33±0.88 at 0-3 days, -1.38±0.74 at 7-14 days, -1.32±0.76 at 1-2 months, and -1.30±0.78 at 4-6 months. Again, no significant differences were observed over time (p>0.05). For axis (AX), the preoperative mean was 100.2±41.9, which showed slight fluctuations postoperatively, including 106.98±46.7 at 0-3 days, 105.48±47.0 at 7-14 days, 100.0±45.5 at 1-2 months, and 101.7±46.2 at 4-6 months. These variations were also not statistically significant (p>0.05).

at 7-14 days, 14.26±2.86 at 1-2 months, and 14.86±1.57 at 4-6 months. No statistically significant differences were observed between these postoperative time points (p>0.05).

Table 3. Intraocular pressure outcomes

Time point	Mean±SD	p-value (preop vs time point)	Comparison with next time point	p-value
Preoperative	13.37±2.34	-	0-3 days	0.05
0-3 days	14.85±2.60	0.05	7-14 days	0.39
7-14 days	14.33±2.74	0.38	1-2 months	0.39
1-2 months	14.26±2.86	0.70	4-6 months	0.39
4-6 months	14.86±1.57	-	-	-

SD: Standard deviation

The uncorrected visual acuity (UCVA) outcomes are listed in Table 4 nd were evaluated at five time points; preoperatively, 0-3 days, 7-14 days, 1-2 months, and 4-6 months postoperatively. The mean UCVA significantly improved from 0.20±0.12 (range: 0.00-0.40) preoperatively to 0.63±0.52 (range: 0.05-1.00) at 0-3 days, 0.76±0.23 (range: 0.10-1.00) at 7-14 days, 0.78±0.23 (range: 0.10-1.00) at 1-2 months, and 0.81±0.22 (range: 0.10-1.00) at 4-6 months. Statistically significant differences were observed between the preoperative and all postoperative time points (p<0.05), highlighting the efficacy of the intervention. While the UCVA showed significant improvement between 0-3 days and subsequent time points (7-14 days, 1-2 months, and 4-6 months, p<0.05), no significant differences were noted between 7-14 days, 1-2 months, and 4-6 months (p>0.05). These results indicate that the most substantial gains in UCVA occur within the first two weeks postoperatively, with visual outcomes stabilizing thereafter.

The BCVA outcomes are listed in Table 5 and were evaluated at five time points; preoperatively, 0-3 days, 7-14 days, 1-2 months, and 4-6 months postoperatively. The mean BCVA significantly improved from 0.31±0.19 (range: 0.05-1.00) preoperatively to 0.82±0.23 (range: 0.10-1.00) at 0-3 days, 0.85±0.22 (range: 0.10-1.00) at 7-14 days, 0.88±0.17 (range: 0.20-1.00) at 1-2 months, and 0.91±0.18 (range: 0.10-1.00)

Table 2. Refractive error outcomes

Parameter	Time point	Mean±SD	p-value (preop vs time point)	Comparison with next time point	p-value
S	Preoperative	-1.75±4.50	-	0-3 days	0.15
	0-3 days	0.00±0.93	0.15	7-14 days	0.64
	7-14 days	0.05±0.90	0.15	1-2 months	0.64
	1-2 months	0.02±0.89	0.15	4-6 months	0.64
	4-6 months	0.02±0.90	0.15	-	-
C	Preoperative	-1.23±0.89	-	0-3 days	0.15
	0-3 days	-1.33±0.88	0.15	7-14 days	0.66
	7-14 days	-1.38±0.74	0.15	1-2 months	0.13
	1-2 months	-1.32±0.76	0.15	4-6 months	0.51
	4-6 months	-1.30±0.78	0.15	-	-
AX	Preoperative	100.2±41.9	-	0-3 days	0.44
	0-3 days	106.98±46.7	0.44	7-14 days	0.43
	7-14 days	105.48±47.0	0.26	1-2 months	0.43
	1-2 months	100.0±45.5	0.23	4-6 months	0.43
	4-6 months	101.7±46.2	0.65	-	-

SD: Standard deviation, S: Sphere, C: Cylinder, AX: Axis

The intraocular pressure outcomes are listed in Table 3 were evaluated at five time points: preoperatively, 0-3 days, 7-14 days, 1-2 months, and 4-6 months postoperatively. The mean value increased from 13.37±2.34 preoperatively to 14.85±2.60 at 0-3 days (p=0.05). Subsequently, the mean values were 14.33±2.74

Table 4. UCVA outcomes

Time point	Mean±SD (min-max)	p-value (preop vs time point)	Comparison with next time point	p-value
Preoperative	0.20±0.11 (0.00-0.40)	-	0-3 days	<0.01
0-3 days	0.63±0.52 (0.05-1.00)	0.001	7-14 days	<0.01
7-14 days	0.76±0.22 (0.10-1.00)	<0.001	1-2 months	0.93
1-2 months	0.78±0.23 (0.10-1.00)	<0.001	4-6 months	0.11
4-6 months	0.81±0.22 (0.10-1.00)	<0.001	-	-

UCVA: Uncorrected visual acuity, SD: Standard deviation, Min: Minimum, Max: Maximum

Table 5. BCVA outcomes

Time point	Mean±SD (min-max)	p-value (preop vs time point)	Comparison with next time point	p-value
Preoperative	0.31±0.19 (0.05-1.00)	-	0-3 days	<0.01
0-3 days	0.82±0.23 (0.10-1.00)	<0.01	7-14 days	0.37
7-14 days	0.85±0.22 (0.10-1.00)	<0.01	1-2 months	0.52
1-2 months	0.88±0.17 (0.20-1.00)	<0.01	4-6 months	0.18
4-6 months	0.91±0.18 (0.10-1.00)	<0.01	-	-

BCVA: Best-corrected visual acuity, SD: Standard deviation, Min: Minimum, Max: Maximum

at 4-6 months. Statistically significant differences were observed between the preoperative and all postoperative time points ($p<0.05$), highlighting the intervention's effectiveness. Although BCVA continued to improve significantly between 0-3 days and 4-6 months ($p<0.05$), no statistically significant differences were found between 7-14 days, 1-2 months, and 4-6 months ($p>0.05$). These findings suggest that the most substantial improvement in BCVA occurs during the early postoperative period, particularly within the first two weeks, with outcomes stabilizing thereafter.

Contrast sensitivity outcomes are listed in Table 6. The contrast sensitivity outcomes were evaluated under various conditions, including photopic and mesopic settings, with and without glare, at spatial frequencies of 3, 6, 12, and 18 cycles per degree (cpd). The measurements were taken preoperatively and at 1-2 months and 4-6 months postoperatively. Overall, contrast sensitivity remained stable over time across all tested conditions, with minor fluctuations that were not clinically significant. The findings suggest that postoperative contrast sensitivity function is well maintained across different spatial frequencies and lighting conditions.

Table 6. Contrast sensitivity outcomes

Contrast sensitivity	cpd	1-2 months (mean±SD)	4-6 months (mean±SD)
Photopic binocular	3	1.52±0.30	1.51±0.30
Photopic with glare	3	1.49±0.27	1.49±0.27
Mesopic binocular	3	1.45±0.29	1.45±0.28
Mesopic with glare	3	1.47±0.28	1.46±0.29
Photopic binocular	6	1.66±0.27	1.67±0.30
Photopic with glare	6	1.7±0.26	1.71±0.27
Mesopic binocular	6	1.66±0.30	1.66±0.28
Mesopic with glare	6	1.73±0.24	1.71±0.28
Photopic binocular	12	1.37±0.32	1.38±0.32
Photopic with glare	12	1.42±0.30	1.45±0.33
Mesopic binocular	12	1.37±0.31	1.38±0.30
Mesopic with glare	12	1.42±0.30	1.42±0.31
Photopic binocular	18	0.96±0.30	0.98±0.36
Photopic with glare	18	1.02±0.30	1.03±0.34
Mesopic binocular	18	0.95±0.33	0.97±0.34
Mesopic with glare	18	0.98±0.32	0.99±0.36

cpd: Cycles per degree, SD: Standard deviation

DISCUSSION

Blue light-filtering IOLs are designed to reduce the transmission of potentially harmful blue and ultraviolet (UV) light to the retina.[6,7] The primary rationale for their development is to mitigate retinal damage and decrease the risk of AMD.[8] Short-wavelength light is suggested to contribute to retinal phototoxicity and the progression of AMD; thus, blue light-filtering IOLs are hypothesized to protect retinal cells by reducing this exposure.[9] Consequently, these lenses may aid in preserving macular health and function, potentially lowering the risk of AMD development.[10,11]

Current literature indicates no significant differences in BCVA and contrast sensitivity between eyes implanted with blue light-filtering IOLs and those with only UV-filtering IOLs.[12-14] Additionally, while blue light-filtering IOLs may induce a slight shift in color perception, this change has been reported as not statistically significant.[13] Clinically, patients generally do not perceive a noticeable difference in color vision between blue light-filtering and non-blue light-filtering IOLs.[13]

The primary findings of our study indicate that these lenses enhance visual acuity, maintain contrast sensitivity, and provide a safe option for implantation. Following the implantation of Acriva BB UD 613 lenses, both BCVA and UCVA significantly improved. These results align with previous research suggesting that blue light-filtering IOLs do not have a significant adverse effect on BCVA or contrast sensitivity.[12]

Studies investigating the impact of blue light-filtering IOLs on sleep quality have found no significant effect.[15] Pittsburgh Sleep Quality Index (PSQI) scores did not differ significantly between individuals with blue light-filtering IOLs and those with conventional IOLs.[16] While UV-blocking IOLs have been associated with a slight improvement in sleep quality in the early postoperative period, this difference was not statistically significant in the long term.[17] Overall, the current body of evidence suggests that blue light-filtering IOLs do not have a meaningful impact on sleep quality.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the single-center

design may limit the generalizability of the results to broader populations with diverse demographic and clinical characteristics. Second, the follow-up period of six months, while sufficient to assess early visual outcomes, may not capture long-term complications such as PCO and its impact on visual function, and possible long-term retinal effects. Additionally, the absence of a control group, such as patients implanted with a UV-only IOL, makes it difficult to determine whether the observed outcomes are specifically attributable to the blue-light filtering feature of the lens or simply the result of standard cataract removal.

CONCLUSION

In this single-center observational study, the Acriva BB UD 613 blue-light filtering monofocal intraocular lens demonstrated significant improvements in uncorrected and BCVA following cataract surgery, which is consistent with expected outcomes following routine crystalline lens extraction. Contrast sensitivity was maintained postoperatively, and no significant adverse effects were observed. These findings suggest that blue-light filtering IOLs are a safe and effective option for implantation in cataract patients.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was approved by the Erciyes University Clinical Researches Ethics Committee (Date: 19.03.2025, Decision No: 2025/150).

Informed Consent

Written informed consent was obtained from all individual participants prior to their inclusion in the study. Participants were fully informed about the study's aims, procedures, potential risks and benefits, and their rights-including the right to withdraw at any time without consequence. All participants voluntarily signed a written informed consent form.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

This study received financial support from VSY Biotechnology, which provided the Acriva BB UD 613 intraocular lenses used in the research. The sponsor had no involvement in the study design, data collection, analysis, interpretation, or the decision to publish the manuscript.

Author Contributions

Concept: HŞ, VK, HKS, MÜ, FH, DGS; Design: HŞ, VK, HKS, MÜ, FH, DGS; Control: HŞ, VK, HKS, MÜ, FH, DGS; Resources: HŞ, VK, HKS, MÜ, FH, DGS; Materials: HŞ, VK, HKS, MÜ, FH, DGS; Data Collection and/or Processing: HŞ, VK, HKS, MÜ, FH, DGS; Analysis and/or Interpretation: HŞ, VK, HKS, MÜ, FH, DGS; Literature Review: HŞ, VK, HKS, MÜ, FH, DGS; Writing the Article: HŞ, VK, HKS, MÜ, FH, DGS; Critical Review: HŞ, VK, HKS, MÜ, FH, DGS.

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