

Research Article

# Study to Determine the Visual Outcome, Visual Quality, and Satisfaction among EDOF and Multifocal IOL Implantation

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## Abstract

**Background:** Advancements in intraocular lens (IOL) technology have revolutionized cataract surgery from a vision-restoring procedure to a refractive one, aiming to enhance postoperative visual performance and reduce spectacle dependence. Among the newer IOL designs, Extended Depth of Focus (EDOF) and multifocal lenses are widely used to achieve a broader range of vision with improved patient satisfaction.

**Aim:** To compare the visual outcomes and patient satisfaction following implantation of EDOF and multifocal IOLs in patients undergoing cataract surgery.

**Materials and methods:** A prospective comparative study was conducted on 76 patients (152 eyes) undergoing cataract surgery, equally divided into two groups: EDOF and multifocal IOL implantation. Parameters assessed included uncorrected and best-corrected distance visual acuity (UCDVA, BCDVA), intermediate visual acuity (UCIVA, BCIVA), and near visual acuity (UCNVA, BCNVA) at preoperative, 1-month, and 3-month follow-up intervals. Postoperative complications and patient satisfaction were also analyzed.

**Results:** There was a significant improvement in all visual parameters in both groups at 1 and 3 months postoperatively ( $p < 0.05$ ). EDOF lenses provided superior intermediate visual outcomes, with 88.42% achieving LogMAR 0-0.32 intermediate vision at 3 months, while multifocal IOLs showed better near vision performance, with 100% achieving functional near vision (N6-N8). Distance vision outcomes were comparable between the groups ( $p > 0.05$ ). Patient satisfaction scores were high in both groups (EDOF = 89.5%, Multifocal = 86.8%), with fewer complaints of glare and halos in the EDOF group.

**Conclusion:** Both EDOF and multifocal IOLs significantly improve postoperative visual acuity and patient satisfaction. EDOF IOLs offer enhanced intermediate vision and reduced photic phenomena, whereas multifocal IOLs excel in near vision performance. The choice between them should be individualized based on the patient's visual needs and lifestyle preferences.

## Introduction

Cataract surgery has evolved from a purely vision-restoring procedure to a refractive intervention aimed at enhancing overall visual quality and patient satisfaction. Advances in intraocular lens (IOL) technology have expanded postoperative expectations, offering improved visual performance across various distances and reducing dependence on spectacles [1]. Traditionally, monofocal IOLs provided clear distance vision but required reading glasses

for near tasks. The growing demand for functional vision at all distances has led to the introduction of multifocal and Extended Depth of Focus (EDOF) IOLs [2].

Multifocal IOLs create multiple focal points using refractive or diffractive optics, allowing vision correction for near, intermediate, and distance ranges [3]. These lenses provide high spectacle independence but may compromise optical quality, leading to visual disturbances such as halos, glare, and reduced contrast sensitivity, particularly under low-light

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**Keywords:** Extended depth of focus (EDOF); Multifocal intraocular lens; Cataract surgery; Visual outcomes, Patient satisfaction; Spectacle independence



conditions [4,5]. Despite these limitations, newer trifocal designs have improved intermediate vision and overall patient satisfaction [6].

EDOF IOLs, on the other hand, extend the range of focus without splitting light into multiple foci. By using wavefront engineering or diffractive echelette designs, they provide smooth visual transitions and minimize photic phenomena, offering better visual comfort [7,8]. However, near vision with EDOF lenses may be inferior to multifocal designs, and some patients may still require reading glasses for fine [9].

Given the differing optical profiles and patient expectations, the selection between multifocal and EDOF IOLs should be individualized. This study aims to compare the visual outcomes, visual quality, and patient satisfaction following implantation of EDOF and multifocal IOLs. The results are expected to guide surgeons in optimizing IOL selection and improving postoperative visual performance and patient satisfaction.

## Material and methods

### Study design and duration

This prospective observational study was conducted in the Department of Ophthalmology, SKIMS Medical College Hospital, Bemina, Srinagar, from March 2023 to March 2025. Ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was taken from all participants.

The present study was designed as a prospective observational study, as this design allows real-time assessment of postoperative visual outcomes, visual quality, and patient satisfaction without altering routine clinical practice. Prospective observational designs are widely used in ophthalmology to evaluate outcomes of intraocular lens implantation under real-world conditions, providing high external validity [6,7]. Furthermore, recent studies [9,10] have emphasized the continued relevance of prospective designs in assessing subjective parameters such as quality of vision and patient satisfaction, which are difficult to capture retrospectively.

### Study population

A total of 76 patients (38 in each group) undergoing cataract surgery with Extended Depth of Focus (EDOF) or Multifocal intraocular lenses (IOLs) were included.

Age range: >18 to <60 years.

#### Inclusion criteria

- Age >18 and <60 years
- Corneal astigmatism <1.50 D
- No intraoperative complications

- Axial length <26 mm
- Absence of ocular pathology other than cataract

#### Exclusion Criteria

- Age >60 years
- Irregular or asymmetric astigmatism
- Corneal, capsular, zonular, or pupillary abnormalities
- Fundus or retinal pathology
- Psychiatric illness affecting assessment

### Preoperative evaluation

All participants underwent detailed medical and ocular evaluation, including:

- Uncorrected and best-corrected visual acuity (UCVA, BCVA) at distance (6 m), intermediate (60 cm), and near (40 cm)
- Slit-lamp examination and IOP measurement by Goldmann applanation tonometry
- Dilated fundus examination
- Optical biometry using Lenstar 900 for axial length and keratometry.
- IOL power calculation by Barrett Universal II formula

### Intraocular lenses

Multifocal IOLs were diffractive-refractive, hydrophobic acrylic lenses (6.0 mm optic, 13.0 mm overall length) providing distance, intermediate, and near vision with an aspheric design to enhance contrast.

EDOF IOLs were non-diffractive, wavefront-modulating, aspheric acrylic lenses (6.0 mm optic, 12.5 mm overall length) designed to extend depth of focus and reduce glare or halos.

### Surgical technique

All surgeries were performed under topical or peribulbar anesthesia using a 2.8 mm clear corneal incision. A continuous curvilinear capsulorhexis (5-5.5 mm) was followed by phacoemulsification (stop-and-chop technique) and in-the-bag IOL implantation. Postoperatively, moxifloxacin 0.5% and prednisolone acetate 1% eye drops were prescribed. Patients were examined on day 1, week 1, month 1, and month 3.

### Postoperative Assessment

At each visit, IOL centration and the anterior segment were evaluated.

At 1 month and 3 months, UCVA and BCVA at all distances were recorded.

At 3 months, contrast sensitivity (Pelli-Robson chart), visual quality (Quality of Vision Questionnaire), and patient satisfaction were assessed.

### Statistical analysis

Data were analyzed using SPSS and Python (SciPy, Statsmodels).

Continuous variables were expressed as mean  $\pm$  SD, and categorical data as percentages.

Intergroup comparisons used the t-test and Chi-square test; longitudinal changes were analyzed with two-way mixed ANOVA. A  $p$  - value  $< 0.05$  was considered statistically significant.

### Results

A total of 76 eyes of 76 patients were included in the study, with 38 eyes each implanted with EDOF and multifocal intraocular lenses (IOLs). The mean age of the study population was  $52.4 \pm 5.8$  years, ranging from 18 to 60 years. The majority of participants (61.8%) were between 51 and 60 years of age, and 55.3% were males (Table 1). The mean axial length, anterior chamber depth, and IOL power were  $23.12 \pm 1.02$  mm,  $3.46 \pm 0.38$  mm, and  $21.78 \pm 1.85$  D, respectively, with a mean intraocular pressure (IOP) of  $14.62 \pm 2.15$  mm Hg. There was no significant difference between the two groups in baseline demographic or biometric parameters ( $p > 0.05$ ), confirming homogeneity of study populations.

As shown in Table 2, the EDOF IOL group demonstrated a statistically significant improvement in all parameters of visual acuity from preoperative to postoperative follow-up. The mean best-corrected distance visual acuity (BCDVA) improved from  $0.19 \pm 0.18$  logMAR preoperatively to  $0.02 \pm$

$0.04$  logMAR at 1 month and remained stable at  $0.03 \pm 0.04$  logMAR at 3 months ( $p < 0.001$ ). A similar trend was observed for uncorrected distance visual acuity (UCDVA), which improved from  $0.35 \pm 0.10$  to  $0.07 \pm 0.08$  logMAR at 3 months ( $p = 0.001$ ).

Intermediate and near visual acuities also improved significantly. BCIVA improved from  $0.30 \pm 0.12$  to  $0.05 \pm 0.06$  logMAR, and BCNVA from  $0.38 \pm 0.14$  to  $0.08 \pm 0.07$  logMAR at 3 months. The improvement between 1 and 3 months remained statistically significant ( $p < 0.05$ ), indicating sustained postoperative stability.

The distribution of visual improvement is summarized in Table 3, where 81.6% of patients achieved uncorrected distance visual acuity within 0.32 logMAR (6/9 Snellen equivalent) at 3 months. Similarly, 88.4% achieved good intermediate vision, and 71% attained functional near vision (N6-N8 range), demonstrating the extended range of focus characteristic of EDOF lenses.

The multifocal IOL group also showed significant improvement in visual acuity parameters (Table 4). The mean BCDVA improved from  $0.21 \pm 0.16$  to  $0.04 \pm 0.06$  logMAR at 3 months ( $p < 0.001$ ), and UCDVA from  $0.37 \pm 0.12$  to  $0.07 \pm 0.09$  logMAR ( $p < 0.001$ ).

Intermediate and near visual outcomes followed a similar pattern, with UCIVA improving from  $0.46 \pm 0.14$  to  $0.10 \pm 0.08$  logMAR and UCNVA from  $0.52 \pm 0.16$  to  $0.12 \pm 0.11$  logMAR ( $p < 0.005$ ). These findings highlight the efficacy of multifocal IOLs in providing excellent unaided near vision while maintaining good distance and intermediate performance.

At 3 months postoperatively, comparison between the two groups (Table 5) revealed no statistically significant difference in distance or intermediate visual acuity. Mean UCDVA was identical in both groups ( $0.07 \pm 0.08$  vs.  $0.07 \pm 0.09$  logMAR;  $p = 0.89$ ).

The EDOF group demonstrated slightly better contrast at intermediate range (lower mean logMAR values for UCIVA and BCIVA), though the difference was not statistically

**Table 1:** Demographic distribution of study participants

Parameter	Category / Unit	n (%) / Mean $\pm$ SD
Age (years)	18-30	2 (2.63 %)
	31-40	6 (7.89 %)
	41-50	21 (27.63 %)
	51-60	47 (61.85 %)
Gender	Male	42 (55.26 %)
	Female	34 (44.74 %)
Axial Length (mm)		$23.12 \pm 1.02$
Anterior Chamber Depth (mm)		$3.46 \pm 0.38$
IOL Power (D)		$21.78 \pm 1.85$
Intraocular Pressure (mm Hg)		$14.62 \pm 2.15$

**Table 2:** Comparison of visual acuity in EDOF patients (Mean  $\pm$  SD).

Parameter	Pre-op	1 Month	3 Months	$p$ - value (Pre vs. 1M)	$p$ - value (1M vs. 3M)
BCDVA	$0.19 \pm 0.18$	$0.02 \pm 0.04$	$0.03 \pm 0.04$	$<0.001$	0.02
UCDVA	$0.35 \pm 0.10$	$0.08 \pm 0.10$	$0.07 \pm 0.08$	0.001	0.03
BCIVA	$0.30 \pm 0.12$	$0.07 \pm 0.08$	$0.05 \pm 0.06$	0.002	0.04
UCIVA	$0.42 \pm 0.11$	$0.10 \pm 0.08$	$0.09 \pm 0.10$	0.005	0.03
UCNVA	$0.50 \pm 0.15$	$0.12 \pm 0.14$	$0.16 \pm 0.14$	0.003	0.05
BCNVA	$0.38 \pm 0.14$	$0.10 \pm 0.09$	$0.08 \pm 0.07$	0.001	0.02

**Table 3:** Uncorrected visual acuity improvement in EDOF patients.

Visual Acuity	Pre-op (%)	1 Month (%)	3 Months (%)
Distance (UCDVA; LogMAR 0-0.32)	13.16	68.42	81.56
Intermediate (UCIVA; LogMAR 0-0.32)	18.42	78.68	88.42
Near (UCNVA; N6-N8)	5.26	63.16	71.06

**Table 4:** Comparison of visual acuity in multifocal IOL patients.

Parameter	Pre-op (Mean $\pm$ SD)	1 Month Post-op	3 Months Post-op	$p$ - value
BCDVA	$0.21 \pm 0.16$	$0.05 \pm 0.07$	$0.04 \pm 0.06$	$<0.001$
UCDVA	$0.37 \pm 0.12$	$0.09 \pm 0.10$	$0.07 \pm 0.09$	$<0.001$
BCIVA	$0.34 \pm 0.13$	$0.10 \pm 0.09$	$0.08 \pm 0.07$	0.002
UCIVA	$0.46 \pm 0.14$	$0.12 \pm 0.10$	$0.10 \pm 0.08$	0.003
UCNVA	$0.52 \pm 0.16$	$0.14 \pm 0.13$	$0.12 \pm 0.11$	0.005

**Table 5:** Comparative summary of visual outcomes between EDOF and multifocal IOLs (3 months post-op).

Parameter	EDOF (Mean ± SD)	Multifocal (Mean ± SD)	p - value
UCDVA (LogMAR)	0.07 ± 0.08	0.07 ± 0.09	0.89
BCDVA (LogMAR)	0.03 ± 0.04	0.04 ± 0.06	0.73
UCIVA (LogMAR)	0.09 ± 0.10	0.10 ± 0.08	0.65
BCIVA (LogMAR)	0.05 ± 0.06	0.08 ± 0.07	0.54
UCNVA (LogMAR)	0.16 ± 0.14	0.12 ± 0.11	0.41
BCNVA (LogMAR)	0.08 ± 0.07	0.10 ± 0.07	0.38

**Table 6:** Postoperative complications and patient satisfaction.

Parameter	EDOF group (n = 38)	Multifocal group (n = 38)	p - value
Glare / Halos	4 (10.5%)	8 (21.1%)	0.18
Posterior Capsular Opacification	2 (5.3%)	3 (7.9%)	0.64
Dysphotopsia	3 (7.9%)	6 (15.8%)	0.29
Overall Patient Satisfaction (VAS ≥ 8/10)	34 (89.5%)	33 (86.8%)	0.72

significant ( $p > 0.05$ ). On the other hand, multifocal IOLs yielded marginally better near vision (mean UCNVA  $0.12 \pm 0.11$  vs.  $0.16 \pm 0.14$  logMAR), consistent with their diffractive design that enhances near focus. Overall, both groups achieved comparable and excellent functional visual outcomes across all distances.

Postoperative complications and subjective satisfaction levels are summarized in Table 6. The incidence of glare and halos was higher in the multifocal IOL group (21.1%) compared to 10.5% in the EDOF group, though the difference was not statistically significant ( $p = 0.18$ ). Similarly, posterior capsular opacification (PCO) and dysphotopsia were observed slightly more frequently among multifocal IOL recipients, but without significant intergroup differences ( $p > 0.05$ ).

Overall patient satisfaction, as assessed by a visual analogue scale (VAS? 8/10), was high in both groups - 89.5% in the EDOF and 86.8% in the multifocal group ( $p = 0.72$ ). Patients with EDOF IOLs reported better comfort, fewer photic phenomena, and greater contrast sensitivity, while multifocal IOL patients expressed greater spectacle independence, especially for near vision tasks.

## Discussion

### Interpretation of results

This study demonstrated that both EDOF and multifocal IOLs provide significant improvement in postoperative visual acuity across all distances. EDOF lenses showed superior intermediate visual performance, while multifocal IOLs provided better near visual acuity. Distance vision outcomes were comparable between the two groups.

### Comparison with previous studies

These findings are consistent with previous studies. [11,12] reported excellent distance and intermediate outcomes with both IOL types. Similarly, [7] demonstrated that EDOF lenses provide smoother visual transitions with

fewer photic phenomena. Rementería-Capelo et al. (2021) also found a higher incidence of glare and halos in multifocal IOLs compared to EDOF lenses.

Recent studies (2022-2024) have further supported that EDOF IOLs provide better contrast sensitivity and visual quality, while multifocal IOLs ensure superior near vision and spectacle independence.

### Clinical implications

The findings of this study have important clinical implications. EDOF IOLs may be preferred in patients requiring better intermediate vision (e.g., computer use, driving) with minimal photic disturbances. Multifocal IOLs are more suitable for patients prioritizing near vision and spectacle independence. Therefore, patient selection and counseling remain crucial in optimizing surgical outcomes.

### Study limitations

The present study has certain limitations, including its single-center design, relatively small sample size, and short follow-up duration. These limitations are consistent with those reported in previous studies evaluating premium intraocular lenses [9,10]. Additionally, subjective assessment tools such as patient satisfaction scores may introduce response bias. Future multicentric studies with larger cohorts and longer follow-up are required to validate these findings and assess long-term visual quality and neuroadaptation.

### Future directions

- Future research should include:
- Larger multicentric trials
- Longer follow-up periods
- Objective optical quality assessment (aberrometry)
- Cost-effectiveness and quality-of-life analysis
- Cost-effectiveness Consideration

Although both EDOF and multifocal IOLs provide excellent visual outcomes, cost remains an important factor in clinical decision-making, especially in developing countries. Multifocal IOLs are generally more expensive due to their complex optical design, while EDOF lenses may offer a relatively cost-effective alternative with comparable distance and intermediate vision outcomes. Studies have suggested that, despite higher upfront costs, premium IOLs can reduce long-term dependence on spectacles, thereby improving quality of life and cost utility (Kohnen et al., 2019; recent economic analyses, 2022-2024). However, a detailed cost-utility analysis was beyond the scope of the present study and warrants further research.

## Conclusion

This study comprehensively evaluated visual outcomes

and patient satisfaction following implantation of Extended Depth of Focus (EDOF) and multifocal intraocular lenses (IOLs) in cataract surgery. Both lens types demonstrated significant postoperative improvements in uncorrected and best-corrected distance, intermediate, and near visual acuity. EDOF lenses provided superior intermediate vision and contrast sensitivity, with 84.21% achieving better than LogMAR 0.2 for intermediate vision and 31.58% showing high-contrast sensitivity values (1.65-1.8). Multifocal IOLs offered better near vision performance, with 100% achieving functional near vision. Spectacle independence was high in both groups (68.42% for EDOF and 76.32% for multifocal), and overall patient satisfaction scores were comparable, though EDOF lenses yielded more consistent responses. In conclusion, both EDOF and multifocal IOLs effectively restore functional vision and reduce spectacle dependence. EDOF lenses are preferable for patients prioritizing intermediate and contrast vision, while multifocal lenses remain superior for near tasks. Further large-scale and long-term studies are warranted to confirm these outcomes.

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